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COMPARISON OF ALTERNATIVE MONETARY STANCE MEASURES FOR THE EURO AREA: EVIDENCE FROM THE FAVAR

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Abstract

This paper examines the validity of recently proposed alternative monetary policy measures for assessing effects of monetary policy in the Euro area during the combined period of global financial crisis and lower bound on interest rates. The alternative measures considered in the paper are Economic Measure of Stimulus introduced by Krippner (2014, 2015) and the two respective shadow short rate measures obtained from the benchmark term structure models proposed by Wu and Xia (2016) and Krippner (2011-2015). By employing the Factor Augmented VAR model we consistently identify the Euro area monetary shock through the Economic Measure of Stimulus and Wu and Xia's benchmark shadow rate, while Krippner's shadow rate exhibit some sensitivity towards different model and sample specifications. The shadow rate obtained from the benchmark Wu and Xia specification, however, exhibit tendency of understating stimulus effect and produces dynamics inconsistent with the actual monetary policy events. Our counterfactual analysis using the preferred alternative stance measure shows that realization of the Euro area industrial production could have potentially been lower up to 0.8%, had the non-standard measures not been introduced by the ECB.

JEL-Codes: E51, E32, E43, E44, E52, E58

Keywords: Non-standard measures, Shadow short rate, Economic measure of stimulus, European Central Bank, FAVAR, Historical decomposition

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[1]The views expressed in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Bank of Slovenia.

1. Introduction

The aftermath of the global financial crisis pushed monetary authorities into devising policy responses beyond standard interest rate. Largely increased balance sheet position and eight different non-standard programs prove that the European Central Bank has been no exception in that. Although, these kinds of measures had not been a complete unknown to the ECB even in the pre-crisis time, they have become the new normal with the exhaustion of further short-term interest rate movement due to a zero lower bound (Peersman, 2011). A natural question, therefore, is how to quantify the monetary measures when main policy rate remains unchanged and thus uninformative.

Wu and Xia (2016) and Krippner (2011-2015) propose the extraction of the shortest rate from the fitted yield curve model that properly accounts for the zero lower bound (ZLB). The short rate extracted from the ZLB-adjusted term structure model is free to evolve to arbitrarily negative values and is commonly denoted the shadow rate. The shadow rate estimate will in general depend on how the traceability of a yield curve model and modelling of lower bound is approached.

The shadow rates estimated by the Wu and Xia's and Krippner's specification, respectively, are for the US data compared by Francis et al. (2014) who show a relatively richer dynamics of the Krippner's shadow rate measure for modelling the monetary policy. A potential drawback of both types of shadow rates, however, is their relative sensitivity to the model specification. Krippner (2014, 2015a), therefore, proposes an additional and a more robust yield curve measure, denoted the Economic Measure of Stimulus, which summarizes the difference between the neutral rate and interest rate expectations.

In this paper we consider the validity of the three respective measures, outlined above, for representing alternative monetary stance measure for the Euro area. We do that by examining the consistency of the measures with respect to various policy events and by exploring their capability to properly identify the non-systemic part of the monetary policy in the Euro area Factor-Augmented Vector Autoregressive model, hereafter denoted the FAVAR.

The FAVAR model essentially relies on a rich set of information by using factors extracted from the large panel of macroeconomic and financial data as regressors in the VAR estimation. The idea of utilizing information from a handful of estimated factors, describing the common variation of macroeconomic variables, has a long tradition in various aspects of economic research and monetary policy analysis. The study by Sargent and Sims (1977) was seminal in introducing a dynamic factor approach into the business-cycle analysis. Similar applications were offered by Singelton (1980), Engle and Watson (1981), Stock and Watson (1989), and Quah and Sargent (1993). Most of the research just listed proposed a way of constructing the lead economic and business cycle indicators from a large set of macroeconomic variables in a degrees-of-freedom preserving fashion. With that, dynamic factor models represented an alternative to the standard time-series econometric models that assumed a certain degree of a priori restrictions on macroeconomic relations. Stock and Watson (2002) were the first to blend both approaches together. They studied forecasting of macroeconomic time series based on a large set of predictors at disposal to a researcher. In order to do that, they augmented the vector autoregression (VAR) modelling, commonly used in time-series forecasting application, with a small number of factors summarizing the information from all candidate predictors. They show a significant improvement of the forecast performance relative to the benchmark VAR model, with gains being further increased with an extended forecasting horizon.

The most notable application of the factor-augmented VAR model in the monetary policy analysis was initially introduced by Bernanke and Boivin (2003) and further extended by Bernanke, Boivin, and Eliasz (2005), hereafter denoted BBE. They show that in comparison to the standard monetary VAR model, analysing monetary transmission through FAVAR produces empirical results that are far more reconciled with the monetary theory and general economic intuition. Furthermore, a special appeal of examining the effects of monetary policy through the FAVAR structure is that it allows the observation of impulse responses for more than a hundred time series, rather than just for the selected subset of variables included in the standard VAR application. This is essentially utilized by Boivin, Giannoni, and Mihov (2007) who tested the sticky price assumption by disentangling fluctuations in prices at sectoral levels and examining them in relation to different macroeconomic and monetary conditions.

Wu and Xia (2016) use the FAVAR to test the validity of their approximated shadow rate and to measure the impact of the monetary policy on the US economy during the zero lower bound period. They found that the shadow rate, extracted from their benchmark term structure specification, exhibited a similar dynamics to the one observed for the Federal Funds Rate in the conventional period, that is before 2009. Moreover, their results imply that without unconventional policies in place, the US unemployment in 2013 would have been higher by approximately 0.23 %, whereas the industrial production index would have been lower by up to 2 percentage points.

The application of the FAVAR for the purpose of analysing monetary policy transmission in the Euro area is rather scarce. A rare exception to this is the analysis provided by Soares (2011) who shows similar results as those obtained for the US as far as the comparison with the benchmark VAR model is considered. Namely, the FAVAR model performs consistently better in terms of producing empirical results that are statistically more precise and in line with the conventional economic wisdom. However, to the best of our knowledge, no such research has been conducted so far for the purpose of analysing the impact of the ECB's monetary policy in the extended period encompassing the global financial crisis and the zero lower bound. With this paper we attempt to close this gap.

Our FAVAR model incorporates factors extracted from 129 Euro area macro and financial time-series and considers three different time periods. The structural analysis reveals that when used in place of a policy rate, the Economic Stimulus Measure and Wu and Xia's shadow rate produce impulse responses that are complied with the conventional economic wisdom. In contrast, using Krippner's shadow rate as a policy stance measure produces impulse responses that exhibit some degree of sensitivity towards a number of factors included in the FAVAR model and a time sample being considered. Examining the alternative measures from the perspective of the realized policy events, however, reveals counter-intuitive evolution and a tendency of understating the stimulus provided by non-standard programs in the case of Wu and Xia's shadow rate. Finally, we deem the Economic Stimulus Measure as the preferred alternative monetary stance rate and use it to estimate the counter-factual quantities of output and price series that would have prevailed in the absence of the ECB's monetary measures introduced in the period between 2008 and 2014. Our estimates show that, had the unconventional measures not been employed by the ECB, the Euro area industrial index would have on average been lower by up to 0.8 % in the crisis period.

The structure of the paper proceeds as follows: Section 2 describes different alternative monetary stance measures considered for the Euro area; Section 3 examines the validity of the individual alternative stance measures through their ability to properly identify the Euro area monetary shock; Section 4 provides the counter-factual analysis; and Section 5 concludes.

2. Alternative monetary policy measures

With the prolonged period of the economy operating near the zero lower bound (ZLB) on interest rates, the central banks' main policy rates become uninformative from the perspective of summarizing the monetary stance. As an alternative, several prominent research contributions, dealing with the matter of measuring the effects of monetary policy [2], advocate the use of the shadow short rates (SSR), derived from the ZLB-adjusted yield curve models. These models exploit the ZLB mechanism for the interest rates as defined by Black (1995), according to which, a yield curve can be decomposed as follows:

$$\underline{R}(t,\tau) = R(t,\tau) + Z(t,\tau) \tag{1}$$

$R(t,\tau)$ represents a shadow yield curve that would prevail in the absence of the zero lower bound on interest rates, and $Z(t,\tau)$ represents an option of investing in a physical currency, which prevents the estimated short rates from evolving to negative values. The SSR rate is the interest rate of the shortest maturity, extracted from the shadow part of the yield curve and it is based on parameters estimated in the ZLB-adjusted framework. Several approaches have been proposed for approximating the interest rate term structure representation in a near-ZLB environment. Wu and Xia(2016) develop a closed form analytic solution by deriving a forward rate pricing formula in discrete time. For extraction of Wu and Xia's SSR from the euro-area yield curve data, a 3-factor model with implicitly calibrated lower bound parameter is considered [3].

Krippner (2015b) and Christensen and Rudebusch (2013), however, mention several caveats in interpreting Wu and Xia's shadow rate as an alternative monetary stance measure. The critique is mainly developed in the context of considerable sensitivity of the estimated shadow rates to the time and maturity span of the yield curve data used, different values of imposed lower bound parameter, and an inconsistency with the realized monetary policy events.

Therefore, in addition to Wu and Xia's benchmark shadow rate for the Euro area, we also consider a shadow rate, extracted from the yield curve model with forward curve approximated in continuous time as defined by Krippner (2011-2015). For the purpose of estimating shadow rates, Krippner (2015b) as a bench-mark specification proposes empirical implementation with two latent factors and the estimated lower bound parameter. The restriction of the latent factors ensures economically meaningful interpretation of the shadow rate measure at the expense of the yield curve fit, whereas the estimation of the lower bound parameter, rather than its implicit calibration, should in principal provide better consistency with the monetary policy events.

However, any SSR measure is essentially an estimated quantity and it is detached from what economic agents actually observe, that is, current and expected interest rates subject to the ZLB constraint. This means, that while the SSR measure can offer an insight into the dynamics of how monetary policy evolves through time in the ordinal sense, making accurate quantitative judgement on the provided monetary stimulus/tightening based on the level of SSR remains questionable. Namely, Krippner's SSR, based on 2 factors and the estimated lower bound parameter, may show resilience towards a different model specification in the sense of its dynamics, but remains prone towards exhibiting significant sensitivity as far as the magnitude is concerned (Krippner, 2015b). This in turn makes the SSR series incomparable among different monetary systems as well as between the ZLB and non-ZLB period. In other words, the 100 bps reduction of the shadow rate in the non-ZLB period does not necessarily reflect the same monetary stimulus as the equivalent reduction in the ZLB period. Conversely, the Economic Measure of Stimulus (EMS), introduced by Krippner (2014, 2015a), allows this sort of comparisons and has been shown to be considerably more robust to different model specifications as compared to the

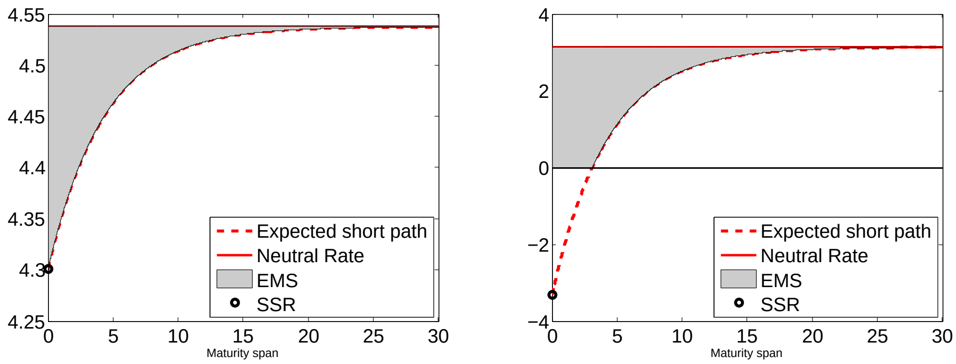
[2] Krippner (2011-2015), Wu and Xia (2016), Bullard (2012), Hamilton (2013), and others

[3] The Wu and Xia's shadow rate series for the Euro area is available at: `http://faculty.chicagobooth.edu/jing.wu/research/data/WX.html`

SSR measure. The EMS essentially summarizes the current and expected path of the short rate with respect to the long-run interest rate, commonly denoted as the neutral rate that reflects neither stimulatory nor restrictive monetary policy. In the yield curve setting, the neutral interest rate can be proxied with the first latent factor under the correct set of restrictions on the term structure model. In particular the EMS measure is represented as the integrated difference between the long-run interest rate and expected path of the short rate over the specified long-term horizon. More precisely, as the EMS relates to the expectations of economic agents which historically observe only positive values of interest rates, the current and expected path of short rate needs to be truncated at zero, where the positive part of the expectation path is denoted as the "effective value" of the SSR. The mechanics of the EMS can best be illustrated by two respective time points depicted in Figure 1.

Figure 1: SSR and EMS - Euro Area

(a) July 2008 (b) July 2012



Source: Bloomberg database; Author's calculations.

The EMS measure is defined by the total shaded area between the expected path of the short rate and the neutral rate. For the July 2008 case, the Euro-area SSR and its expected path exhibit only positive values, meaning that no truncation is needed to calculate the EMS. On contrary, in July 2012 only the effective part of the SSR is considered for monetary stimulus, since the observed interest rates can not fall below zero. This is particularly significant as, in contrast to the SSR measure, the EMS can account for the attenuated stimulus effect in the ZLB period that arises as a consequence of restricted movement of the medium- and long-term part of the yield curve. In addition to the accounted non-linearity, the comparability of the EMS is further ensured by the fact that both, in the non-ZLB as well as in the ZLB period, we essentially consider the same categories, the effective part of the SSR and the neutral rate, where the information on both is obtained from the same term-structure model. As these yield categories reflect monetary policy expectations, they can equally be affected by measures beyond key interest rate. Furthermore, the EMS contains a richer set of information as it embeds the whole shadow part of the yield curve as opposed to the specific point of the shortest maturity considered in the case of SSR. In other words, the EMS considers the current and future misalignments of monetary policy as relevant for economic agents' decisions, as opposed to the SSR, where only the current prevailing gap between the short rate and the neutral rate is taken into account (Krippner, 2015b).

The comparison of the alternative monetary stance measures for the Euro area can further be elaborated by observing Figure 2. We use the published Wu and Xia's SSR series, which is based on the Wu and Xia's (2016) benchmark discrete time Shadow/term-structure specification with 3 factors and the lower bound parameter calibrated to 25 basis points. The depicted Krippner's SSR and EMS time series are calculated using ZLB-adjusted ANSM model approximated according to Krippner (2011-2015) and with estimated lower bound parameter. [4]. The yield curve data spans twelve different maturities (0.25, 0.5, 1, 2, 3, 5, 7,10, 15, 20, and 30 years) and it includes German government bond yields up to year 2005, concatenated with the Euro Area Overnight Index Swaps from 2006 to 2015 [5].

Before selecting the preferred measures to enter the analysis of the Euro-area monetary transmission in the next Section, we discuss their characteristics from the perspective of their empirical robustness. First thing to note is the entirely parallel dynamics of the EMS measures, extracted respectively from 2- and 3-factor specification of the Shadow/ANSM model. This means that the EMS(2) and EMS(3) at any point in time agree on the direction of current and expected monetary policy.

However, a consistent divergence in terms of magnitude requires an additional discussion on which Shadow/ANSM specification provides more plausible estimates of the EMS in terms of absolute values. As already outlined, the EMS summarizes the monetary policy by putting current and expected interest rate in the perspective of neutral rate. The latter should, in line with the general monetary wisdom, predominantly be determined by the long-run fundamentals, resembled in output and inflation expectations, and less so by the prevailing monetary policy. How well these characteristics are summarized in the context of the yield curve modelling, will therefore depend on the extent to which the current monetary policy translates into dynamics of the Level factor variable that proxies for the neutral rate.

From the comparison demonstrated in Figure 2 it can be observed that the 3-factor specification better captures the attenuated effects as the added factor provides additional flexibility in terms of explaining the dynamics of short and medium term interest rates. Instead, in the 2-factor specification this dynamics is partially absorbed by long term yields which influence the cyclicality of the Level factor variable. In that respect, the EMS(3) represents the measure that is more consistent in both, empirical and theoretical context.

In contrast to the EMS, the alternative SSR measures exhibit considerable divergence when compared across different yield curve specifications. In recent literature, Krippner's SSR, extracted from the 2-factor model (hereafter denoted as K-SSR(2)), and Wu and Xia's SSR, extracted from the 3-factor model (here after WX-SSR(3)), have often been set as the benchmark alternative monetary stance measures for the US case. A considerable detachment of the two competing measures can first be noted at the end of 2012 with the somewhat counter-intuitive evolution of the WX-SSR, indicating a shift to restrictive policy following the introduction of the Outright Monetary Transaction program and more explicit ECB's forward guidance on easier financing condition in the future. Furthermore, in the period between 2013 and 2014, we can also observe two respective runs of non-zero realizations of Wu and Xia's SSR, where the positive values even exceeded market-observed data of Eonia rate. According to Krippner (2015b), the rationale for the counter-intuitive dynamics could be sought in the unjustifiably high level at which the lower bound parameter can potentially be calibrated in a yield curve model.

Therefore, Krippner as the benchmark yield curve framework for the SSR extraction proposes a specification under which the lower bound parameter is estimated. However, observing the K-SSR(3), extracted from the yield curve framework with a model-based lower bound parameter, reveals that the number of factors should also play a crucial role in explaining the tendency of understating the monetary stimulus. Namely, the K-SSR(3), in a large portion of the examined

[4]The calculations are based on the modified versions of Matlab code, available at the Reserve Bank of New Zealand website: Link to code

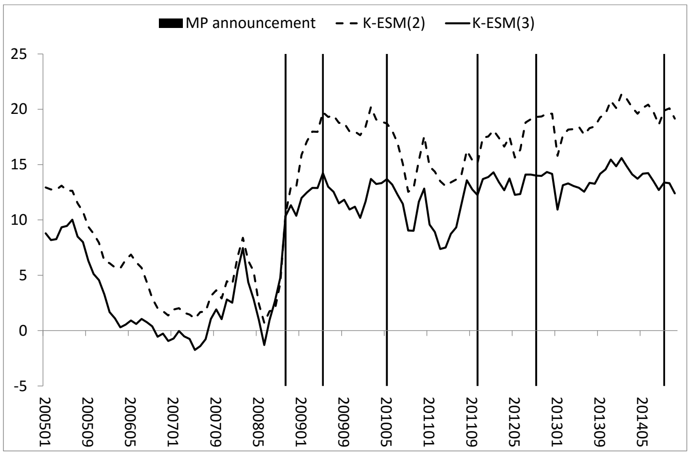
[5]Bloomberg yield curve series: F910 and S0133Z

sample does not offer any richer dynamics than the Eonia rate, which is materially constrained by the ZLB. This means that, while the additional flexibility of the 3-factor ZLB-adjusted yield curve helped improve the empirical consistency of the ESM measure, it has a counterproductive effect in case of the SSR.

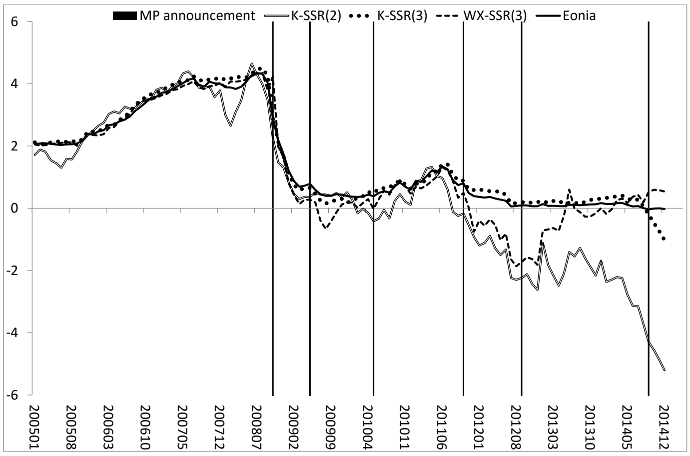
The reason for that can be found in the nature of the 3-factor model in finding a better fit to the data in ZLB. Namely, in the ZLB environment, a better fit to the data will be sought in the part of the yield curve that does not materially violate the calibrated or estimated lower bound and in that sense still exhibits plausible realizations. In that respect, the information of the shorter part of the yield curve is either down or up-weighted, depending on whether the observed yields are above or below the lower bound. Krippner (2015b) shows that greater flexibility in the 3-factor yield curve models is manifested in obtaining the better fit on the up-weighted part of the yield curve through the adjusted Slope factor. As the SSR rate is in the Arbitrage-free Nelson Siegel model obtained as the sum of the Level and the Slope factors, the sensitivity of the SSR in the 3-factor model becomes obvious. In contrast, the 2-factor specification produces SSR estimates that are consistent with actual policy events and exhibit robustness towards different modelling settings (time sample, maturity span, initial parameters, estimation technique) at the expense of the yield curve fit.

Figure 2: Monetary policy measures - Euro Area

(a) 2- and 3-factor EMS



(b) Alternative SSRs



Source: ECB Statistical Data Warehouse, Bloomberg database, Author's calculations.

In the following section, we examine the benchmark measures from the perspective of their dynamic relation to macroeconomic variables and suitability for examining the monetary policy transmission in the Euro area.

3. Structural analysis

Apart from exhibiting a relative robustness to differing yield curve models and showing consistency with the monetary policy events, to be considered a valid alternative policy stance measure, our preferred SSR or ESM rates need to enable a proper identification of the monetary policy shocks. Namely, a policy easing summarized by our policy measure should in line with the empirically and theoretically supported conventional wisdom manifest itself in positive responses of economic activity and general price levels; see Sims (1992), Wu and Xia (2016), Bernanke and Gertler (1996), and Bernanke, Eliasz, and Boivin (2005). Failing to recreate the monetary policy stylized facts would in turn mean that one has not been able to identify the monetary policy shock and the choice of policy rate should be reconsidered. We employ the factor-augmented vectorautoregressive (FAVAR) approach, introduced by Bernanke et al. (2005), to analyze the responses of macroeconomic variables to shock to our respective alternative monetary policy measures, presented in the previous section.

3.1. The FAVAR model

The idea of the FAVAR model is to use a small number of factor variables to summarize and exploit the information contained in a large number of macroeconomic and financial time series. The set of factor variables is then included in the VAR model along with the monetary policy measure. Compared to the standard monetary VAR analysis, the FAVAR approach has several notable advantages: Namely, in order to preserve the degrees of freedom needed for the proper inference on the estimated parameters, the standard VAR commonly consists of only a small number of variables. This inherently implies the assumption that monetary policy decisions rely solely on the information provided by the variables included in the VAR model. The information not incorporated within the included variables will therefore be secluded to the system's error, which can potentially lead to misleading estimated responses of variables to identified monetary shock. An example of a counterintuitive increase of the general price level to a tightening monetary shock, in the literature commonly denoted the "price puzzle", is an example of this, which can in this fashion be explained by a lack of information on future inflation that is usually incorporated in a central bank's decision making process, Sims (1992).

In addition to a reasonable choice of monetary stance measure, the scarce number of macroeconomic variables included in the standard VAR model also demands from a practitioner a proper judgement on the appropriateness of macroeconomic series to accurately represent the economic activity or the general price level. Namely, the real GDP level and the consumer price index alone, may not offer a complete indication of the economic activity and general price level prevailing in a particular economy. In contrast, augmenting the VAR model by a small number of factors that consistently summarize a large set of macroeconomic and financial time series could potentially solve for both, the omitted variable bias problem and the problem of properly identifying the channels of monetary transmission.

Moreover, the FAVAR model allows a simultaneous examination of effects of monetary policy decisions on more than a hundred variables of interest. These are assumed to be driven by the following factor structure:

$$X_t' = \beta^f F_t' + \beta^y Y_t' + w_t' \tag{2}$$

Where X_t is the $Nx1$ informational vector of macroeconomic and financial time series that can be explained by $Kx1$ vector of unobserved factors and the observed factor Y_t, where the latter is represented by one of the alternative stance measures, presented in Section 2. In this context, the number of observed variables N, included in the informational vector, will be much greater than the number of explanatory factors, $(K + 1 << N)$. β^f is a NxK matrix of factor loadings, whereas β^y is a $Nx1$ vector of loadings on policy rate. The joint dynamics of factor variables can be expressed with the FAVAR equation:

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = \Phi(\boldsymbol{L}) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + e_t \tag{3}$$

where $\Phi(\boldsymbol{L})$ represents a lag polynomial of order d, e_t is the reduced error term with a mean zero and covariance matrix Q, Y_t is an alternative measure representing a policy rate, and F_t is the $Kx1$ vector of unobserved factors.

The unobserved factors are uncovered in the static fashion as the part of the space covered by the first K principal components of the dataset X_t, that is not described by the Y_t [6]. This is achieved by following the recursive assumptions, according to which, the unobserved factors do not respond to a monetary policy innovation within the period. In that respect, the informational variables contained in the x_t are divided to the within a period pre-determined data, denoted "slow-moving variables", and to the data sensitive to contemporaneous policy shocks, denoted "fast-moving variables".

Macro factors are therefore assumed not to respond to the policy rate within a period and are thus constructed as $\widehat{pc} - \widehat{b}_{pc,y} Y_t$, where $\widehat{pc} - \widehat{b}_{pc,y}$ are coefficients estimated in regression $\widehat{pc}_t = b_p c \widehat{pc}^* + \widehat{b}_{pc,y} Y_t + n_t$. The pc and pc^* correspond to principal components, which are respectively extracted from the entire dataset and a subset corresponding to the slow-moving variables marked with "*". In equation (2), a particular element of β_i^y then equals zero in case X'_{ti} corresponds to a slow-moving variable and undertakes the non-zero values in case of the fast-moving variables. With respect to that, it is assumed that there is only a limited informational set provided by the fast-moving variables that is not accounted by the monetary policy rate.

Finally, the recursive assumption requires separate identification of structural innovation in the equation (3) corresponding to the monetary shock. This is done by re-expressing the reduced form residuals of the FAVAR as a product of a lower triangular matrix of the Cholesky decomposed residual variance-covariance matrix Q and the matrix of structural innovations.

Our informational matrix X incorporates 129 macroeconomic and financial time series collected from the Eurostat and the ECB's Statistical Data Warehouse. In order to ensure stationarity we applied standard transformation procedures, whereas the seasonal adjustment was provided by the X-13ARIMA procedure. The latter procedure was also used for the data imputation on the portion of the data set exhibiting incomplete series in the period between 1995 and 2000. The balanced panel of original data, therefore, spans the period between 2000 and the end of 2014. We resort to quarterly frequency, with linear interpolation performed on originally monthly data. A detailed data description of the dataset is available in Appendix C.

3.2. Alternative policy rates as linear monetary stance measures

Before proceeding to the impulse response analysis, we first utilize the FAVAR model to test whether our alternative measures (Wu and Xia's SSR, Krippner's SSR, and the Economic Measure of Stimulus) exhibit constant dynamic relations with the macro-economic variables throughout the conventional and ZLB period. If true, the test should offer a first indication of whether a particular alternative measure could be used in place of a conventional policy rate in ZLB times. Namely, an appealing feature of the alternative stance measures, stressed in

[6] Instead of estimating factors separately in a static fashion, BBE (2005) as an alternative propose Bayesian likelihood techniques for simultaneous estimation of factors and equation 3. However, their results show that the potential gains of this approach do not seem to offset the computational burden accompanying the likelihood methods. In contrast to statistical factor models, Forni and Gambetti (2009) develop a structural dynamic factor framework.

Section 2, is their co-movement with the conventional policy measures in periods with interest rates sufficiently above zero, on the one hand, and their ability to produce rich dynamics also in the low interest environment, on the other. This characteristic of alternative measures is best depicted in Figure 2, panel (b), where aligned movement of the Eonia rate and SSR measures can be observed in the period before 2009 and in 2011, when interest rates exhibited sufficiently positive values. On contrary, in the period of constant Eonia rate, due to a binding lower bound on interest rates, we can see the autonomous dynamics of the SSR rates. Replacing conventional rates with a valid alternative measure should, therefore, allow a linear interpretation of monetary policy shocks throughout the entire sample, spanning both the non-ZLB and ZLB period. Conversely, a considerable structural break in the coefficients corresponding to the FAVAR model, incorporating one of the alternative measures, would suggest that our policy measure of choice does not inherit ability to continuously summarize the monetary measures in the ZLB period.

We test for the change in the estimated FAVAR parameters at two potential break points. The first one indicates the end of the year 2007 and captures the run-up to the global financial crisis, whereas the second date is set to the end of year 2009, reflecting the beginning of the sovereign crisis in the Euro area. To construct the test statistic we re-estimate the upper block of equation (3) as proposed by Wu and Xia (2016):

$$F_t = \nu + \rho F_{t-1} + d_{(t<Dec2007)}\beta_0 Y_{t-1} + d_{(Dec2007<t<Dec2009)}\beta_1 Y_{t-1} + d_{(t>Dec2009)}\beta_2 Y_{t-1} + e_t \tag{4}$$

Where F_{t-1} is the matrix of lagged factor values, Y_{t-1} is the matrix of lagged policy rates, d is a dummy variable undertaking value 1 either before, between, or after the designated break dates. The equation (14) is, as in the case of the impulse response analysis, being re-estimated with alternating monetary measures, where in addition to alternative policy measures we now also consider the Euro OIS rate (EONIA). The latter is used as a proxy for the Euro-area conventional rate for which we assume a distinct structural break to be revealed in the GFC-ZLB period. Following the above specification, the null hypothesis assumes no structural break in coefficients upon the determined breakpoints, $H_0 : \beta_0 = \beta_1 = \beta_2$. To test the null hypothesis the following likelihood ratio statistics is defined:

$$(T - k)(log|e_R e_R| - log|e_U e_U|) \tag{5}$$

With T representing the number of observations, k being the number of regressors, $e_R e_R$ is the estimated covariance matrix with the imposed null hypothesis restriction, and $e_U e_U$ is the covariance matrix of unrestricted regression. Table 1 reports the likelihood ratio statistics with its significance level for each policy measure considered and corresponding 2-, 3-, 5-, and 7-factor FAVAR specifications. The reported results suggest that the null hypothesis cannot be rejected at any significant level for the EMS measure as the policy rate, regardless of the number of factors included in the FAVAR. This means that a dynamic relation of the EMS measure to macroeconomic variables does not change considerably with respect to the designated breaking points, and can therefore successfully compensate for the information not captured by the conventional policy rate in the ZLB period.

In contrast, the hypothesis of stable parameters for models with shadow rate alternatives cannot be rejected only for the 2-factor specification. This means that the models beyond 2-factor specification and with a shadow short rate in place of a policy measure would most probably produce biased impulse responses of the key macro variables. In other words, reading off the reduction of the SSR at negative values would very likely not resemble the same monetary stimulus as the reduction at levels sufficiently above zero. However, compared to the conventional stance measures, as i.e. EONIA rate, the test statistics related to the shadow rate alternatives in general remain lower, especially when the lower dimensional FAVAR specifications are considered.

Table 1: Likelihood ratio statistics for structural breaks in parameters

	WX-SSR	Krippner SSR	Economic Measure of Stimulus	Eonia rate
FAVAR(2)	14.56**	6.77	9.22	39.88***
FAVAR(3)	15.56**	18.12**	10.16	41.94***
FAVAR(5)	32.10***	32.66***	11.40	32.64***
FAVAR(7)	48.47***	31.68***	17.47	43.36***

Notes: ***, **, * - indicate significance at 1 %, 5 %, and 10 %, respectively. The null hypothesis assumes the constant parameters throughout the entire estimated sample. On contrary, rejecting the hypothesis at significant level indicates a structural break in the system.

3.3. The impulse response analysis

For the purpose of the impulse response analysis, we separately consider three different time periods to capture the potential shifts in the Euro-area monetary transmission mechanism, outlined with the above structural break exercise. In that respect, the first period encompasses the whole time period for which the data is available, 1995Q1 - 2014Q4, the second indicates the common-currency union and the balanced panel of the original data, 2000Q2 - 2014Q4, and the third incorporates the combined period of the global financial crisis and zero-lower-bound (the GFC-ZLB period), 2008Q2 - 2014Q4. For each period we estimate three respective FAVAR models, each corresponding to a different alternative policy rate, presented in Section 2, the EMS(3), WX-SSR(3) and the K-SSR(2). To determine the appropriate number of factors to be included in the benchmark Euro-area FAVAR model we follow the Bai and Ng's (2002) testing procedure which suggests that the Euro-area economy is properly represented by 7 unobserved factors, a result already obtained by Soares (2011).

The preferred factor specification is further justified by the proportion of variation that the factors included in the observation equation 2 explain for some of our key macro variables. From Table 2 it can be observed that the factor specifications corresponding to 2 and 3 factors, respectively, do not provide a meaningful representation of the Euro-area industrial production, as the estimated R-adjusted coefficient does not exceed 50 % for that variable. In order to observe the potential gains of adding additional information to the model and relative sensitivity of our alternative measures from the perspective of monetary transmission analysis, we (in addition to the 7-factor FAVAR) also estimate impulse responses for 2-, 3-, and 5- factor FAVAR with results secluded to Appendix A[7].

The above structure of the modelling framework, which incorporates different time samples, factor specifications and alternative monetary measures in place of a policy rate, should in principal serve the following purposes: a) Out of the three alternative measures, proposed by the recent literature, determine the one that most reliably summarizes the monetary stance and at the same time enables identification of the Euro-area monetary shock; b) Observe the gains of adding the information to a monetary VAR analysis in describing the Euro-area policy transmission mechanism; c) Observe how the monetary transmission mechanism has changed with respect to the ZLB environment; d) Taking into account all previous points, offer a most suitable framework for modelling monetary policy consistently through conventional and ZLB periods.

[7]Lag orders for each specification are determined based on standard likelihood ratio statistics with the exception of GFC-ZLB period where lag order is set to 1 in order to enable proper inference on such a small sample.

Table 2: R-adjusted observation equation (2000Q2 sample)

	Industrial production	real GDP	HICP	Employment	exports
2-factors	0.42	0.85	0.60	0.55	0.75
3-factors	0.42	0.91	0.76	0.64	0.87
5-factors	0.57	0.95	0.90	0.72	0.87
7-factors	0.56	0.95	0.92	0.86	0.89

Notes: The table reports the proportion of variation explained by predicting factors entering the observation equation as independent variables. The R-adjusted estimates are represented for selected aggregate variables that should in principle best resemble economic activity and prices.

Figure 3 depicts cumulative impulse responses produced by our preferred 7-factor FAVAR specification. The figure is divided into three panels, with panel (a) corresponding to the impulse responses estimated on the full data sample, 1995Q1 - 2014Q4, panel (b) depicts responses estimated on the common-currency sample, 2000Q2 - 2014Q4, and panel (c) refers to the period spanning the global financial crisis and low interest environment. In each period we depict the responses of the Euro-area industrial production index and the harmonized index of consumer prices (HICP), based on three separate FAVAR models, which, respectively, as a policy rate incorporate one of the benchmark alternative stance measures proposed by the recent literature (EMS(3), WX-SSR(3), and K-SSR(2)).

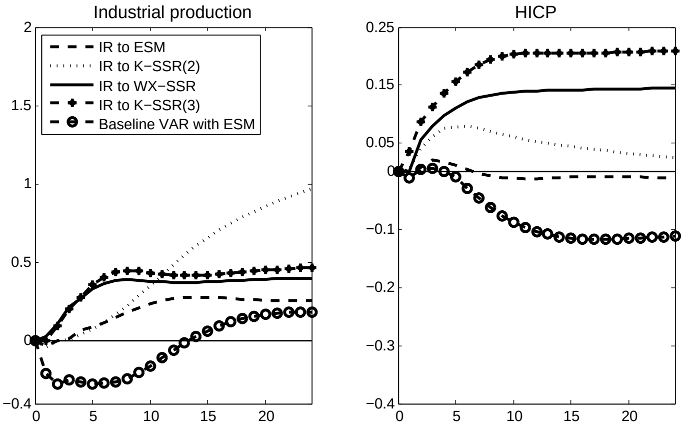
In Section 2 we discussed how dynamics of the SSR measure changes, depending on the number of factors that a yield curve model, from which the SSR is obtained, includes. To see how this changed dynamics is manifested in the monetary transmission analysis, we therefore also include impulse responses corresponding to the Krippner's SSR, extracted from the 3-factor yield curve model (K-SSR(3)). In addition, the impulse responses of the baseline monetary VAR are included to observe the potential gains of augmenting the VAR model with latent factors for the purpose of the Euro-area monetary policy transmission analysis.

We first analyze the impulse responses from the perspective of comparing different alternative measures and their ability to identify the monetary shock in the Euro area. As a criterion of proper monetary shock identification we set the alignment of impulse responses with the conventional monetary wisdom. That is, an unanticipated monetary expansion should be closely followed by increases in output and prices, where monetary expansion is expressed as the 25 bps increase in the EMS case and 25 bps decrease in case of SSR measures. Different FAVAR specifications (related to changing time sample and a number of factors included), incorporating Wu and Xia's policy rate (WX-SSR) produce responses that are broadly in line with the conventional monetary wisdom. In Figure 3, this is visible from the expected positive responses of the industrial production and HICP to innovation in WX-SSR rate for all time samples. The responses of the industrial production do, however, exhibit a considerable degree of persistence, which is inconsistent with the notion of the long-run money neutrality. In addition, as far as the magnitude of the price responses is concerned, the heterogeneity related to different time samples can be observed. Namely, the maximum price response to a 25 bps decrease in the WX-SSR drops from 0.14 percentage points, estimated for the full sample (panel (a)) to approximately 0.05 percentage points in the common-currency and ZLB periods (panels (b) and (c)).

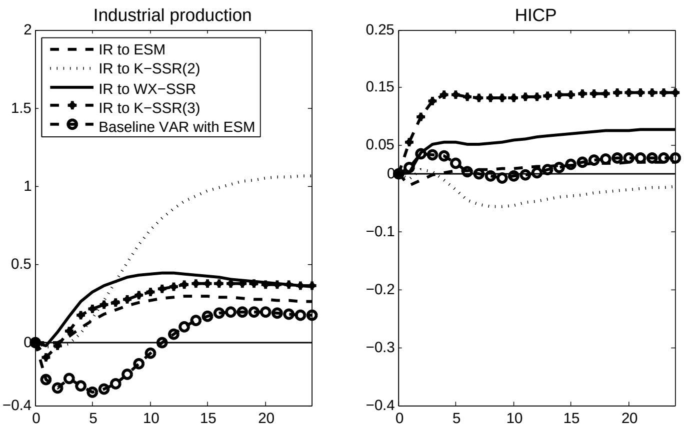
The responses implied by the ESM are intuitive, but, as in the case of WX-SSR, a somewhat sluggish dynamics of the industrial production can be spotted, in particular for the overall and common-currency estimation period (panels (a) and (b)). Namely, the peak 0.28 percentage point increase (averaged over both time samples) in industrial production can be observed only 2 years after the 25 basis point increase in EMS. The delayed and persistent response of industrial production, however, is not unique to the alternative policy measures used in our analysis. In that respect, Soares (2011) shows that maximum impact of monetary policy shock on the Euro-area output, using a conventional policy rate, is attained 22 months after the initial shock. Similarly, Bernanke et al. (2005) show that a very persistent output response is an occurrence that is commonly revealed also in the US data.

Figure 3: 7-factor FAVAR impulse response comparison for alternative policy measures

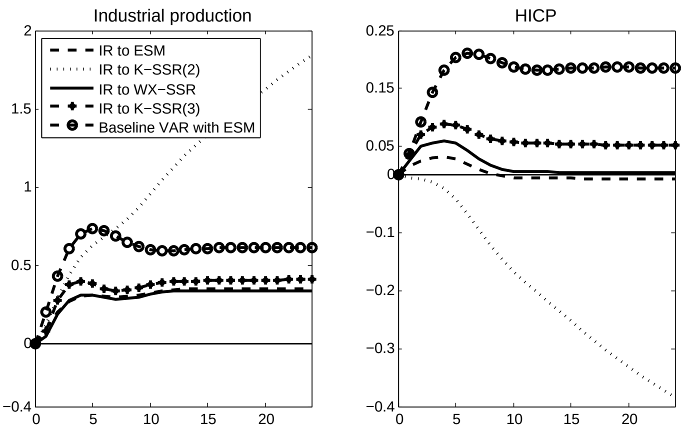
(a) Full sample



(b) Common currency sample



(c) GFC-ZLB period



Notes: The figure presents the impulse responses of the Euro area industrial production index and HICP to an expansionary monetary shock, 25 basis point increase in the EMS and reciprocal decrease in the SSR measures. Panel (a) refers to the impulse responses obtained in the 1995Q1-20014Q4 sample, panel (b) refers to the 2002Q2-2014Q4 sample, and panel (c) refers to the 2008Q2-2014Q4 sample.

The impact of shock to EMS on prices is small and insignificant (original impulse responses with corresponding confidence intervals are available in Appendix B). A relatively small price response can be attributable to a rather limited impact that macroeconomic disturbance, such as monetary policy shock, has on disaggregated price fluctuations. In particular, Boivin et al (2007) for the US data show that the price dynamics is predominantly driven by sectoral disturbances, whereas only about 17 % of fluctuations can be associated with the aggregated monetary shocks.

While the impact of monetary shock on prices remains relatively stable from the perspective of magnitude and the peak estimated response, some qualitative changes in dynamics can be observed, when different time samples are considered. Namely, in panels (a) and (c), reflecting the overall and GFC-ZLB period, the HICP responds immediately, with the peak response being attained 3 quarters after monetary policy innovations, followed by a slightly negative, but persistent negative impact that takes place after 10 quarters. In contrast, panel (b) reveals the initial short-lived puzzling response for the common-currency sample, where positive and a very persistent impact on prices is eventually achieved after 3 quarters. As the structural break analysis, reported in Table 4, reveals no significant change in estimated parameters for the FAVAR incorporating EMS, the explanation can again be sought in disaggregated price responses. Boivin et al (2007) point at a significant disperse reaction of sectoral price levels to aggregate monetary shock, where HICP categories that respond promptly and most flexibly correspond to sectors where produced quantities increase the least. The latter will essentially depend on the degree of competition and market power prevailing in a particular industry, which can potentially change in time, but the formal examination of this argument surpasses the scope of this analysis.

From Figure B.10 (Appendix B), one can observe that sectors that seem to govern the dynamics of the aggregated consumer price level in the Euro area are the ones referring to the activities connected to goods, transport, energy, and clothing, as the responses of these categories qualitatively mimic the overall HICP response produced by the EMS. The sectors that exhibit most flexible price responses are related to food, housing, water, and electricity, where peak responses are attained between 3 and 5 quarters, with the dying-off effect taking place 12 quarters after the initial shock.

In contrast to the EMS and Wu and Xia's SSR, the Krippner's SSR (K-SSR(2)) exhibits some degree of sensitivity in estimated responses towards different factor and sample specifications of the FAVAR. Namely, from Figure A.8 (Appendix A), a strong counter-intuitive negative response of industrial production to a shock in K-SSR can be observed, that seem to occur only with the 5-factor FAVAR specification. Likewise, the 7-factor FAVAR reports a strong expected increase in a price response estimated on the entire sample (Figure 3, panel (a)), while for the GFC-ZLB period a strong puzzling price effect is revealed (Figure 3, panel (c)). Inconsistency in responses pertaining different FAVAR specifications suggests that the K-SSR(2) measure may not offer a reliable monetary shock identification. The exhibited dynamic relation to macro variables reconciled with the conventional economic wisdom in the case of WX-SSR, however, does not necessarily reflect its superiority towards the K-SSR(2) measure. Instead, the differing results of respective SSR measures further prove the discussion on sensitivity of SSR series, initiated in Section 2, according to which, the evolution of SSR series in the ZLB period will highly depend on a number of factors that a yield curve model from which SSR is estimated incorporates.

How divergent dynamics, resembled on a rather small portion of the examined sample in Figure 2, can affect the overall monetary transmission analysis, we illustrate by additionally examining the impulse response functions corresponding to K-SSR, extracted from the 3-factor yield curve model (K-SSR(3)). Namely, the results in this case are now fully reconciled with the economic theory and would point towards the proper identification of a monetary shock in the Euro area. However, these responses are achieved at the expense of uninformative dynamics of the SSR measure from the perspective of indicating the monetary stance consistent with the actual monetary policy events. In other words, while the SSR measure, obtained from the 3-factor term-structure model, enables the identification of monetary transmission channel, the actual values of the SSR measure will not resemble the true stimulus provided by the ECB in a particular moment in time. Conversely, the EMS measure seems to meet both criteria: i) It develops dynamics consistent with the actual monetary policy events; ii) A monetary shock identified through the EMS produces responses that are broadly in line with the monetary wisdom and are strongly consistent with the stylized facts reported for conventional monetary policy rates and other country cases. In addition, the structural break analysis showed that the FAVAR incorporating the EMS exhibits no structural break in the estimated parameters, which expose the EMS as an eligible candidate measure to be used in a place of a conventional policy rates when it becomes uninformative due to a zero lower bound.

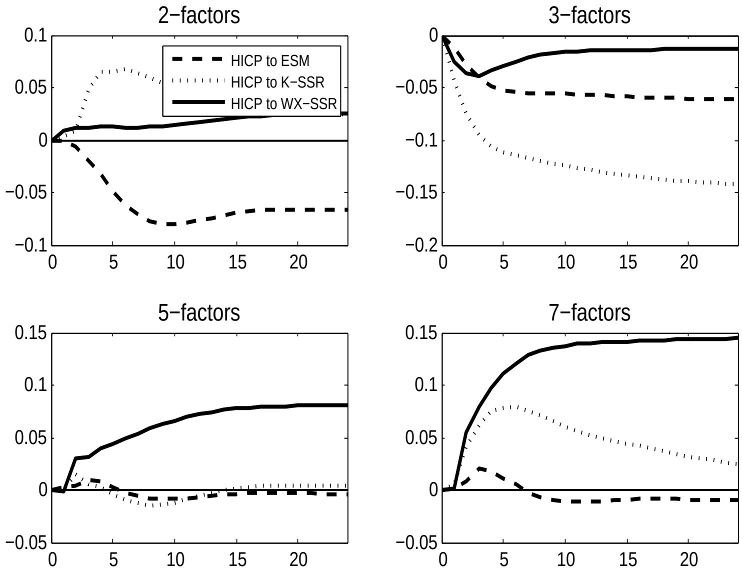
The above impulse response and structural break analyses, therefore, revealed EMS as the preferred alternative monetary stance measure for the Euro area. Along with the benchmark FAVAR specification incorporating 7 factors, our proposed data-rich modelling framework can then directly be compared to the standard monetary VAR, a baseline model widely used for the purpose of modelling monetary policy. The baseline impulse responses depicted in Figure 3 are produced by the 3-variate VAR model, incorporating the Euro-area industrial production index, HICP, and EMS measure as the policy rate [8].

The upper panel of Figure 3 shows that the baseline VAR produces a puzzling price response for the overall sample period (1995Q1-2014Q2). In addition to the price puzzle, a considerable counter-intuitive output response is revealed for the baseline VAR model as the industrial production index drops by 0.27 percentage points upon an unanticipated monetary expansionary shock (25 bps increase in EMS). Employing the information-rich FAVAR framework instead, offers a remedy for puzzling price and output responses that, according to Sims (1992), have a tendency to occur in a baseline monetary VAR analysis due to the information shortage. Likewise, increasing a number of explanatory factors in the FAVAR framework, generally improves results from the perspective of reducing the puzzling price effect for all three benchmark alternative measures considered. Figure 4 depicts the HICP responses to shocks in EMS, WX-SSR, and K-SSR, respectively, that were separately produced by 2-, 3-, 5- and 7-factor FAVAR specification, estimated on the full sample (1995Q1 - 2014Q4).

The upper left panel of Figure 4 discloses a significant puzzling response produced by all three alternative measures in the 2-factor FAVAR specification. By adding additional factors to the FAVAR, the counter-intuitive price response becomes almost non-existent for all three alternative measures. The gradual elimination of the puzzling effect with an increasing number of factors thus confirms the discussed implications of the model information shortage and further justifies our choice of preferred 7-factor FAVAR specification for representation of the Euro-area monetary transmission.

[8]To determine lag order of the Baseline VAR model, the standard Dickey-Fuller test was performed for the overall and common currency sample, suggesting the lag order of 3 and 2, respectively. For the ZLB period, the lag order was set to 1 to enable a proper statistical inference.

Figure 4: FAVAR and the price puzzle phenomena



Notes: Figure depicts impulse responses of HICP variable to shocks in respective alternative monetary measures that were separately obtained from 2-, 3-, 5-, and 7-factor FAVAR model, estimated for the full sample (1995Q1-2014Q4).

The main conclusions that can be taken out from the above analysis can thus be summarized around the following points: a) Out of the three alternative stance measures considered in the analysis, the Economic Stimulus Measure, proposed by Krippner (2014, 2015a), most consistently summarizes the actual monetary policy effects and can be considered as the best policy tool for the analysis of the Euro-area monetary transmission; b) the benchmark FAVAR framework successfully deals with the information-shortage present in the standard VAR analysis that can be associated with the common counter-intuitive responses of the key macroeconomic variables; c) the impulse responses, obtained in our benchmark FAVAR specification, suggest that in contrast to the rather sluggish dynamics of the output related to the monetary policy in the pre-crisis period, the translation of the monetary shock to output is much faster and more direct in the combined period of the global financial crisis and the ZLB, however, with an almost non-existent effect on prices.

4. Macroeconomic implications

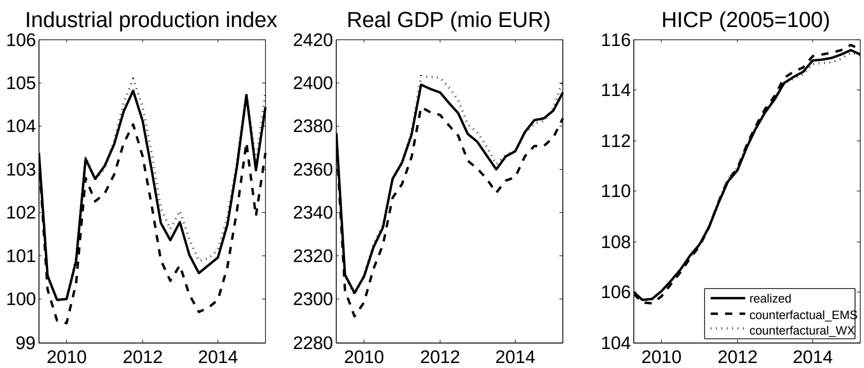
In this section we attempt to put the actual tangible quantity on the effects of the ECB policies during the GFC-ZLB period. Namely, from 2008 till 2014, the ECB introduced several non-standard programs, including three covered bond purchase programs (CBPP), the collateral framework and the provision of additional liquidity, the securities markets program (SMP), and the outright monetary transactions program (OMT). In order to measure the impact of the non-standard programs we decompose our macroeconomic variables into their initial deterministic component and a stochastic component, incorporating the sum of all past shocks, an approach also employed by the Wu and Xia (2016) on the US data.

Hence, by setting contributions of the monetary policy rate variable to zero, we can observe the realization of macro variables, had the non-standard measures not been introduced. In accordance to the analyses, provided in Sections 2 and 3, the preferred policy variable choice is Economic Stimulus Measure, introduced by Krippner (2014, 2015a), as it exhibited most consistent dynamics with the actual policy events and provided the most reliable identification of a monetary policy shock. To elaborate on the points raised in Section 3, the analysis also reports results for the Wu and Xia's SSR. The period for which the contribution of shock, recognized through the alternative policy variables, is excluded, encompasses the time between 2008Q3 and 2014Q4.

The solid line in the Figure 5 represents the actual realizations of macroeconomic variables, the dashed line represents the counter-factual path predicted by the EMS measure, and the dotted line are realizations that would occur in the absence of the ECB interventions according to Wu and Xia's SSR measure. The evolution of the counter-factual path of the GDP, produced by the Wu and Xia's SSR, above the realized quantities confirms the initiated discussion in Section 2 on underestimation of the non-standard programs by the SSR measures, derived from the 3-factor yield curve models and with an explicitly calibrated lower bound parameter. Furthermore, as our counter-factual analysis reveals and as it was already suggested by Figure 2, by simply reading-off the dynamics of the Wu and Xia's SSR would (e.g. in the late 2013 and 2014) suggest that the ECB's policies were actually restrictive, which would be inconsistent with the intent of the non-standard programs introduced.

In contrast, the EMS measure points towards an accommodative nature of the unconventional policies, devised by the ECB throughout the GFC-ZLB period. In particular, for the period from 2009 to 2014, we estimate that the Euro-area industrial production index and the real GDP would have on average been lower by 0.8 and 0.6 percent, had the monetary policy measures not been introduced. Furthermore, the accommodative effects on the real economy were achieved at little or zero cost of higher inflation.

Figure 5: Counterfactual analysis



Source: *Eurostat; author's calculations.*

5. Conclusion

This paper explored usefulness of the recently proposed alternative policy stance measures for a continuous assessment of monetary policy effects throughout the period of conventional and unconventional monetary policy conduct. In particular, our focus was placed on the Economic Measure of Stimulus, introduced by Krippner (2014, 2015a), and the shadow rates obtained from the respective benchmark yield curve models proposed by Wu and Xia (2016) and the model of Krippner (2011-2015). We estimated the factor-augmented VAR (FAVAR) model in order to examine the capability of the proposed measures to identify monetary policy shock in the Euro area. We find that the shocks to Economic Stimulus Measure and Wu and Xia's benchmark SSR produce intuitive macroeconomic responses, consistent with the conventional economic wisdom. However, a detailed analysis of the SSR measures reveals that the assessed impact on the real economy would essentially be specific to the yield curve modelling framework used for their extraction. With respect to that, we can consider the Economic Measure of Stimulus the most adequate to summarize the monetary stance continuously through conventional and unconventional periods.

From the perspective of monetary transmission analysis in the Euro area, an increasing factor structure successfully removes puzzling price responses, commonly present within the standard monetary VAR model. In that manner, the information-rich content of the FAVAR in combination with the Economic Stimulus Measure provides a reliable framework for empirical modelling of monetary policy in the lower bound period. In the period spanning the global financial crisis and the zero lower bound, however, both, the standard baseline VAR model and the FAVAR model, produce an expected effect on the output and prices. This indicates that the unconventional monetary policies have indeed had the accommodative effects on the Euro-area economy. In particular, we show that in the period between 2008Q3 and 2014Q4, the realization of the Euro-area industrial production would on average, in the absence of the ECB interventions, be approximately 0.8 % lower.

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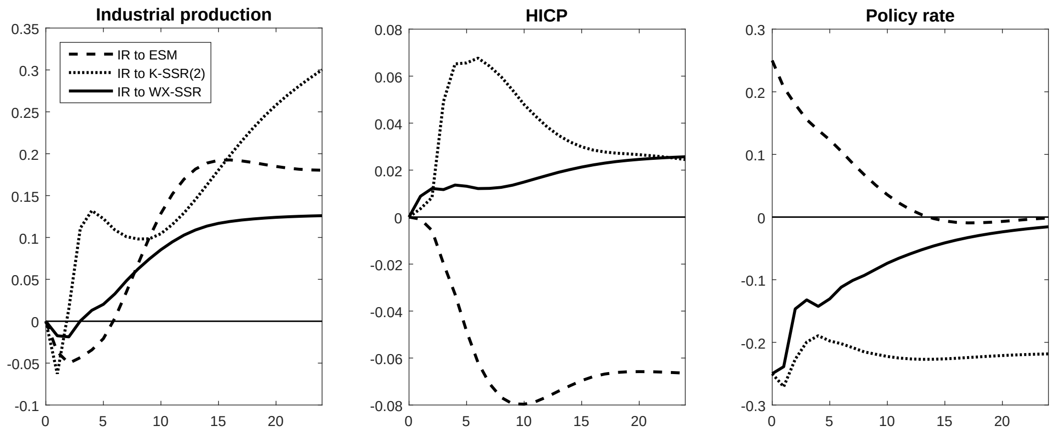
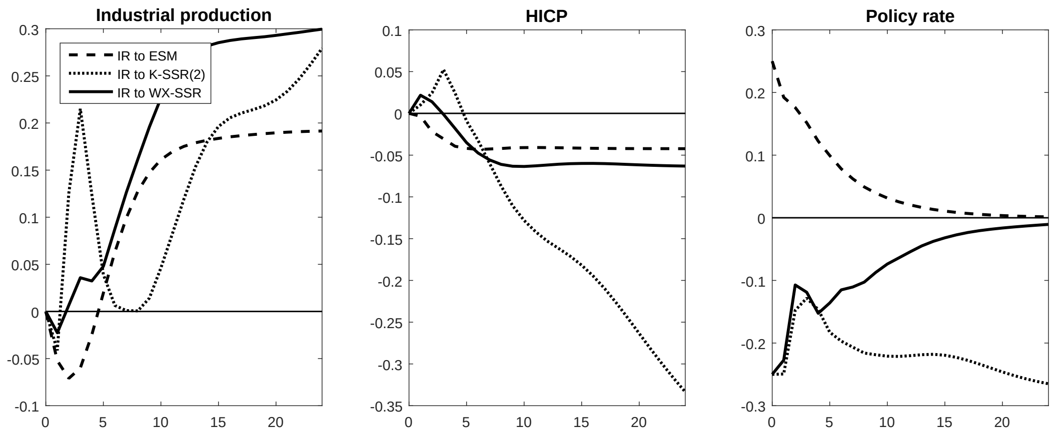
Appendix A. IR comparison with various factor specification

Figure A.6: 2-Factor FAVAR

(a) Full sample



(b) Common currency sample



(c) GFC-ZLB period

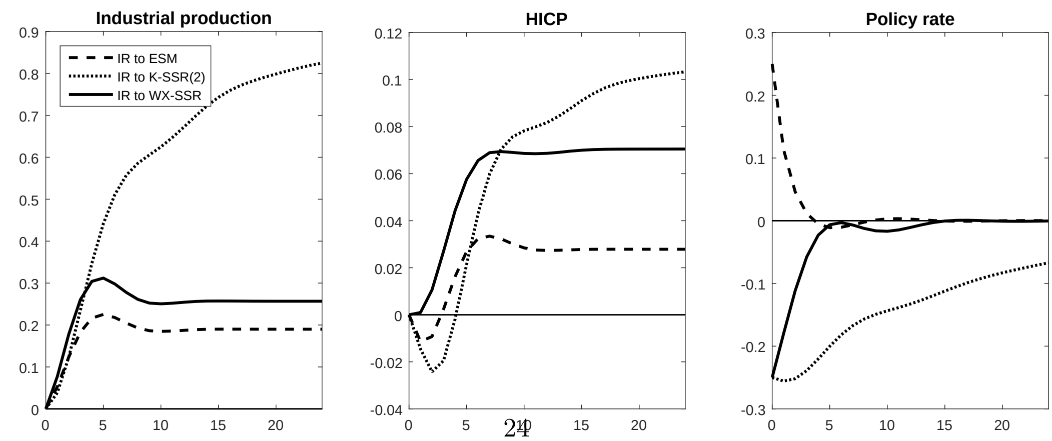
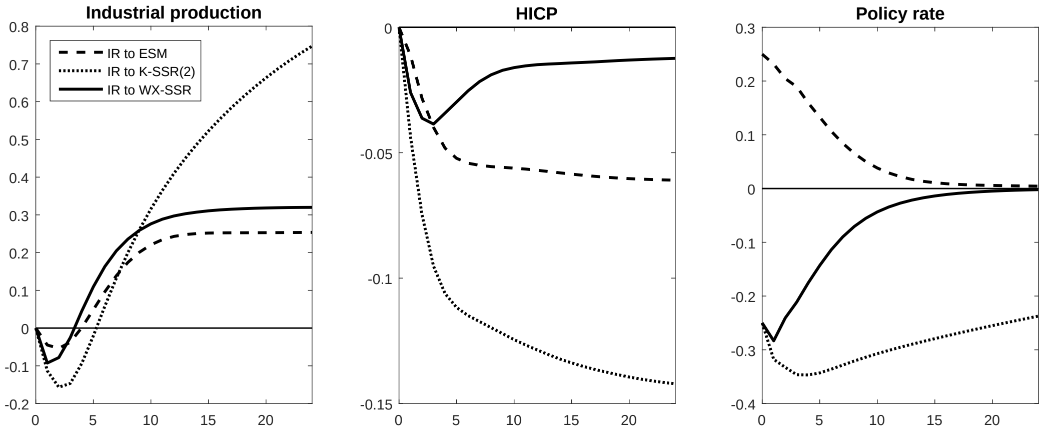
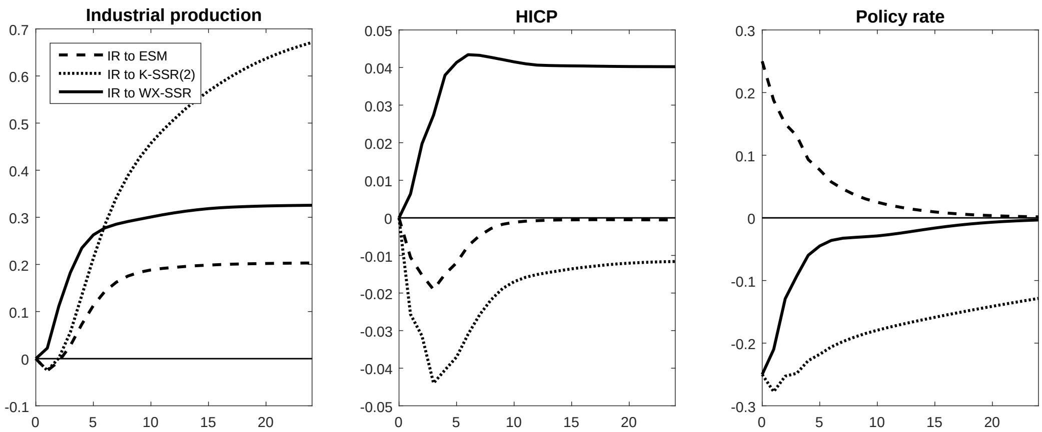


Figure A.7: 3-Factor FAVAR

(a) Full sample



(b) Common currency sample



(c) GFC-ZLB period

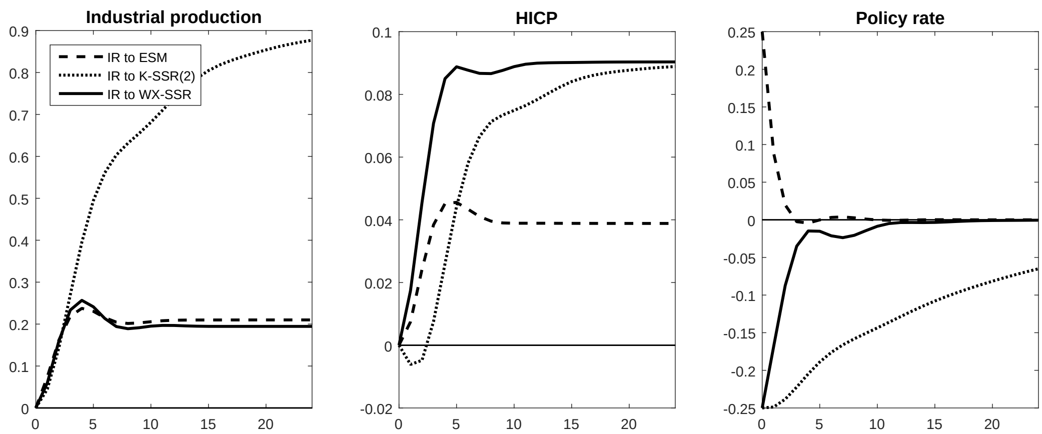
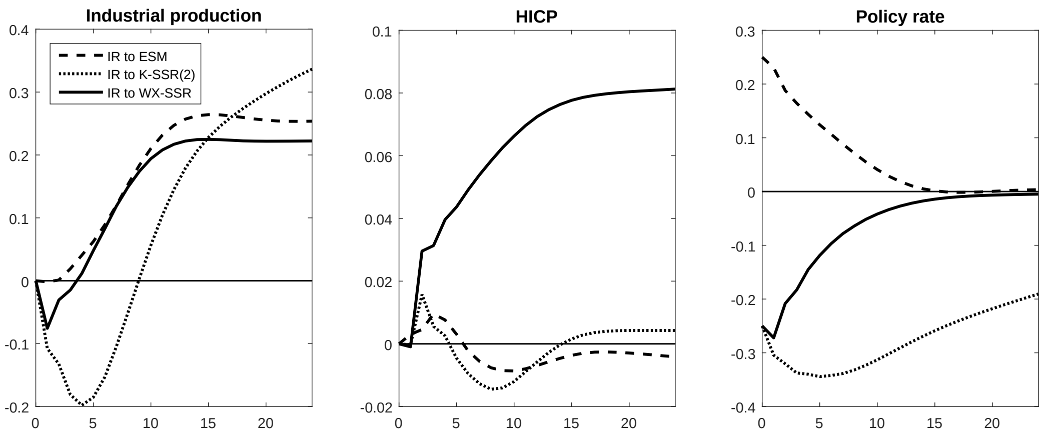
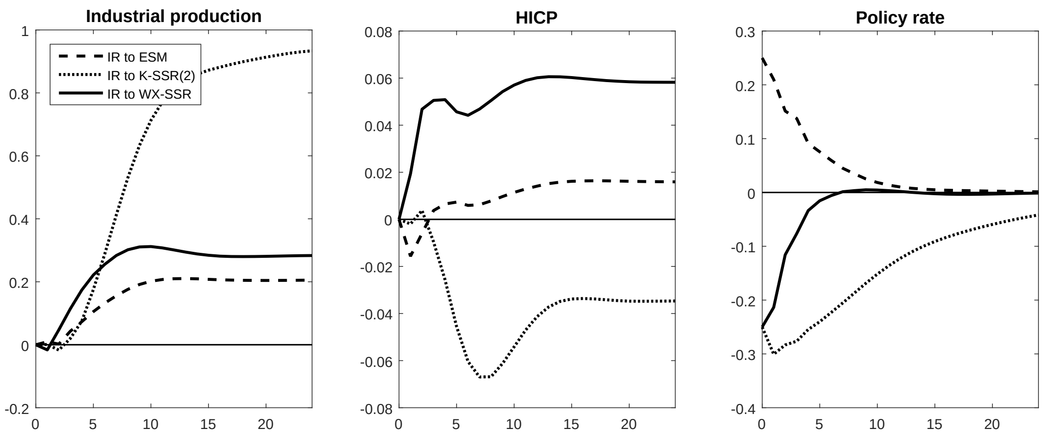


Figure A.8: 5-Factor FAVAR

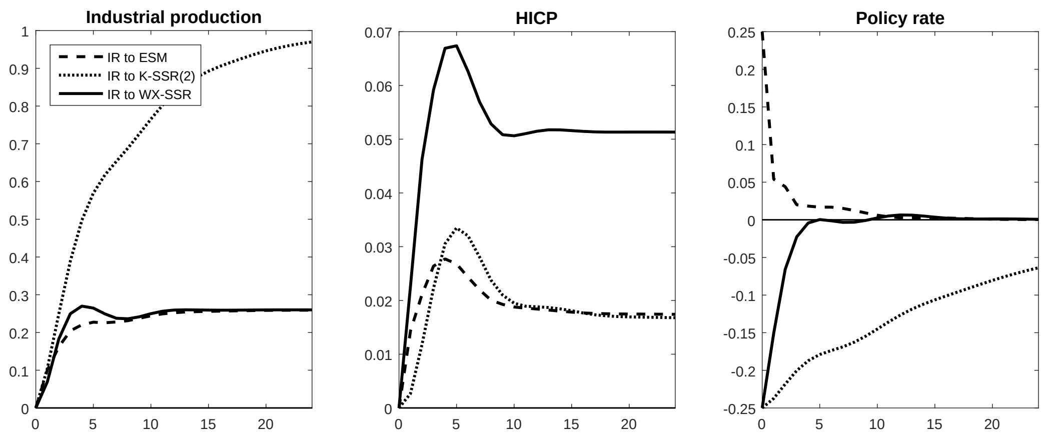
(a) Full sample



(b) Common currency sample



(c) GFC-ZLB period



Appendix B. IRFs with CI and disaggregated sector variables

Figure B.9: IRFs - macro variables (95% CI to EMS response)

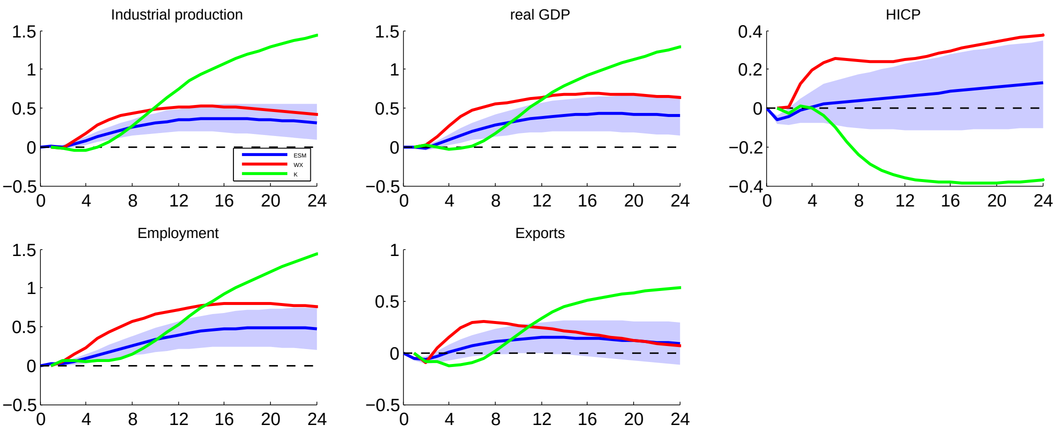


Figure B.10: HICP - disaggregated (95% CI to EMS response)

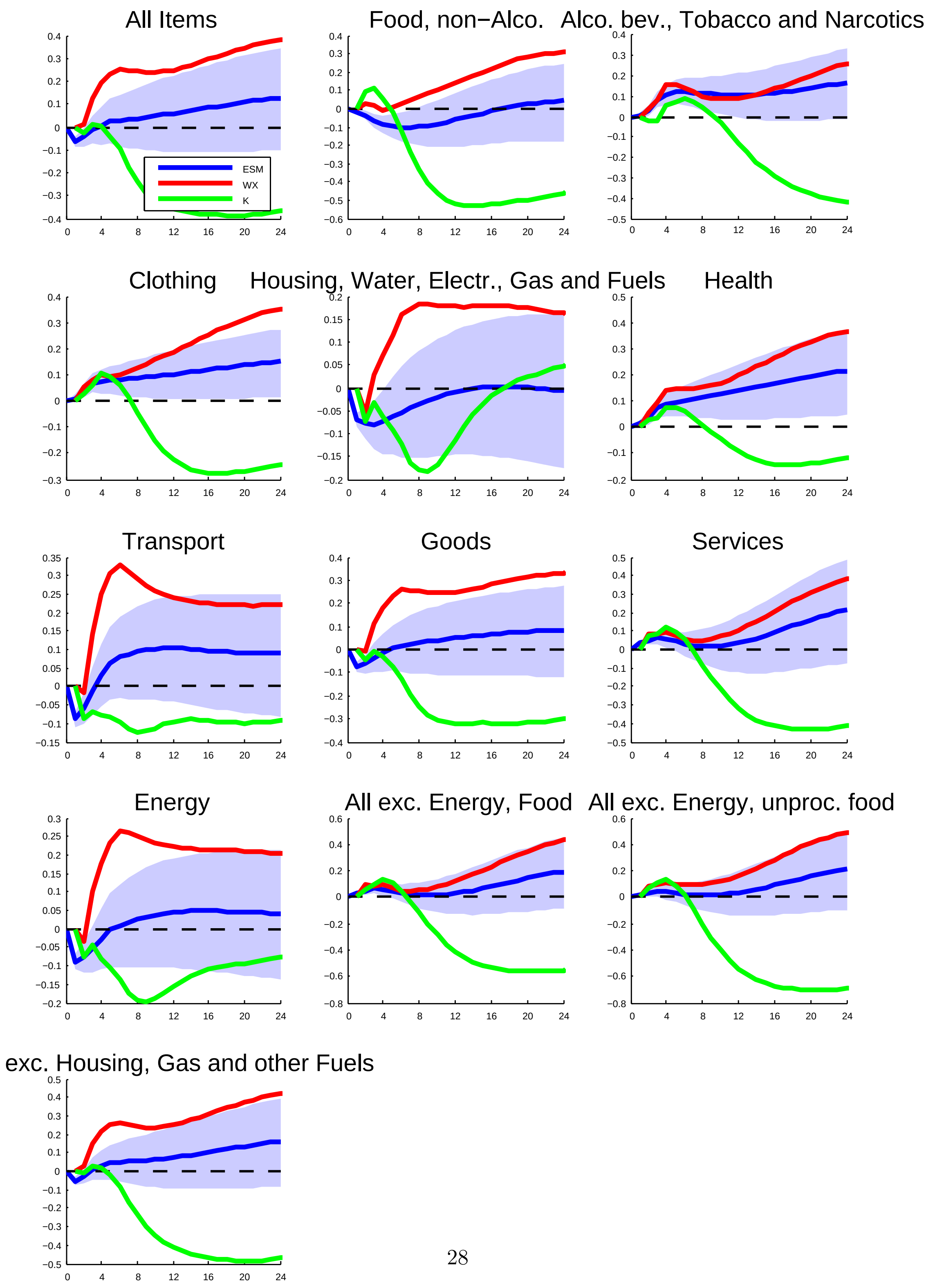


Figure B.11: Industrial production - disaggregated (95% CI to EMS response)

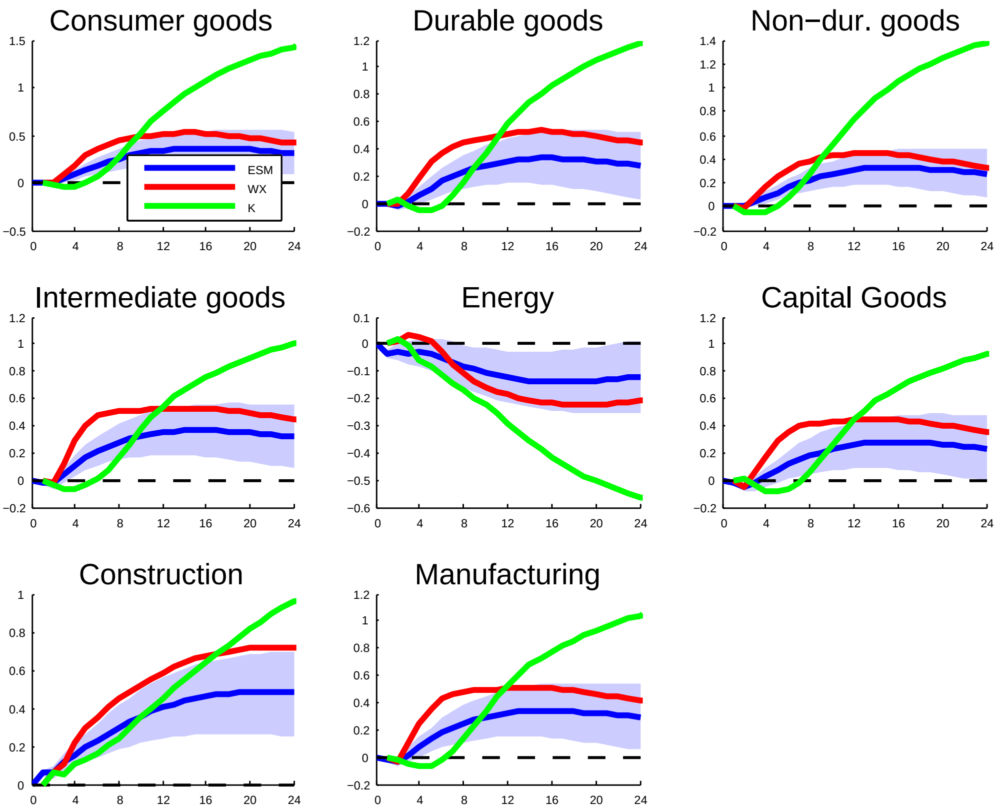
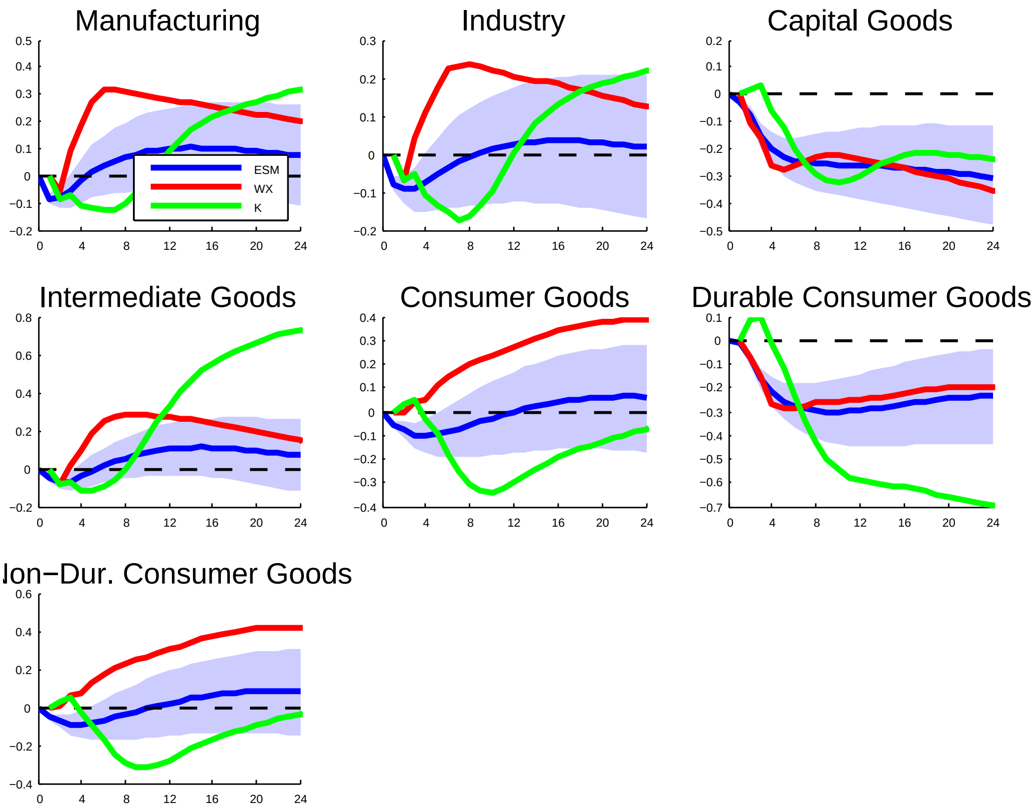


Figure B.12: Producer price index - disaggregated (95% CI to EMS response)



Appendix C. Data

Table D1: FAVAR Database description

Variable	Tr. code	Source
Output		
Industrial production (2005=100)-Total	5	SDW
Industrial production (2005=100)-Consumer goods	5	Eurostat
Industrial production (2005=100)-Durable Consumer Goods	5	Eurostat
Industrial production (2005=100)-non-durable consumer goods	5	Eurostat
Industrial production (2005=100)-Intermediate Goods	5	Eurostat
Industrial production (2005=100)-Energy	5	Eurostat
Industrial production (2005=100)-Capital Goods	5	Eurostat
Industrial production (2005=100)-Construction	5	Eurostat
Industrial production (2005=100)-Manufacturing	5	Eurostat
Real GDP (2010 = 100)-Total	5	Eurostat

Table D1: FAVAR Database description

Variable	Tr. code	Source
Real GDP (2010 = 100)-Gross Value Added	5	Eurostat
Real GDP (2010 = 100)-Final Private Consumption	5	Eurostat
Real GDP (2010 = 100)-Government Expenditures	5	Eurostat
Real GDP (2010 = 100)-Investments - Gross Fixed Capital Formation	5	Eurostat
Real GDP (2010 = 100)-Exports - Goods & Services	5	Eurostat
Real GDP (2010 = 100)-Imports - Goods & Services	5	Eurostat
GDP current prices (2010 = 100)-Total	5	Eurostat
GDP current prices (2010 = 100)-Gross Value Added - constant prices	5	Eurostat
GDP current prices (2010 = 100)-Final Private Consumption	5	Eurostat
GDP current prices (2010 = 100)-Government Expenditures	5	Eurostat
GDP current prices (2010 = 100)-Investments	5	Eurostat
GDP current prices (2010 = 100)-Exports - Goods & Services	5	Eurostat
GDP current prices (2010 = 100)-Imports - Goods & Services	5	Eurostat
Prices		
HICP-All Items	5	Eurostat
HICP-Food and non-Alcoholic Beverages	5	Eurostat
HICP-Alcoholic beberages, Tobacco and Narcotics	5	Eurostat
HICP-Clothing and Footwear	5	Eurostat
HICP-Housing, Water, Electricity, Gas and Fuels	5	Eurostat
HICP-Health	5	Eurostat
HICP-Transport	5	Eurostat
HICP-Goods	5	Eurostat
HICP-Services	5	Eurostat
HICP-Energy and Unprocessed Food	5	Eurostat
HICP-Overall Index excluding Energy, Food, Alcohol and Tobacco	5	Eurostat
HICP-Overall Index excluding Energy and unprocessed food	5	Eurostat
HICP-Overall Index excluding Housing, Water, Electricity, Gas and other Fuels	5	Eurostat
Producer price index-	5	Eurostat
Producer price index-	5	Eurostat
Producer price index-	5	Eurostat
Producer price index-	5	Eurostat
Producer price index-	5	Eurostat
Producer price index-	5	Eurostat
Producer price index-	5	Eurostat
Commodity prices - Total non-Energy	5	SDW
Commodity prices - Oil Price, Brent Crude	5	SDW
Price Deflators-GDP	5	Eurostat
Price Deflators-GVA	5	Eurostat
Price Deflators-Private Final Consumption	5	Eurostat
Price Deflators-Government Expenditure	5	Eurostat
Price Deflators-Gross Fixed Capital Formation	5	Eurostat
Price Deflators-Exports	5	Eurostat
Price Deflators-Imports	5	Eurostat
Labour market		
Employment (1000 persons, SA)-Total	5	Eurostat
Employment (1000 persons, SA)-Employees	5	Eurostat

Table D1: FAVAR Database description

Variable	Tr. code	Source
Employment (1000 persons, SA)-Self-Employed	5	Eurostat
Employment (1000 persons, SA)-Agriculture	5	Eurostat
Employment (1000 persons, SA)-Industry	5	Eurostat
Employment (1000 persons, SA)-Services	5	Eurostat
Labour Productivity - person based (2010=100, SA)-Total	5	Eurostat
Labour Productivity - person based (2010=100, SA)-Agriculture	5	Eurostat
Labour Productivity - person based (2010=100, SA)-Industry	5	Eurostat
Labour Productivity - person based (2010=100, SA)-Construction	5	Eurostat
Labour Productivity - person based (2010=100, SA)-Trade	5	Eurostat
Labour Productivity - person based (2010=100, SA)-Financials	5	Eurostat
Labour Productivity - person based (2010=100, SA)- Services	5	Eurostat
Unit Labour Costs-Total	5	Eurostat
Unit Labour Costs-Agriculture	5	Eurostat
Unit Labour Costs-Industry	5	Eurostat
Unit Labour Costs-Construction	5	Eurostat
Unit Labour Costs-Trade	5	Eurostat
Unit Labour Costs-Financials	5	Eurostat
Compensation per Employee (2000=100, SA)-Total	5	Eurostat
Compensation per Employee (2000=100, SA)-Manufacturing	5	Eurostat
Compensation per Employee (2000=100, SA)-Industry	5	Eurostat
Compensation per Employee (2000=100, SA)-Construction	5	Eurostat
Compensation per Employee (2000=100, SA)-Trade	5	Eurostat
Compensation per Employee (2000=100, SA)-Financials	5	Eurostat
Compensation per Employee (2000=100, SA)-Services	5	Eurostat
Industrial New Orders and Turnover		
New Orders (2005=100, SA)-Manufacturing	5	Eurostat
New Orders (2005=100, SA)-Capital Goods	5	Eurostat
New Orders (2005=100, SA)-Durable Consumer Goods	5	Eurostat
New Orders (2005=100, SA)-Intermediate Goods	5	Eurostat
Turnover-Manufacturing	5	Eurostat
Turnover-Capital Goods	5	Eurostat
Turnover-Consumer Goods	5	Eurostat
Turnover-Durable Consumer Goods	5	Eurostat
Turnover-Intermediate Goods	5	Eurostat
Turnover-Non-Durable Consumer Goods	5	Eurostat
Turnover-Energy	5	Eurostat
Business tendencies	2	Eurostat
Financial market		
Exchange Rates-USD/EUR	5	Eurostat
Exchange Rates-JPY/EUR	5	Eurostat
Exchange Rates-GBP/EUR	5	Eurostat
Exchange Rates-CHF/EUR	5	Eurostat
Dow Jones Euro Stoxx Index-DJE 50	5	SDW
Dow Jones Euro Stoxx Index-DJE Broad	5	SDW
Dow Jones Euro Stoxx Index-Industrials	5	SDW
Dow Jones Euro Stoxx Index-Utilities	5	SDW

Table D1: FAVAR Database description

Variable	Tr. code	Source
Dow Jones Euro Stoxx Index-Oil and Gas Energy	5	SDW
Dow Jones Euro Stoxx Index-Consumer Goods	5	SDW
Dow Jones Euro Stoxx Index-Consumer Services	5	SDW
Dow Jones Euro Stoxx Index-Basic Materials	5	SDW
Dow Jones Euro Stoxx Index-Technology	5	SDW
Dow Jones Euro Stoxx Index-Healthcare	5	SDW
Dow Jones Euro Stoxx Index-Telecommunications	5	SDW
Dow Jones Euro Stoxx Index-Financials		
Money aggregates		
Money Aggregate (mil. EUR, SAWD)-M1	5	SDW
Money Aggregate (mil. EUR, SAWD)-M2	5	SDW
Money Aggregate (mil. EUR, SAWD)-M3	5	SDW
Money Aggregate (mil. EUR, SAWD)-MFI credit to Government	5	SDW
Money Aggregate (mil. EUR, SAWD)-Consumer Credit	5	SDW
Balance of payments		
BOP Items (Net, mil. Eur, SA, BPM5)-Current Account	5	SDW
BOP Items (Net, mil. Eur, SA, BPM5)-Capital Account	5	SDW
BOP Items (Net, mil. Eur, SA, BPM5)-Financial Account	5	SDW
BOP Items (Net, mil. Eur, SA, BPM5)-Reserves	5	SDW
BOP Items (Net, mil. Eur, SA, BPM5)-Exports all items	5	SDW
BOP Items (Net, mil. Eur, SA, BPM5)-Imports all items	5	SDW
Interest rates %, 3-month average		
ECB MRO	5	SDW
3M EURIBOR	5	SDW
6M EURIBOR	5	SDW
1Y EURIBOR	5	SDW
3Y EA Government Benchmark Bond	5	SDW
5Y EA Government Benchmark Bond	5	SDW
10Y EA Government Benchmark Bond	5	SDW
AWM database Short Term Nominal Rate	5	SDW
Shadow Short Rate	5	SDW
Foreign		
GDP-Japan	5	Eurostat
GDP-UK	5	Eurostat
GDP-USA	5	Eurostat
GDP-Argentina	5	Eurostat
GDP-Brazil	5	Eurostat
GDP-India	5	Eurostat
GDP-Russia	5	Eurostat
HICP-Japan	5	Eurostat
HICP-UK	5	Eurostat
HICP-USA	5	Eurostat
HICP-Argentina	5	Eurostat
HICP-Brazil	5	Eurostat
HICP-India	5	Eurostat
HICP-Russia	5	Eurostat