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The aggregate and country-specific effectiveness of ECB policy: evidence from an external instruments (VAR) approach*

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Abstract

This paper studies the transmission of ECB monetary policy, both at the aggregate euro area and the country level. We estimate a VAR model for the euro area in which monetary policy shocks are identified using an external instrument that reflects policy surprises. For that purpose we use the change in German bunds at meeting days of the Governing Council. The identified monetary policy shock is then put into country-specific local projections in order to derive country-specific impulse responses. We find that (i) the transmission is very heterogeneous, both across channels and across countries, (ii) policy is transmitted through spreads, yields and the exchange rate, but less through banks and the stock market, and (iii) the strength of the transmission depends on structural characteristics of member countries, among them are current account balanced, debt to GDP levels, and the strength of banking systems.

Keywords: Euro area, VAR, external instrument, local projections, monetary transmission

JEL classification: E52, E32, E44

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1 Introduction

In the aftermath of the 2008/09 financial crisis and the subsequent European debt crisis after 2010, the European Central Bank adopted a series of unconventional policy measures. With short-term interest rates at the effective lower bound, additional stimulus was provided mainly through asset purchases by the ECB. Given the persistently low level of inflation and the sluggish recovery despite several years of expansionary monetary policy, the assessment of ECB policy is controversial. In particular, three questions haven recently been raised: First, the issue of whether some of the transmission channels of monetary policy are severely impaired. If true, a policy relying on specific channels of transmission risks becoming ineffective. Second, the question of whether monetary policy in general is becoming less effective, that is whether there are decreasing returns to monetary policy.¹ If true, ECB policy steps must become bolder over time to maintain a given level of effectiveness. Third, the debate about whether monetary policy benefits some member countries more than others. If true, a given monetary policy would contribute to de-synchronization of cycles in the euro area.

The underlying reason for this uncertainty is that the ECB operates in uncharted territory with limited knowledge about how unconventional policies are transmitted to the real economy. Analyzing monetary policy has become more difficult since 2008 as the overall policy stance is no longer appropriately summarized by the short-term policy rate. Rather, the ECB uses several instruments at the same time, thus making the use of vector autoregressive (VAR) models difficult, which rely on a single policy indicator. Moreover, with a large share of monetary policy being transmitted through asset markets, and this share becoming larger over the recent years, identifying monetary policy shocks in VAR models has become harder. The traditional triangular identification scheme that imposes restrictions on the contemporaneous interaction among the variables, is not suitable with financial data. Sign-restrictions, a popular alternative to the Cholesky ordering, require imposing more or less controversial restrictions onto the dynamic interaction.

In this paper, we study monetary transmission in the euro zone, both at the aggregate euro area level and the disaggregated country level. For that purpose, we use an external instruments VAR approach to identify an ECB policy shock. The external instruments approach, which has recently been made popular by the work of Stock and Watson (2012), Mertens and Ravn (2013), and Gertler and Karadi (2015), identifies the simultaneous dynamics of monetary policy and asset prices with the help

¹See, for example, the recent warning of ECB vice president Vítor Constâncio (2016) against underestimating the effectiveness of monetary policy, or "talking down", monetary policy.

of the behavior of an instrument on central bank meeting days. Thus, the approach is well suited to identify policy in the euro area which is a main determinant of financial markets' prices. The assumption is that around an ECB announcement the instrument reflects only the policy surprise, which is orthogonal to other potential shocks driving the VAR system. In our application, we use the change in the yield on German bunds as our external instrument and corroborate the robustness of our findings by using the change in Euribor Futures as an alternative instrument.

Based on the identified policy shock, we address the above mentioned questions as follows: First, we provide evidence on the effects of a monetary policy shock at the aggregate euro area level for a 2002-2016 sample. The estimated impulse response functions show a small but significant effect on output and inflation, a strong response of interest rates and the exchange rate, and almost no response of lending to the non-financial sector. Thus, policy transmission through credit markets is severely impaired. The effectiveness of policy changes only marginally in a post-2008 subsample.

Second, we use the identified euro area policy shock to estimate several country-specific impulse response functions from local projections (Jordà, 2005). This provides us with the effects of the common monetary policy on individual countries and excludes the feedback from the country level to ECB policy. The assumption is that the ECB is directing policy to the euro area aggregate, not to specific countries in line with its mandate. The results show a large heterogeneity of the effects of monetary policy across member countries with the strength of the responses of output and inflation varying across countries. In several countries the transmission through equity prices and through the bank system in terms of bank lending is broken.

Third, we relate the country-specific effects of monetary policy, i.e. the peak impulse responses, to a set of structural characteristics of member countries. Among these indicators are the share of non-performing loans, the ease-of-doing-business indicator as a measure of the absence of structural reforms, the current account balance, and the debt-to-GDP ratio. These indicators are averaged over the sample period. A set of scatter plots reveals that the effects of ECB policy are much smaller in structurally weak economies. Although this evidence does not necessarily show causal effects, the results are consistent with the view that structural factors, i.e. characteristics independent from monetary policy, severely dampen the transmission of ECB policy. Our findings give rise to several policy implications, which we derive in detail below. We will discuss the implications for ECB policymaking, for the design of the optimal policy mix in member countries and for the medium-term future of the European convergence process.

Our project connects several strands of the recent literature: Hachula et al. (2016) and Andrade et al. (2016) also use an external instruments approach to estimate euro area VAR models. However, their focus is different. The first paper estimates the effects of monetary policy shocks on fiscal policy variables in the euro area and studies whether fiscal discipline deteriorates after a monetary policy easing. The authors indeed find an increase in public expenditure after an expansionary policy shock. Andrade et al. (2016) focus on the ECB Asset Purchase Programme (APP) implemented since January 2015.² Two other recent papers, Cesa-Bianchi et al. (2016) and Ha (2016), use the external instruments approach for identification in an open economy VAR model and put the shock series into local projections.³ Wieladek and Pascual (2016) use a Bayesian VAR model with a battery of alternative identification schemes to study the euro area in 2012-2016. Counterfactuals on the euro area and the country level, respectively, show that monetary policy has a very large effect. Since January 2015 it has led to real GDP being 1.3% higher than in the absence of Quantitative Easing (QE). The same policy has benefitted Spain the most and Italy the least. Boeckx et al. (2016) use a sign-restricted VAR model to study the effects of unconventional monetary policy shocks that drive up the ECB's balance sheet.⁴

While the previously mentioned papers work with monthly or quarterly data, Fratzscher et al. (2016) use daily data to study the responses of a broad range of asset prices to ECB announcements prior to 2013. They find that unconventional policy boosts asset prices and spilled over to other economies' equity markets but not to other bond markets. The work by Burriel and Galesi (2016) also focuses on euro area and country-specific effects of policy, but uses a different methodology. The authors estimate a Global VAR model for the euro area which allows for spillovers among euro area countries. They find these intra-EMU spillovers to be sizable. In addition, they document a large heterogeneity of cross-country effects of monetary policy shocks. This paper proceeds as follows: section two outlines the VAR model with an external instrument, which is our benchmark model, as well as the data used. The section also discusses our findings for the aggregate euro area and presents results based on an alternative external instrument. Section three introduces the local projections approach and discusses the country-specific results. The section concludes by link-

²A very useful survey of the transmission channel of unconventional ECB policy is provided by Fiedler et al. (2016).

³Altavilla et al. (2015) construct an indicator of credit supply tightening in the euro area and include it as an external instrument in a VAR model.

⁴Hristov et al. (2014), Altavilla et al. (2016) and De Santis (2016) provide additional evidence on selected ECB programs such as the OMT program and the Asset Purchase Programme, respectively.

ing the disaggregated results to country-specific structural determinants. Section four draws on these findings and discusses the main policy implications.

2 A euro area VAR model with an external instrument

2.1 Data

As outlined in the previous chapter we analyze the transmission of monetary policy in the EMU with the help of a VAR model. Hereby we make use of monthly data from 2002/01 until 2016/10.

In order to address the question of how monetary policy is transmitted in the EMU, we first have to define a measure of the policy stance. Prior to the financial crisis the ECB focused on interest rate policy. With the zero lower bound (ZLB) and the introduction of unconventional monetary policy the ECB extended its policy toolkit. It is for this reason that we use the (shadow) short rate provided by Wu and Xia (2016) for the interval available (i.e. from 2004/09 until the end of our sample) as the measure of the monetary policy. Until 2004/08 the EONIA rate represents the monetary policy stance, which we receive from Thomson Reuters Datastream.

The external instrument we apply are daily changes in the German Government Bond (“bund”) yield with a maturity of ten years.⁵ In 2.5 we show, that the results are also robust to applying changes in Euribor Futures as the instrument. The data of both external instruments stem from Thomson Reuters Eikon.

For the VAR Model we use financial variables as well as variables that shed light on the real side of the economy. We generally draw on seasonally adjusted data for the changing composition of the EMU. However, financial variables that are not expected to contain seasonal patterns are not adjusted. A complete list of all variables, their adjustment and their sources can be found in Table (2).

2.2 Methodology

In this sub-chapter we describe how we combine the conventional VAR methodology with the event study approach. We build upon the methodology of Stock and Watson (2012), Mertens and Ravn (2013) and Gertler and Karadi (2015) in order to overcome the problems of endogeneity without imposing sign or zero restrictions.

⁵Choosing German Government Bonds with other maturities as the instrument yields similar results.

The endogeneity issue is particularly relevant for financial variables, which are supposed to react instantly to a monetary policy shock. In particular, we expect the unconventional monetary policy toolkit to primarily influence the financial variables. Therefore, a Cholesky ordering can potentially provide misleading results.

It is also hard to argue in favor of sign or zero restrictions. Upon imposing restrictions, presumptions about the behavior of the included variables have to be made. This is problematic in the case of unconventional monetary policy, where we know very little about its transmission. However, under the assumption that an accurate instrument can be found, we are able to capture the transmission of the complete set of monetary policy tools.

Our goal is to estimate the structural VAR model according to equation (1)

$$S^{-1}Y_t = C + \sum_{j=1}^p B_j Y_{t-j} + \sum_{k=0}^q D_k X_{t-k} + U_t. \quad (1)$$

Hereby Y_t represents the endogenous and X_t the exogenous variables at time t . While C captures constants, the matrices B_j and D_k contain the coefficients on the lags of the endogenous and exogenous variables up to lag length j and k , respectively. The simultaneous effect of one endogenous variable to another is captured by S^{-1} and U_t stands for the vector of error terms.

Due to the endogenous nature of the variables in Y_t , we are not able to solve the structural VAR uniquely. Hence, we first estimate the reduced form VAR, which results by multiplying each side of equation (1) by S

$$Y_t = S \cdot C + \sum_{j=1}^p S \cdot B_j Y_{t-j} + \sum_{k=0}^q S \cdot D_k X_{t-k} + \varepsilon_t. \quad (2)$$

The reduced form innovations are then given by equation (3)

$$\varepsilon_t = S \cdot U_t. \quad (3)$$

Here S is a square matrix with the dimension equal to the number of endogenous variables. The i -th column in S captures the response of the vector of reduced form innovations, ε_t , to an increase in the i -th element of the structural shock U_t . As we are only interested in the responses to a structural monetary policy shock u_t^{MP} , we only have to identify the column s^{MP} in S that captures the impact of u_t^{MP} on the vector ε_t . Now let ε_t^{MP} be the reduced form innovation of the monetary policy equation and s^{MP} be the element of s that describes its response to the structural shock, u_t^{MP} , such that equation (4) holds

$$\varepsilon_t^{MP} = s^{MP} \cdot u_t^{MP}. \quad (4)$$

Accordingly, ε_t^q and s^q are reduced form error terms and the respective elements in s that correspond to other variables

$$\varepsilon_t^q = s^q \cdot u_t^{MP}. \quad (5)$$

Solving for u_t^{MP} in the equations (4) and (5) leads to

$$u_t^{MP} = \frac{\varepsilon_t^{MP}}{s^{MP}} = \frac{\varepsilon_t^q}{s^q}, \quad (6)$$

which can be rearranged to

$$\varepsilon_t^q = \frac{s^q}{s^{MP}} \varepsilon_t^{MP}. \quad (7)$$

Finally, with the reduced form error terms as both the dependent and the explanatory variable, respectively, an estimate for $\frac{s^q}{s^{MP}}$ can be found. In order to overcome the possible endogeneity of ε_t^q and ε_t^{MP} , we apply a two-stage least squares approach. From the first stage we receive $\widehat{\varepsilon_t^{MP}}$ as an estimate that only captures changes in monetary policy that do not stem from a simultaneous change in ε_t^q . Given these estimates and the variance covariance matrix of the reduced form VAR model, we are able to uniquely identify all components of s

$$\varepsilon_t^q = \frac{s^q}{s^{MP}} \widehat{\varepsilon_t^{MP}} + \xi_t. \quad (8)$$

The crucial point in this framework is to find an accurate instrument Z_t which is by definition correlated with ε_t^{MP} but orthogonal to ε_t^q .

For our baseline euro-wide model the endogenous variables consist of the log of industrial production (excluding construction), the log of the harmonized index of consumer prices, a corporate bond spread, and the (shadow) short rate.⁶ We further add the log of oil prices as an exogenous variable.

The sample consists of monthly data from 2002:01 until 2016:10.⁷ The Akaike and the Schwarz information criteria both suggest lag length of one for the baseline model. In order to minimize serial correlation in the residuals we chose to include six lags. However, the choices of one and six lags lead to similar results. After estimating the baseline four-variable model, we add a fifth variable to our baseline

⁶In the baseline model, the corporate bond spread is the spread between the yield on AA rated and BBB rated bonds. However, spreads between corporate bonds with other ratings lead to similar results.

⁷Data from the ECB'S Bank Lending Survey as well as loan data are only available from 2003 onwards. Hence, a shorter sample size is used for models containing these variables.

model to shed light on several aspects of the transmission process. This fifth variable is taken from the following list of variables: the unemployment rate, the log of the real exchange rate, the log of the Euro STOXX 50, the log of the MSCI Euro Index, euro area government bond yields, the log of the loan volume granted by financial institutions, the corresponding loan rate and the net percentage change⁸ of credit standards and credit demand, both obtained from the Bank Lending Survey.

2.3 Choosing an instrument

The choice of the instrument deserves special attention. We use changes in the German 10-year government bond yield on meeting days and a small number of other selected dates as the instrument.⁹ Our choice rests on the efficient market hypothesis (EMH). The EMH states that movements in asset prices only appear if new information is received. Thus, under the assumption that news other than the monetary policy decisions on the meeting days and the the selected special events are white noise, the changes in German bond yields on these days represent changes in the monetary policy stance. For example, an increase in the German bond on these days, i.e. a positive surprise component, reflects a monetary tightening.

With the adoption of unconventional policies important news about monetary policy emerged also on non-meeting days. Hence, we supplement the set of meeting days by three additional events. These are the announcement of the two tranches of the Securites Markets Programme (SMP) on 05/10/2010 and 08/07/2011, respectively, as well as President Draghi's "Whatever-it-takes"-speech on July 26, 2012. The monthly series for our instrument consists of the change in German yields on these specific days, that is if the Governing Council meets on one Thursday in a given month, the yield change on this day is used as the monthly entry in the instrument series. If there is both a Governing Council meeting and one of the additional events in a given month, we sum up the yield changes on these two days in order to get an estimate for the surprise component of that month.

This measure for the monetary policy stance brings several advantages. First, the surprise component serves as a consistent measure for the entire monetary policy

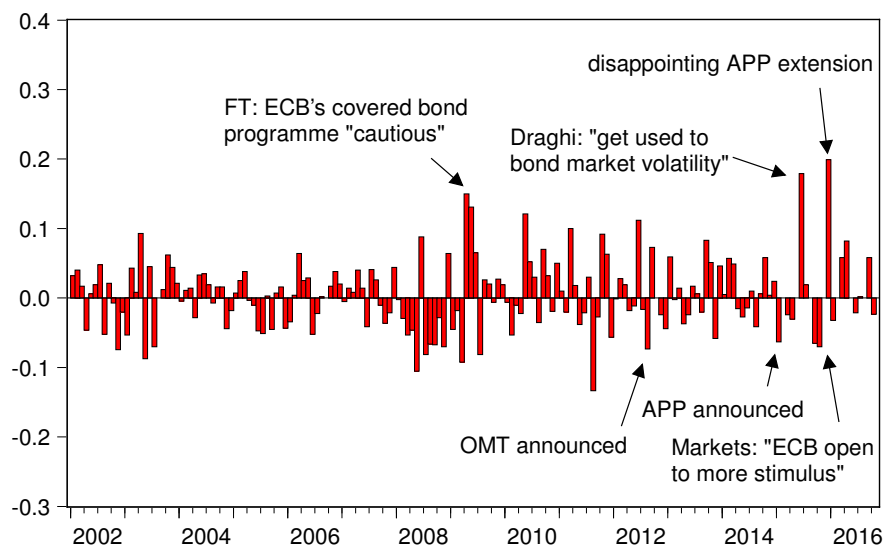
⁸Within the Bank Lending Survey the banks answer whether they tightened lending standards "considerably", "somewhat", eased "somewhat" or "considerably" or left the standards unchanged. The net percentage change is the difference in the percentage of banks that tightened its lending standards (either "somewhat" or "considerably") and the share of banks that eased them. Accordingly, the net percentage change in the credit demand is the share of banks that expect an increase in the demand for loans (either "considerably" or "somewhat") minus the share that expect a decrease in the demand.

⁹In 2.5 we also apply changes in Euribor Futures. However, only minor changes in the results are obtained for this alternative instrument.

toolkit. With the ECB adopting unconventional policies it extended its set of policy instruments. By having one measure reflecting the entire set of policy instruments we do not face the problem of disentangling the effects of each instrument, which is particularly challenging as those have been used simultaneously.

Second, the focus on market reactions allows us to directly measure the unanticipated part in a policy change. This is better suited for identifying a policy shock, as according to the EMH only those should influence asset prices. For example, an increase in the interest rate that is lower than expected is recognized as an expansionary monetary policy in the view of market participants. Finally, the external instruments approach clearly defines an unexpected monetary policy shock, which is the starting point of every analysis within the VAR model.

Figure 1: Monetary Policy Surprises Obtained from 10-Year Bunds



Notes: Policy surprises are defined as the change in the yield on 10-year German bunds on ECB meeting days and selected other days. This series is used as an external instrument in the VAR identification.

The development of the surprise component, Z_t , from 2002 until 2016 is plotted in Figure (1). As the surprise component fluctuates around zero it can be concluded that there is no systematic bias in the market expectations.¹⁰ The largest swings are found to be after the financial crisis in 2007. President Draghi's remark "get used to market volatility" on June 2015 and the disappointment about the size of the additional stimulus adopted in December 2015 account for the peaks in the surprise

¹⁰On a ten percent significance level a *t*-test confirms that the surprise component is not different from zero.

component. In contrast, the announcements of the Outright Monetary Transactions (OMT) program in September 2012 and the Asset Purchase Programme (APP) led to the lowest surprise components.

Before we turn to the results of our approach, we test if the considered instrument is accurate. First, we test for the information content of the instrument by an event study. Thus, we run the regression

$$\Delta y_t = \alpha + \beta \cdot \Delta Z_t^{daily} + \epsilon_t, \quad (9)$$

where the daily changes in asset prices are regressed on a constant and the surprise component, i.e. the changes in the German 10 year bond yield Z_t^{daily} , using OLS. For this estimation we *only* consider the meeting days and the selected special events which leaves us with a total of 175 observations. The list of dependent variables consists of the log of the euro to U.S. dollar exchange rate, the Euribor Futures rate¹¹ and the corporate bond spread¹².

Table 1: Monetary Policy Surprises in an Event Study

y_t		coef.	p -value
(log) Exchange Rate	$\hat{\alpha}$	0.000	0.48
	$\hat{\beta}$	0.071	0.00
Euribor Future	$\hat{\alpha}$	-0.006	0.17
	$\hat{\beta}$	0.893	0.00
Corporate Bond Spread	$\hat{\alpha}$	-0.004	0.17
	$\hat{\beta}$	0.015	0.80

Notes: Results from an event study regression of y_t on policy surprise series with the slope coefficient β and a constant α .

The results of the regressions are presented in Table (1). In all three cases we obtain the expected, with the appreciation of the Euro and the increase in the Euribor Future being statistically significant. This hints that changes in the German bond yield indeed contain information about the ECB'S monetary policy stance.

We further evaluate this question by testing for a weak instruments problem. The explanatory power of the instrument can be examined by regressing the reduced form VAR residuals of the monetary policy equation on a constant and the external instrument. As described by Li and Zanetti (2016), this equals the first stage in

¹¹At any point in time we consider the future that is the 8th next to deliver. Since the nearest six delivery months are consecutive calendar months and the 7th and 8th months the following March, June, September or December, the delivery is roughly in one year. Our presented results are robust to other continuation futures.

¹²The corporate bond spread presented here is the spread between AA and BBB rated bonds.

our two-stage least squares regression from (8). For the changes in the German 10 year bond yields the corresponding F-statistic is 12.47 in the baseline case. Following Stock et al. (2002), a value for the F-statistic lower than ten indicates a weak instrument issue. With the German bond yields avoiding the weak instrument problem and showing plausible results for the event study regression, we are confident about our choice of an accurate instrument. We are then able to estimate the impulse-responses from our VAR model whose results are discussed below.

2.4 Results

We start by estimating the effect of an expansionary monetary policy that leads to a 25bp drop in the shadow rate. All results are presented as impulse response functions together with a 90% confidence interval.

Baseline model

The results from the baseline VAR model are presented in Figure (2). The shock leads to a persistent fall in the shadow short rate. The responses of the other three variables have the expected sign and are statistically significant. It takes ten months until industrial production increases significantly. This time lag is in line with our expectations. Prices, in contrast, increase immediately. These two responses indicate that ECB policy stabilized both real economic activity and inflation. Bockx et al. (2016) find similar results by imposing sign restrictions in an euro area VAR model. Following Zhu (2013) the corporate bond spread, reflects the external finance premium and, hence, the credit channel of monetary policy transmission. We find that spreads narrow immediately upon the monetary easing, which is consistent with the presence of the credit channel.

Cholesky identification

For a comparison, we apply a Cholesky identification instead of the external instruments approach. The implied ordering of the variables is the following: log of industrial production, log of consumer prices, the shadow short rate, and the corporate bond spread. The restriction imposed implies that monetary policy affects the spread contemporaneously but all other variable with a time lag of one month. The results are shown in Figure (3). While prices and industrial production show results which are very similar to the baseline findings, the corporate bond spread does not react significantly. This might be the result of the endogenous nature of both the shadow rate and the bond spread, which is not adequately captured by the Cholesky identification. This also lends support to the external instruments approach which

we use for identification in our baseline model.

Extending the baseline model with other real and nominal variables

We now turn to the responses of additional variables which were not included in our baseline model. As outlined in the previous sub-section, we add one variable at a time as a fifth variable to our model. To save space, we only report the impulse response for the fifth variable as in Hachula et al. (2016). Figure (4) shows the results for euro area government bond yields, the real exchange rate, unemployment, and the monetary base. Bond yields immediately fall after a monetary easing. Surprisingly, the increase in industrial production found before is not accompanied by a significant decrease in the unemployment rate. Though the sign of the unemployment response is negative, on a ten percent confidence level it cannot be ruled out that its response is actually zero. One explanation for the modest decrease in unemployment might be the heterogeneity of cycles in the euro area. Our results might reflect that since the European debt crisis unemployment in core and periphery countries respond differently to a monetary policy shock. This hypothesis is supported by our country-specific results presented below. An immediate effect of an expansionary policy shock is a strong depreciation of the euro in real terms. The insignificant response of the monetary base does not come as a surprise as it is mainly driven by unconventional monetary policy decisions that become important in the second half of the sample only. This is in line with Peersman (2011), who also finds only a modest increase in M0 after an expansionary monetary policy shock in the pre-crisis period. However, we expect the monetary base to increase significantly once we consider a more recent sample period.

Extending the baseline model with credit market variables

The response of credit market variables, see Figure (5), is mixed. We find that the total loan volume to non-financial institutions increases, though the response is only statistically significant in the first period. The loan rate, that is the interest rates on new loans, falls immediately after the monetary easing. A deeper insight into bank lending follows from the Bank Lending Survey variables. Hereby we differentiate between lending standards and expected credit demand. A monetary expansion reduces bank lending standards, thus supporting the existence of a risk taking channel. The demand for credit increases. A significant reaction in both bank lending and credit demand, is also found by Ciccarelli et al. (2015). Our findings underpin the structural problems of the euro area credit market: aggregate lending does not increase despite relaxed standards and higher credit demand.

Extending the baseline model with stock market variables

The results for the stock market variables are also inconclusive, see Figure (6). Though both, the Euro Stoxx 50 as well as the MSCI Euro Index have the expected positive sign, their responses turn out to be insignificant. Hence, for the entire time span we do not find evidence for a policy transmission through stock market. This is surprising since the stock market rally over the past years is often believed to be a consequence of Quantitative Easing. This supports the notion of cross-country heterogeneity which is also found by Bredin et al. (2009) and Bohl et al. (2008). Both, the heterogeneous dimension as well as the timescale dimension will be discussed in more detail below. Furthermore, we shed light on the impact on policy uncertainty and market volatility as measured by the VSTOXX. We find an immediate and significant decrease in the economic policy uncertainty. One possible reason for this is that a more expansionary policy stance relaxes the budget constraints of governments and therefore facilitate structural reforms. In addition, measures such as the OMT program eased the financial market stress and the fear of a euro area break-up. In contrast, the VSTOXX does not show an immediate reaction. It takes seven months until a significant reduction of volatility can be found.

The post-2008 sample

In order to address the question of how unconventional monetary policy is transmitted, we present evidence from the crisis period only. We interpret the sharp decrease in the ECB'S key interest rate as the begin of the era of unconventional monetary policy. The results based on a sample from 2008:10 until 2016:10 are shown in Figures (7) through (10). With the shorter time span we reduce our lag length to two.

Overall the reactions remain similar to those from the full sample VAR model. However, with respect to Figure (7) a faster reaction of industrial production as well as an insignificant response of the corporate bond spread can be observed. The insignificant response of the corporate bond spread indicates that the credit channel is absent for the average euro area during the crisis. This also adds to the notion of a broken transmission through the financial system and a large degree of cross-country heterogeneity, respectively.

From Figure (8) we see that both the exchange rate channel and the transmission through government bond yields are present. Again a monetary expansion does not lead to lower unemployment. The unconventional monetary policy works through an extension in the monetary base, which turns out to increase significantly after

one quarter. The financial market reactions indicate that the monetary policy shock occurs with the announcement of a purchase program. The purchases themselves, which were often starting two or three months after the announcement, increase the ECB's balance sheet but do not move markets.

The responses of the credit variables to an unconventional monetary policy shock, see Figure (9), are similar to a conventional monetary policy shock, although the reactions of expected credit demand is smaller than in the first sample. Finally, the stock market reactions are presented in Figure (10). Interestingly, neither the Euro Stoxx 50 nor the MSCI Euro Index react significantly. However, an extension of unconventional monetary policy leads to an instant reduction in policy uncertainty. Several dimensions of the results for the aggregate euro area, e.g. the lack of a significant unemployment and stock market responses and the broken transmission through the financial system, suggest that we can obtain more information from a country-specific perspective. This is pursued further in the next chapter.

2.5 Alternative Instrument

As outlined before, we also check our results by applying three months Euribor Futures as the instrument. Under the efficient markets hypothesis, the Future indicates the three month Euribor rate at the delivery day. In total 28 delivery months are available for trading, the nearest six are consecutive calendar months, the other 22 are the successive March, June, September, and December deliveries of the following years. In this respect we focus on continuous future time series. More precisely, we consider the Euribor Future that is the 12th next to deliver at any point in time, so that the delivery month is roughly two years ahead.¹³

We first present impulse-responses from our baseline model for the 2002:1-2016:10 period (see Figure (11)).¹⁴ The responses are overall similar to those obtained from bond yields as instrument. In line with that industrial production rises and the corporate bond spread falls significantly after an expansionary monetary policy shock. Although the increase in the CPI is not statistically different from zero, the magnitude of the response is similar.

The impulse-responses for the shorter sample-size, i.e. from 2008:10 until 2016:10, are also akin to those from 2.4 (see Figure (12)). The drop in the shadow short rate is accompanied by an increase in GDP and CPI. The latter is again not significantly different from zero, but the magnitude of the effect is similar to the model with

¹³However, other Euribor Futures lead to similar results.

¹⁴The results of the other variables are in line with our findings in the previous chapter. Further results are available upon request.

German bunds as an instrument. Additionally, the corporate bond spread shows no clear reaction. As outlined in the previous chapter, we thus conclude that the monetary transmission via the credit channel is impaired during the financial crisis period. We will discuss the degree of impairment of monetary policy transmission across EMU-countries in more detail in the following chapter.

3 Country-specific effects of euro area monetary policy

In this chapter we study the country-specific responses to a common monetary policy shock. Hence, at this stage we want to exclude the feedback from domestic economic conditions to euro area monetary policy. Since we have identified a common monetary policy shock in the previous section, there is no identification problem to solve in this stage. Therefore, we use local projections as suggested by Jordà (2005) in order to derive country-specific responses.

An impulse response is defined as the response of a variable's h periods ahead forecast to a monetary policy shock in t . This responses is not derived from a full-scale VAR model with interactions among all endogenous variables, but rather from a single-equation framework that does not allow for a feedback from the endogenous variable to monetary policy.

We estimate with a series of regressions of a dependent variable dated $t + h$ on the monetary policy shock in t as well as a set of control variables. The estimated model is the following

$$y_{t+h} = \alpha_h + \beta_h MP_t^{EA} + \gamma_h' \sum_{s=1}^q \mathbf{x}_{t-s} + \varepsilon_{t+h}, \quad (10)$$

where y_t is the dependent variable and \mathbf{x}_t is a vector of country-specific control variables. We include up to q lags of control variables. The euro area monetary policy shock is denoted by MP_t^{EA} . Hence, the coefficient β_h measures the impact of a change in policy at t on the dependent variable h periods ahead. Plotting β_h as a function of h provides us with an impulse response function.

For our purpose local projections are advantageous for two reasons: (1) they rest on a very small number of parameters to be estimated. This leaves enough degrees of freedom, which is particularly useful for studying the post-2008 transmission mechanism. (2) Since we estimate a single equation only, the results are more robust to misspecifications in other parts of the model. While we typically model dynamic systems of equations, e.g. VAR models, *because* we want to capture the

feedback from the economy to policy, we deliberately exclude this feedback here. Due to the fact that the dependent variable is h periods ahead, the error terms will exhibit serial correlation. We therefore apply a Newey-West correction to our estimation errors, which we use to construct a confidence band around the estimated series of β_h coefficients. As suggested by Jordà (2005), the maximum lag for the Newey-West correction is set to $h + 1$.

We estimate local projections for 10 member countries which together account for more than 95% of euro area GDP: Germany, France, Spain, Italy, Portugal, Greece, Ireland, Netherlands, Finland and Austria. The sample period is 2002:1 to 2016:1 and the data frequency is monthly. The sample is slightly shorter than the sample used in the previous section due to limited data availability. We estimate the model for each of the following variables: (log) industrial production, (log) price level, unemployment rate, (log) real exchange rate, (log) stock prices, (log) loans to the private sector, government bond yields, and interest rate on new bank loans. The data sources are provided in the data appendix.

We keep the list of control variables short. The vector of control variables is chosen with regard to the nature of the dependent variable. For business cycle variables such as unemployment and prices, we include one lag of the dependent variable, of other business cycle variables and also the lagged exchange rate and lagged oil prices. For financial variables such as stock prices and bond yields, we include only the first lag of the dependent variable itself. Changing the vector of control variables has no substantive effect on our estimated impulse response functions.

The euro area monetary policy shock, MP_t^{EA} , is based on the identification of policy surprises discussed before. Since the variables included in the local projections are in levels, we use the cumulative series of policy surprises, ΔZ_t , and regress the shadow policy rate derived by Wu and Xia (2016) on the cumulative surprise series. The fitted shadow rate gives us the part of the shadow policy rate that is driven by policy surprises. We use this series as our policy shock, MP_t^{EA} .

3.1 Results

The results are presented in Figures (13) to (19) in the appendix. In each figure, we plot the impulse response function explained before following a monetary policy easing shock, the 90% error band around this impulse response and, as a pair of red lines, the error band around the estimated impulse response for the respective euro area variable. This comparing the dotted country-specific impulse response and the red error bands allows us to assess whether a given country's response deviates

significantly from the response of the euro area as a whole.¹⁵

We find that unemployment decreases in most euro area countries following a monetary policy shock, see Figure (13). The strength of the response, however, varies considerably across countries. While the fall in unemployment is not significant in Germany, France, and the Netherlands, among others, it is very pronounced in Spain, Ireland, and Portugal. Figure (14) reports the responses of industrial production. Here, the difference across the responses in the three of the largest euro area economies, Germany, France, and Spain are indistinguishable. For some crisis countries, e.g. Portugal and Italy, industrial production does not respond significantly to monetary policy. This implies that the expansionary monetary policy implemented by the ECB since 2010 does not benefit real activity in these countries.

Figure (15) shows the responses of consumer prices, most of which do not respond significantly to a monetary policy shock. In contrast, the response of the real effective exchange rate, see Figure (16), is highly significant for each member country. For Portugal, Greece, and Spain the response is considerably weaker than the area wide exchange rate response. Hence, expansionary monetary policy does not equally transmit into an expansionary real depreciation.

The responses of the main stock price indexes, see Figure (17), is inconclusive. While stock prices increase for France, Germany, Ireland, the Netherlands, and Finland, these responses are often insignificant. For some countries we even observe a significant decrease in stock prices following a monetary tightening. This is true for Italy, Spain, and Greece and might reflect the fact that despite the recent monetary easing stock prices fell in several crisis countries. Overall, the results are consistent with the insignificant response of stock prices at the euro area level presented in the previous section.

The responses of loan rates, see Figure(18), suggest that credit conditions in Spain, Greece, and Ireland, do not benefit from easier monetary conditions. For Germany, France, and Italy, however, the results are consistent with a significant drop in credit conditions after a monetary easing. The responses of loans rates clearly show that the transmission to the loan market is divided between Northern and Southern Europe. For Germany, France, the Netherlands, Austria, and Finland credit conditions are highly sensitive to monetary policy, while for all other countries monetary policy has no grip on loan rates.¹⁶ A similar pattern emerges from Figure

¹⁵The euro area time series for each variable is constructed as the weighted average of the country specific variables. For that purpose the GDP weights from the ECB website have been normalized in order to account for member countries which are not included here, that is, the GDP weights for the 10 countries used here always add up to 100 percent.

¹⁶This finding is in line with the results of Boeckx et al. (2016).

(19), which shows the response of bond yields. Yields strongly decrease in Germany, France, the Netherlands, and Finland, but less markedly in countries like Portugal and Spain.

Overall, we find the responses of macroeconomic variables such as unemployment, industrial production and prices to be heterogeneous across member countries. The responses of financial variables such as bond yields and loan rates are consistent with this and the heterogeneity in their responses might offer an explanation in terms of a severely broken transmission through the financial system.

To conclude this section, Figure (20) summarizes the peak responses for each variable across countries. As a matter of fact, the peak response is a simplified way to summarize the entire impulse response function. It does not capture the shape of the response or its significance. Keeping these caveats in mind, we will now aim at explaining the country- and variable-specific peak responses in terms of the structural characteristics of euro area countries.

3.2 Relating policy transmission to structural characteristics

One key finding of the previous subsection is that the transmission of common monetary policy is heterogeneous across member countries, both in terms of strength and in terms of sign. To study these systematic differences, we now relate each peak responses for each variable to a set of structural characteristics of euro area economies. The structural characteristics are the following: (log) per-capita GDP, the World Bank's ease of doing business-indicator as a proxy for (the absence of) the need for structural reforms, the share of non-performing loans in total loans, the share of bank capital to GDP, the current account balance to GDP, and the overall level of debt to GDP. All variables are averaged over the sample period. The assumption we make is that in the long-run, i.e. for our averages over 15 years, these structural variables are independent from monetary policy.

We present the most important results as scatter plots in Figures (21) to (23).¹⁷ Each figure also contains a regression line and a confidence band. Let us, for the ease of interpretation, assume that the ECB eases monetary policy. Figure (21) shows that the policy easing is transmitted more strongly to countries with fewer structural problems, as represented by a lower "ease of business" index, a lower share of non-performing loans, a current account surplus, and a low debt-to-gdp ratio. The empirical fit of the simple regression is remarkably good as the distribution of dots

¹⁷The full set of results, i.e. a set of scatter plots for each endogenous variable and each structural indicator, is available upon request.

around the regression line is relatively good, although one should keep in mind that we cover 10 countries only.

Figure (22) shows the scatter plot for the response of bond yields. We expect that a policy tightening reduces bond yields. This is indeed the case for countries which are structurally sound, have safe banking systems, a balance or a surplus on their current account and a low debt-to-GDP ratio. As expected, Greece and the other crisis countries have a severely impaired transmission mechanism as bond yields do not respond at all to ECB policy.

Stock prices, see Figure (23) exhibit similar results. We expect stock prices to increase after a policy easing. Again, this is the case for structurally sound countries only. Countries with weak fundamentals appear insensitive with regard to monetary policy. For example, stock markets in countries like Spain and Italy do not seem to benefit from a policy easing.

As a matter of fact, a cautionary remark is warranted here. We show correlations which do not necessarily imply causality. In addition, we have only 10 countries in our data set. Nevertheless, the results are consistent with the view that structural factors impair the transmission of monetary policy to weak economies. This suggests that structural reforms play an important role in strengthening the transmission of monetary policy. Since the ECB designs policy for the aggregate euro area, it cannot target individual economies. Rather, domestic policy should address the hurdles that damage monetary transmission.

4 Conclusions

In this paper we studied the monetary transmission mechanism in the euro area - both based on aggregate and country-specific data. To identify a monetary policy shock, we estimated an external instruments VAR that disentangles the contemporaneous correlation between monetary policy and financial variables in the euro area.

Our findings are threefold: First, we document the heterogeneity of the monetary transmission process across transmission channels. Overall, monetary policy is transmitted through the exchange rate, the adjustment of bond yields, and changes in lending rates. Monetary policy is less effective with regard to changes in credit aggregates, that is, the banking system and stock markets. These findings suggest that monetary transmission is severely hampered by state of banking systems, e.g. the ongoing deleveraging and the burden of non-performing loans.

Second, we shed light on the heterogeneity of policy transmission across mem-

ber countries. For that purpose we included the ECB's monetary policy shock in country-specific regressions. This makes sure that the policy shock is the same across countries and that a feedback from country-specific variables to euro area monetary policy is excluded. We show that some transmission channels, e.g. the exchange rate adjustment, are relatively similar across countries, while the transmission through financial variables such as yields and loan rates varies greatly among member countries.

Third, we relate the country-specific responses to structural characteristics of member countries. Although this analysis is relatively informal and based on scatter plots only, we believe the results are informative and consistent with the other findings: countries with weaker banking systems, a smaller need of structural reforms and non-negative current account balances exhibit a stronger response to monetary policy. That implies that expansionary policy benefits the relatively sound countries. One policy conclusion of our findings addresses the burden sharing between monetary policies and other branches of policy. A "one-size-fits-all" monetary policy might not be the best tool to boost demand if national banking systems are blocked - not least since banks provide most financing in continental Europe. Over many years since the eruption of the European debt crisis monetary policy was overburdened with the task of reviving economic activity. In light of the findings presented here this has moderate effects on the crisis countries and strong effects on the core economies. Structural policies and, if feasible, fiscal policies appear more suitable as they bypass the banking system.

A second implication addresses monetary policy itself. Should the ECB still target euro area aggregates although the underlying heterogeneity of policy transmission is large? We believe that monetary policy should continue doing so in order to reduce political interference in monetary policy decisions. It should be the task of other policies, i.e. fiscal, structural or macroprudential, to target the country-specific deviations from the euro area aggregate.

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A Data Sources and Definitions

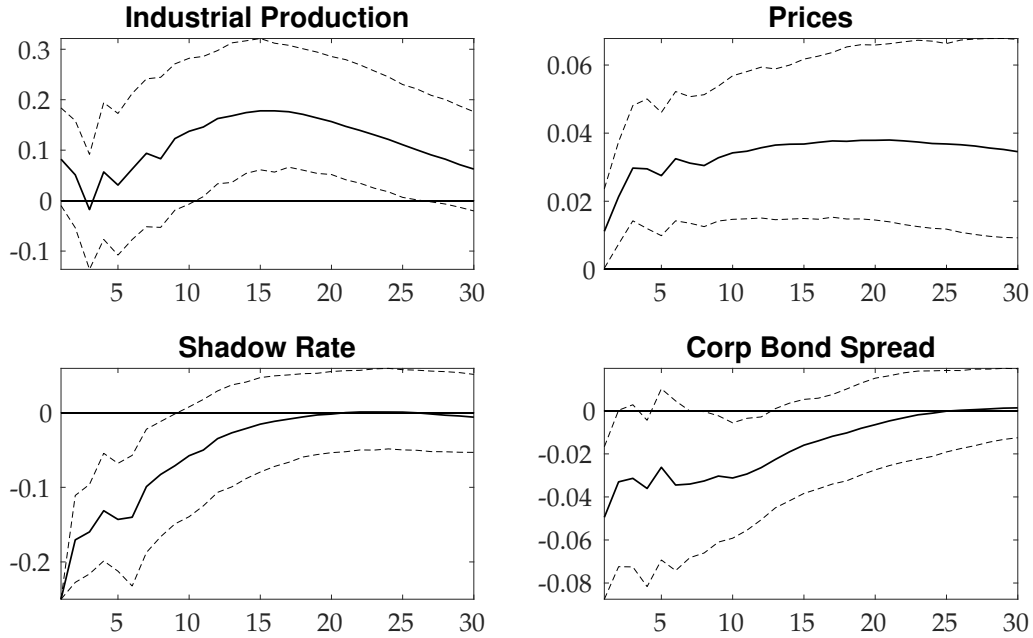
Table 2: Data Sources

Variable	Adj.	Source
Bank Lending Standards	NSA	Bank Lending Survey
Credit Demand	NSA	Bank Lending Survey
Crude Oil Prices (Brent Europe)	SA	FRED
EONIA Rate	NSA	Datastream
Euriobor Future	NSA	Eikon
Euro Stoxx 50	NSA	Datastream
Eurobond 10y all Ratings	NSA	ECB
FTSE EURO CORP Bond Yield (excl. Banks)	NSA	Datastream
German Government Bond Yield	NSA	Eikon
Harmonised Index of Consumer Prices	SA	ECB
Industrial Production (excl. Construction)	SA	ECB
Loans to Non-Financial Institutions	SA	ECB
Monetary Base	NSA	ECB
MFI Loan Rate	SA	ECB
MSCI Euro Index	NSA	Datastream
Policy Uncertainty	NSA	policyuncertainty.com
Real Exchange Rate (vis-a-vis group of 19 trading partners)	NSA	ECB
Shadow Rate	NSA	Wu and Xia (2016)
Unemployment Rate	SA	ECB
VSTOXX	NSA	Datastream

Notes: (Non-) Seasonally adjusted data series are indicated by "SA" ("NSA").

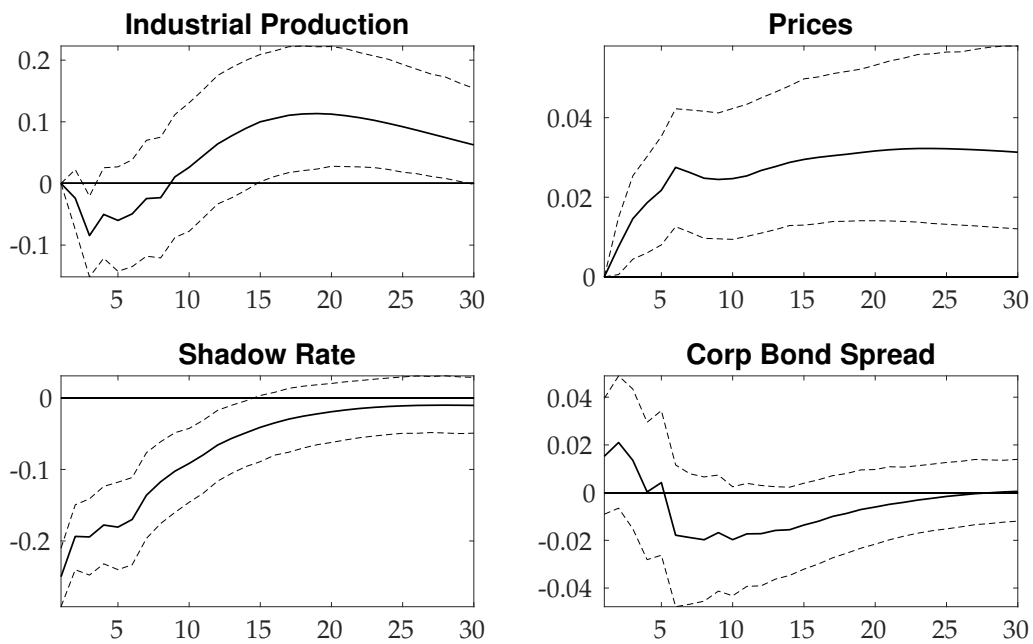
B Figures and Tables

Figure 2: Baseline VAR Model



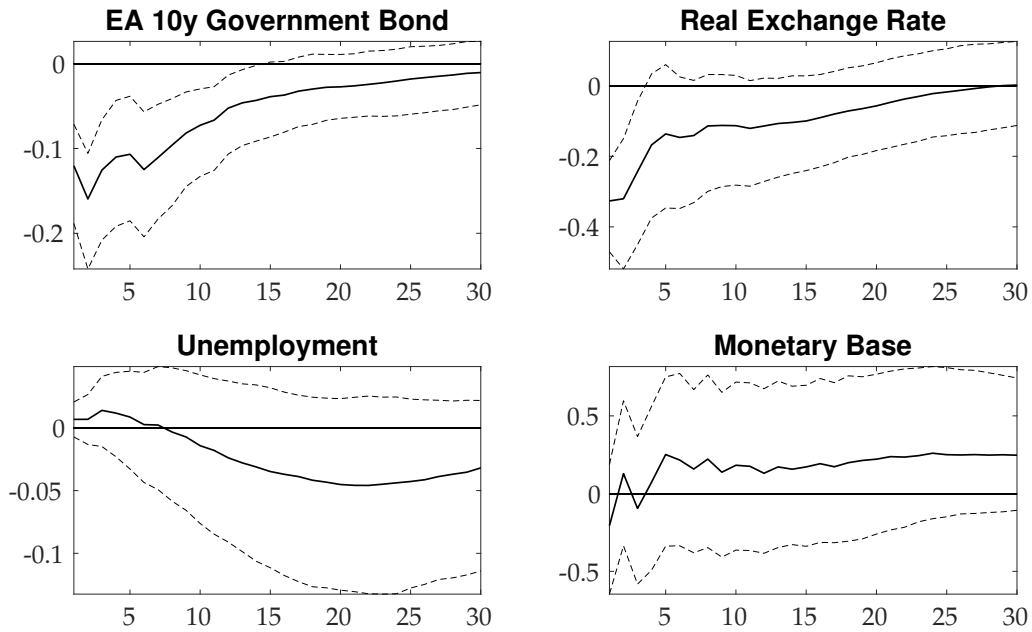
Notes: Responses to an expansionary monetary policy shock of 25bp obtained from baseline VAR model with external instruments and 90% confidence band.

Figure 3: VAR Model with Cholesky Identification



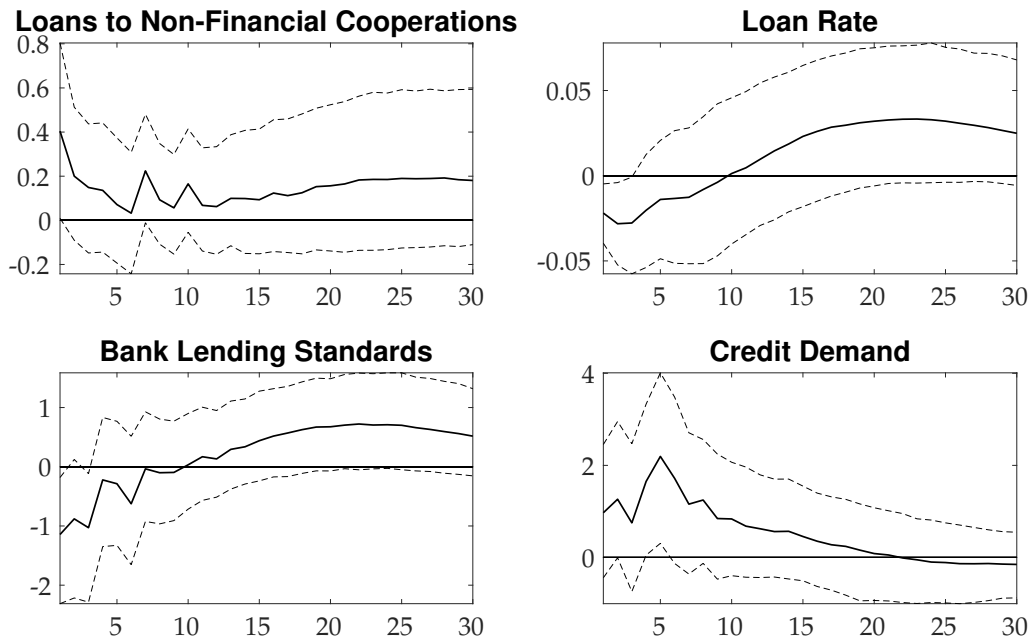
Notes: Responses to an expansionary monetary policy shock of 25bp obtained from alternative VAR model identified recursively and 90% confidence band.

Figure 4: Alternative 5th Variable: Additional Real and Nominal Variables



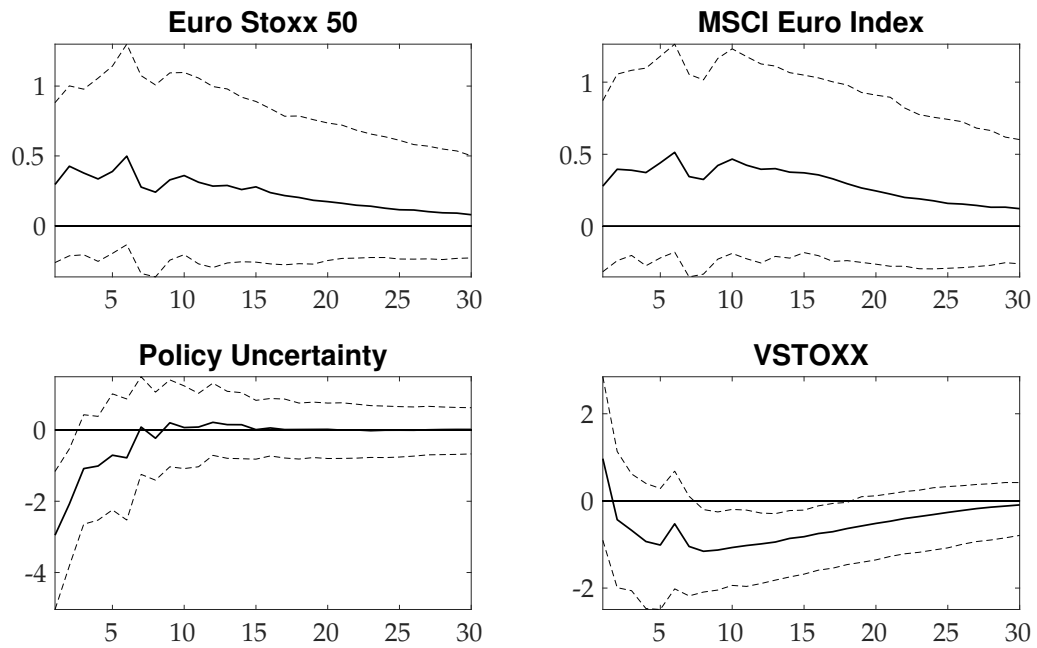
Notes: Responses of alternative choices for the 5th variable to an expansionary monetary policy shock of 25bp obtained from baseline VAR model with external instruments and 90% confidence band.

Figure 5: Alternative 5th Variable: Credit Market



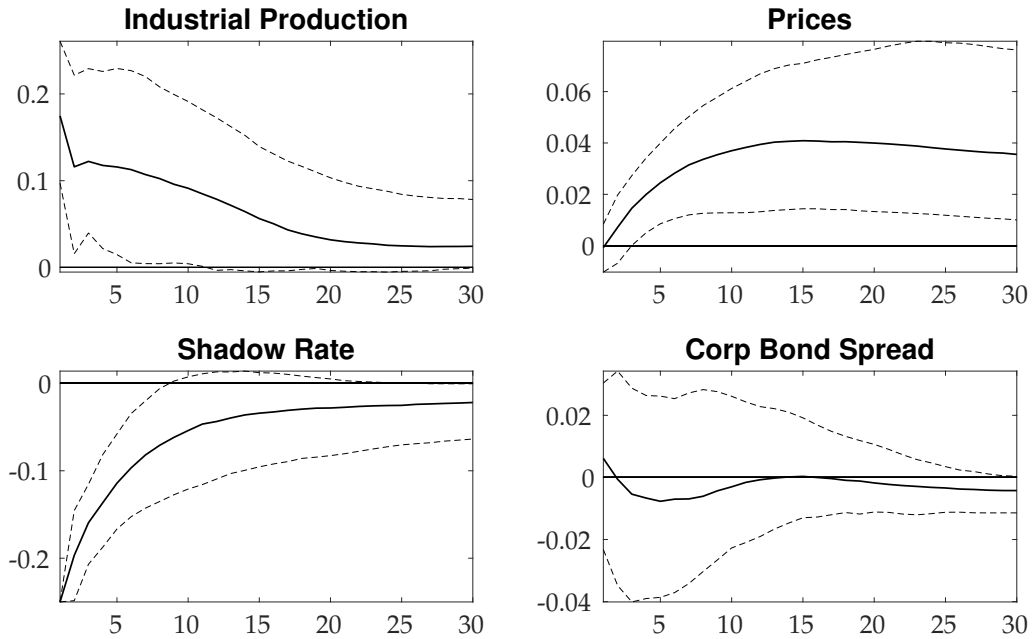
Notes: Responses of alternative choices for the 5th variable to an expansionary monetary policy shock of 25bp obtained from baseline VAR model with external instruments and 90% confidence band.

Figure 6: Alternative 5th Variable: Stock Market



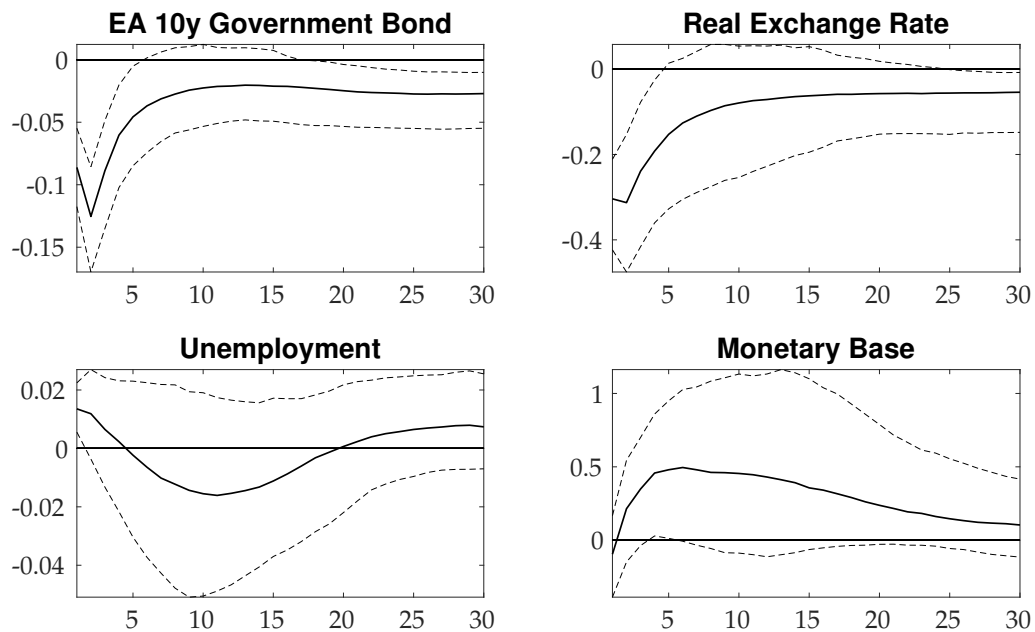
Notes: Responses of alternative choices for the 5th variable to an expansionary monetary policy shock of 25bp obtained from baseline VAR model with external instruments and 90% confidence band.

Figure 7: Baseline VAR Model (2008:10 - 2016:10)



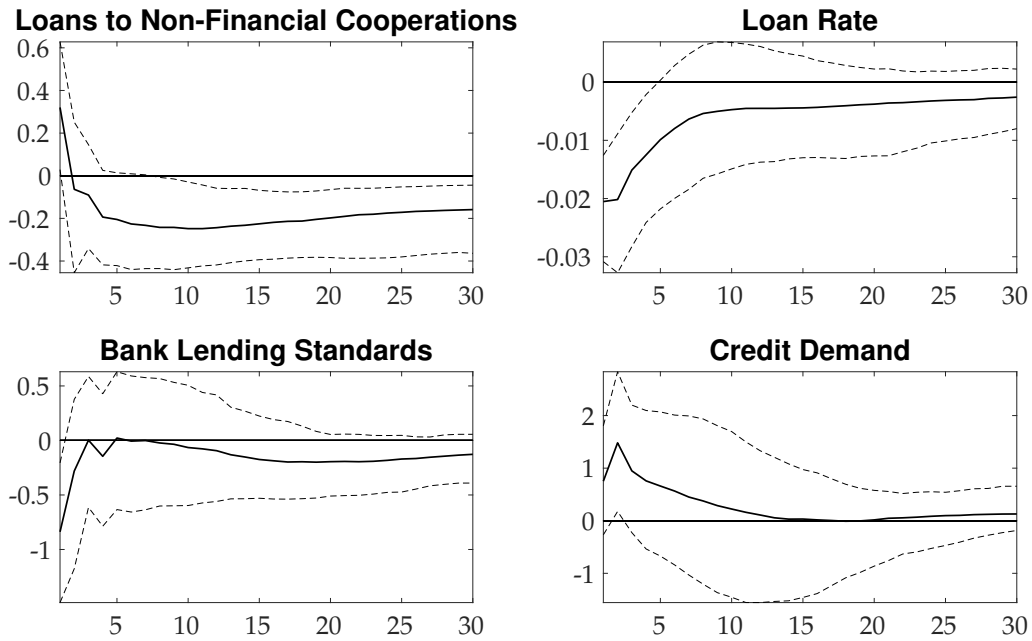
Notes: Responses to an expansionary monetary policy shock of 25bp obtained from baseline VAR model estimated over post-crisis sample with external instruments and 90% confidence band.

Figure 8: Alternative 5th Variable: Additional Real and Nominal Variables (2008:10 - 2016:10)



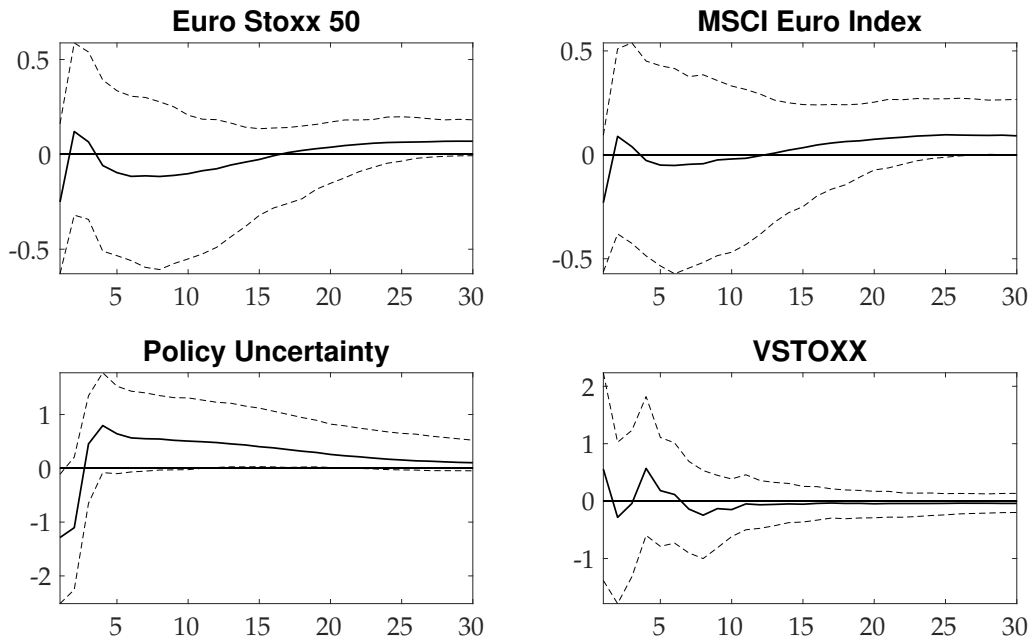
Notes: Responses of alternative choices for the 5th variable to an expansionary monetary policy shock of 25bp obtained from baseline VAR model estimated over post-crisis sample with external instruments and 90% confidence band.

Figure 9: Alternative 5th Variable: Credit Market (2008:10 - 2016:10)



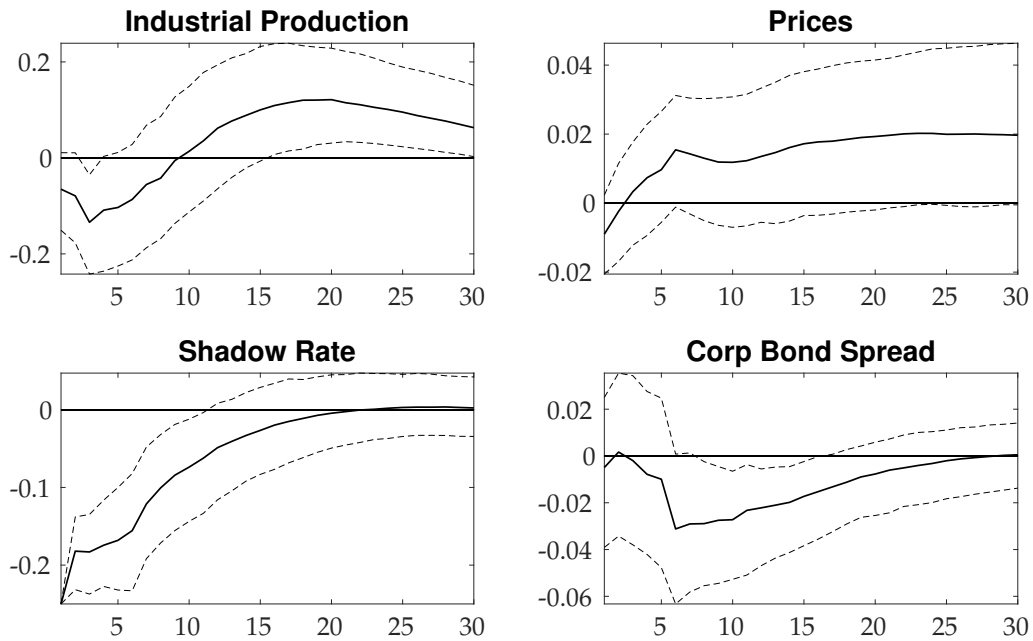
Notes: Responses of alternative choices for the 5th variable to an expansionary monetary policy shock of 25bp obtained from baseline VAR model estimated over post-crisis sample with external instruments and 90% confidence band.

Figure 10: Alternative 5th Variable: Stock Market (2008:10 - 2016:10)



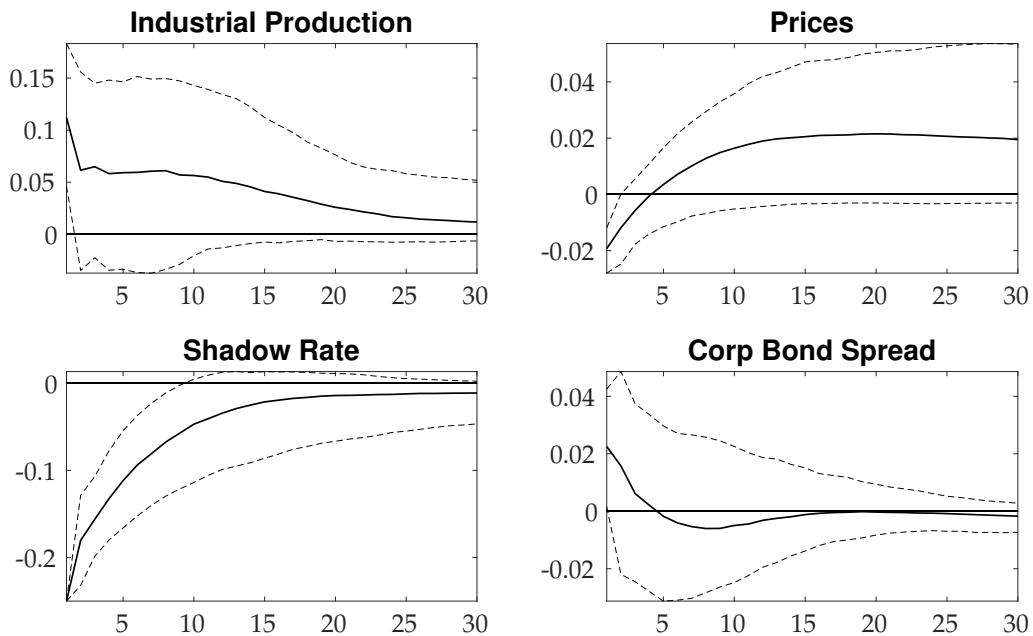
Notes: Responses of alternative choices for the 5th variable to an expansionary monetary policy shock of 25bp obtained from baseline VAR model estimated over post-crisis sample with external instruments and 90% confidence band.

Figure 11: Alternative Instrument VAR Model



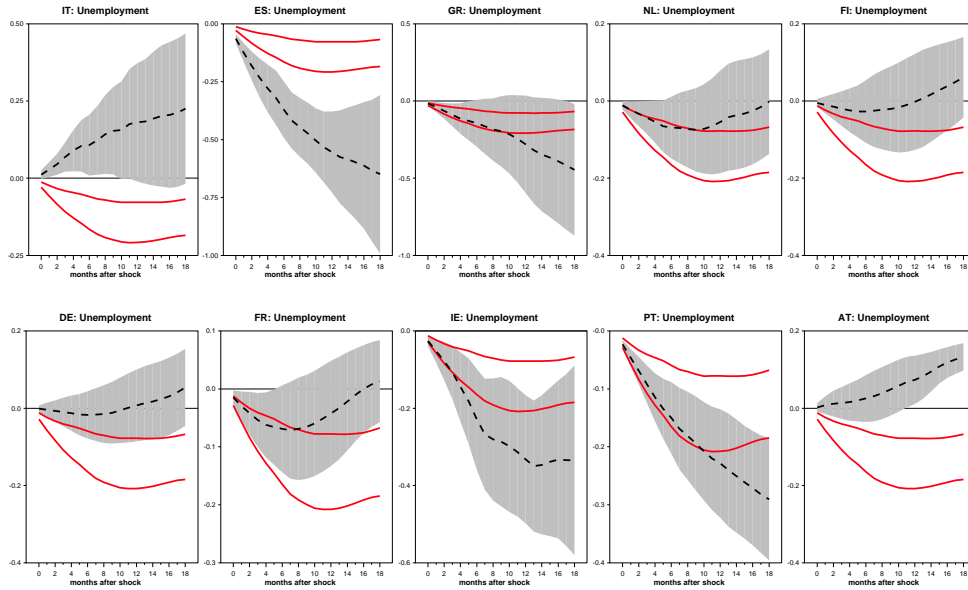
Notes: Responses to an expansionary monetary policy shock of 25bp obtained from baseline VAR model estimated with external instruments and 90% confidence band.

Figure 12: Alternative Instrument VAR Model (2008:10 - 2016:10)



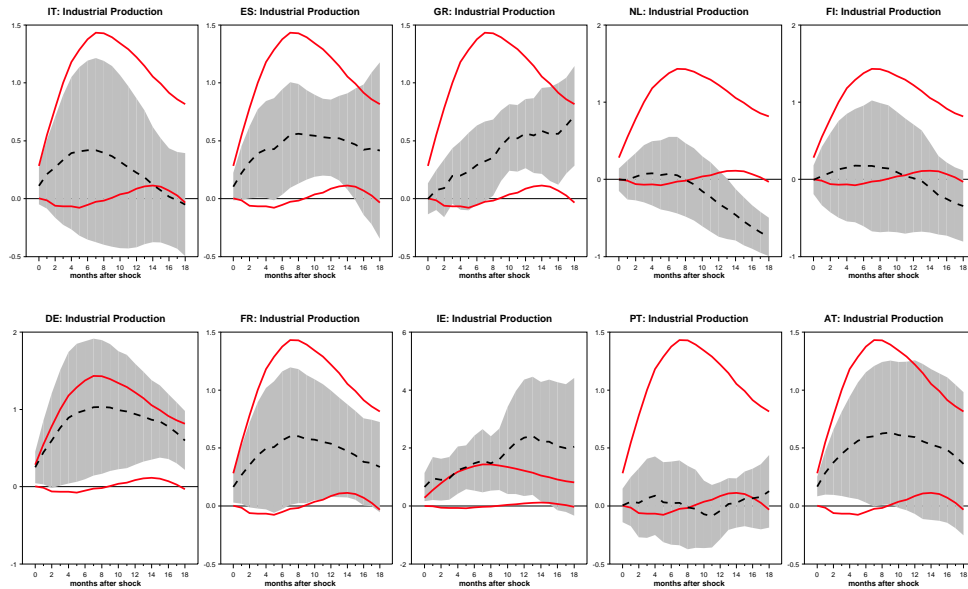
Notes: Responses to an expansionary monetary policy shock of 25bp obtained from baseline VAR model estimated over post-crisis sample with external instruments and 90% confidence band.

Figure 13: Response of Unemployment



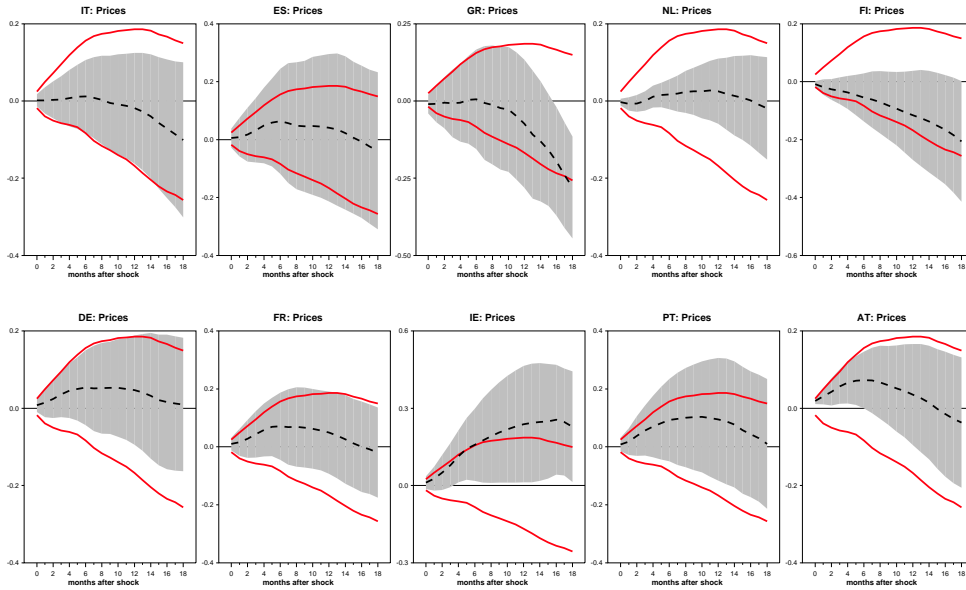
Notes: Country-specific response to a euro area monetary policy easing shock of 25bp (dotted line) obtained from local projections and 90% error bands (shaded area). The solid lines are the error bands around the average euro area response.

Figure 14: Response of Industrial Production



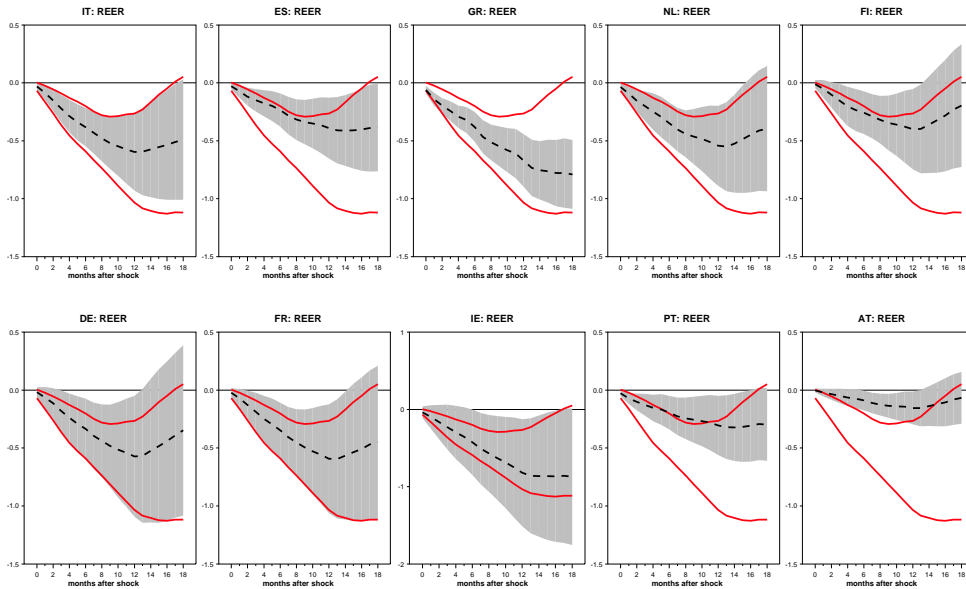
Notes: Country-specific response to a euro area monetary policy easing shock of 25bp (dotted line) obtained from local projections and 90% error bands (shaded area). The solid lines are the error bands around the average euro area response.

Figure 15: Response of HICP



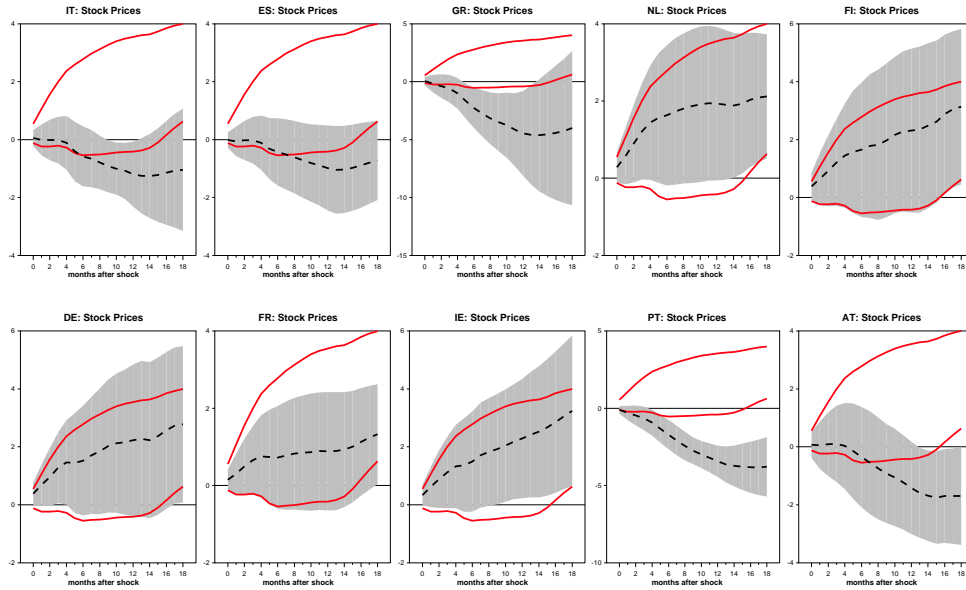
Notes: Country-specific response to a euro area monetary policy easing shock of 25bp (dotted line) obtained from local projections and 90% error bands (shaded area). The solid lines are the error bands around the average euro area response.

Figure 16: Response of REER



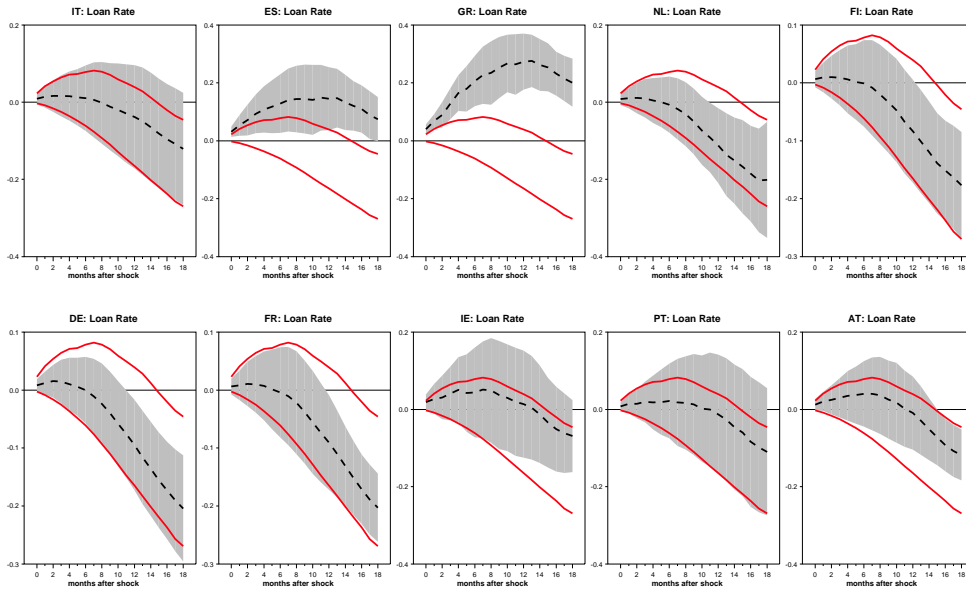
Notes: Country-specific response to a euro area monetary policy easing shock of 25bp (dotted line) obtained from local projections and 90% error bands (shaded area). The solid lines are the error bands around the average euro area response.

Figure 17: Response of Stock Prices



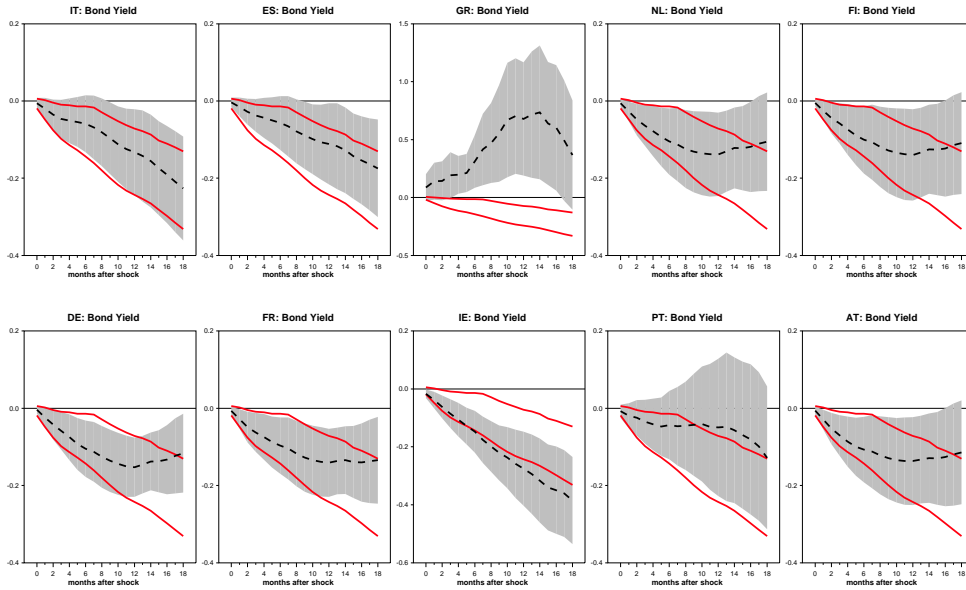
Notes: Country-specific response to a euro area monetary policy easing shock of 25bp (dotted line) obtained from local projections and 90% error bands (shaded area). The solid lines are the error bands around the average euro area response.

Figure 18: Response of Loans Rate



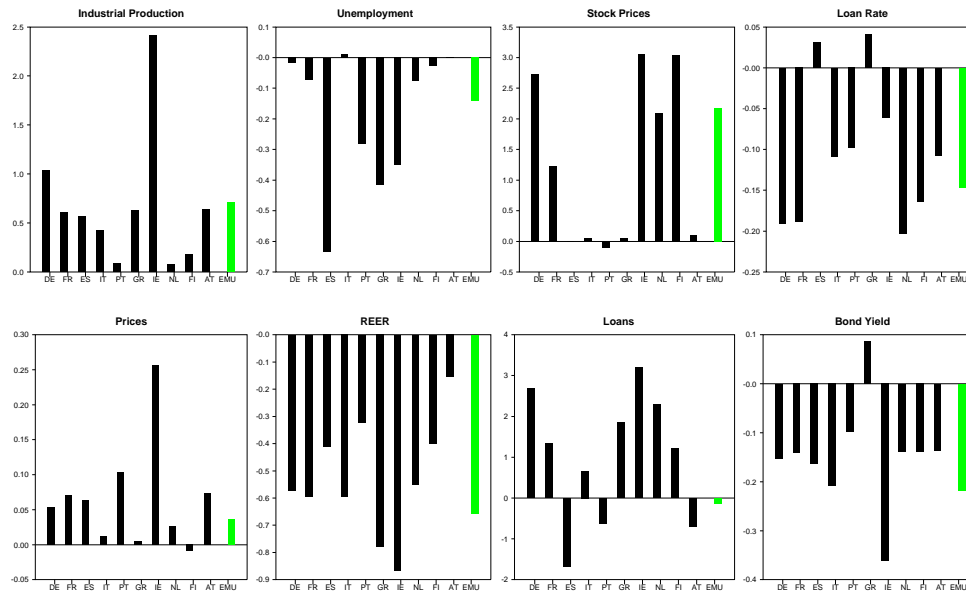
Notes: Country-specific response to a euro area monetary policy easing shock of 25bp (dotted line) obtained from local projections and 90% error bands (shaded area). The solid lines are the error bands around the average euro area response.

Figure 19: Response of Bond Yield



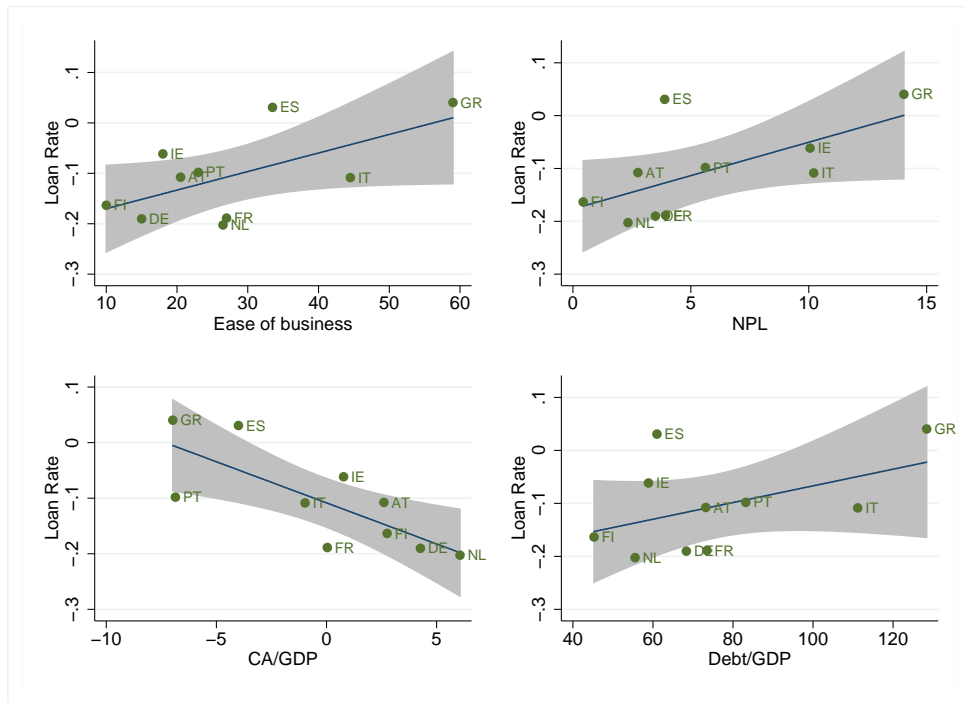
Notes: Country-specific response to a euro area monetary policy easing shock of 25bp (dotted line) obtained from local projections and 90% error bands (shaded area). The solid lines are the error bands around the average euro area response.

Figure 20: Peak Responses



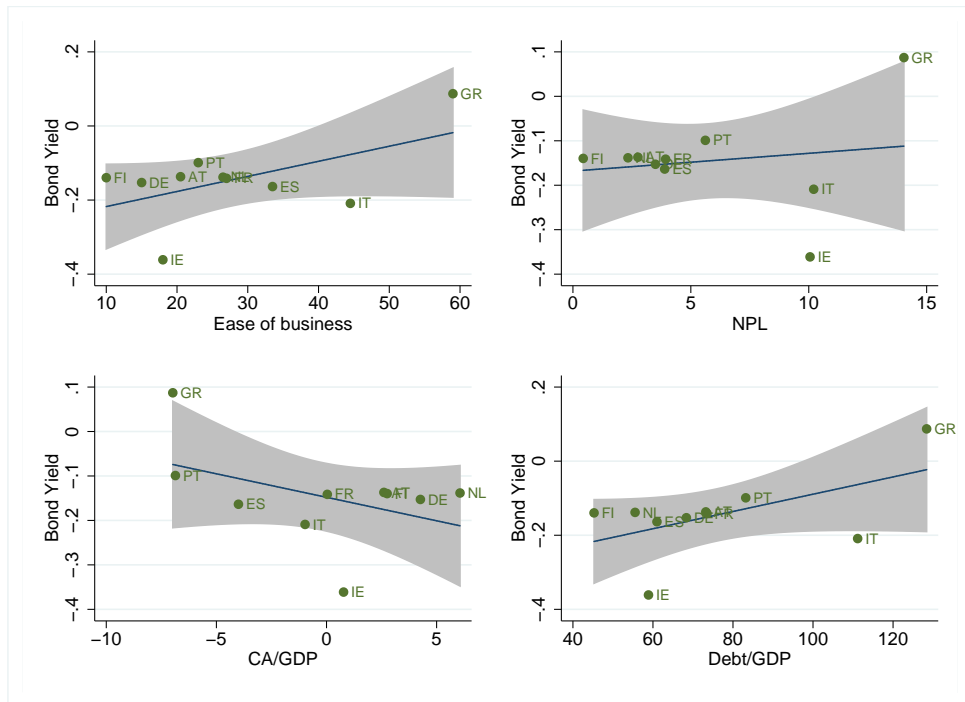
Notes: Peak of country-specific responses (black bars) to an expansionary euro area monetary policy shock of 25bp. The green bar shows the peak response of the euro area.

Figure 21: Response of Loan Rate vs. Fundamentals



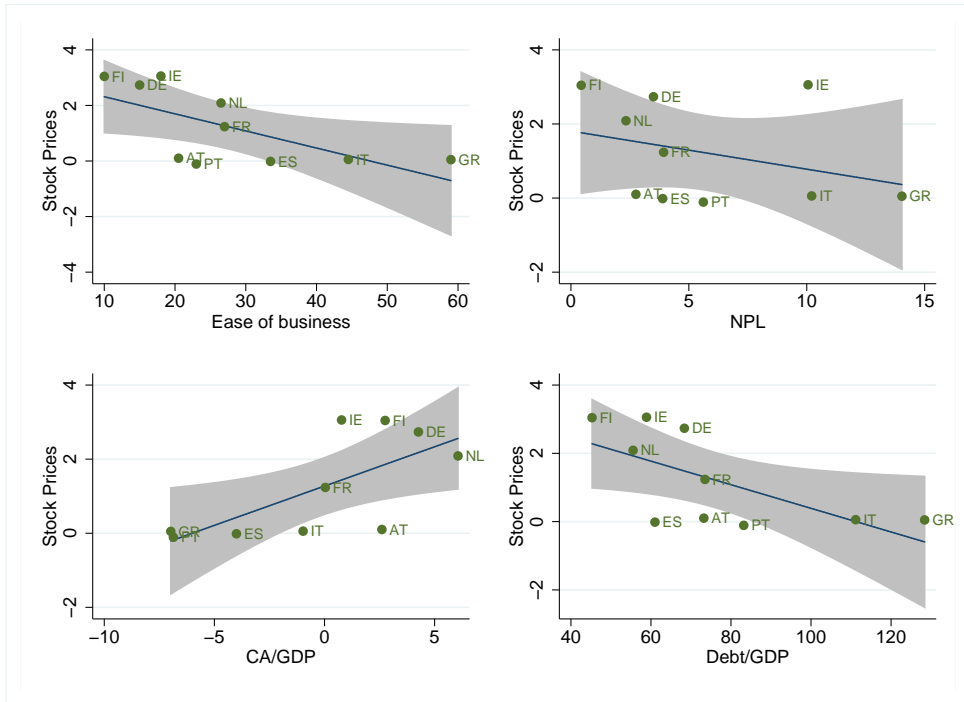
Notes: Scatter plot of country-specific peak responses (vertical axis) against sample average of structural characteristics. The solid line reflects an OLS regression with the shaded area being a 90% confidence band.

Figure 22: Response of Bond Yield vs. Fundamentals



Notes: Scatter plot of country-specific peak responses (vertical axis) against sample average of structural characteristics. The solid line reflects an OLS regression with the shaded area being a 90% confidence band.

Figure 23: Response of Stock Prices vs. Fundamentals



Notes: Scatter plot of country-specific peak responses (vertical axis) against sample average of structural characteristics. The solid line reflects an OLS regression with the shaded area being a 90% confidence band.