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The Effect of Monetary Policy on Systemic Risk in the Euro Area*

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Abstract

This paper empirically investigates the effect of monetary policy on systemic risk within the Euro area. We estimate a Bayesian proxy-VAR where we exploit high-frequency identified monetary policy surprises for identification. Employing aggregate as well as market specific systemic risk measures, we provide novel evidence on the heterogeneous risk transmission of conventional and unconventional monetary policy on different financial markets. We find that expansionary conventional monetary policy, near term guidance and forward guidance decrease systemic risk whereas quantitative easing (QE) increases systemic risk. While the effects are qualitatively homogeneous for near term guidance and forward guidance, there exists heterogeneity in the risk transmission of conventional monetary policy and QE across different financial markets. The latter increases systemic risk significantly within bond markets, foreign exchange markets and among financial intermediaries. This might be caused by increased *search for yield* behaviour as QE distinctively reduces longer term interest rates. Our analysis shows that there is a potential threat to financial stability caused by QE which should be concerned by monetary- and macroprudential policymakers.

Keywords: Monetary Policy, CISS, Systemic Risk, Bayesian-Proxy-VAR, High-Frequency Identification

JEL Codes: C32, E44, E52, G10

1 Introduction

Financial instability poses a substantial threat to the real economy and potentially leads to a loss of output and increased unemployment. The global Financial Crisis of 2007-08 was not only a reminder of the scope of the damage systemic risk can cause, but also proved price stability and microprudential supervision of individual credit institutions insufficient to avert the crisis. Moreover, policymakers realised that a stable financial system is a prerequisite for price stability (Constâncio et al., 2019; European Systemic Risk Board, 2014; Smets, 2014). For this reason,

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the monitoring of systemic stress[1] and the implementation of macroprudential policy, that aims at increasing resilience of the financial system and smoothing financial cycles, gained importance. Not only can the focus on these new policies help to stabilise the financial system but reduced systemic risk can also decrease the probability of monetary policy becoming constrained by the zero lower bound (Smets, 2014). In this context, the question of how monetary policy may interact with financial stability, and more specifically whether there are positive or negative side effects of monetary policy on financial stability has become a concern for both academic scholars (see for instance Acharya et al., 2012; Bernanke, 2020; Borio & Zhu, 2012, etc.) and policymakers (e.g. Draghi, 2017; European Systemic Risk Board, 2014). Additionally, in its currently ongoing Strategy Review, the European Central Bank (ECB) dedicates a specific workstream to monetary policy and its interaction with financial stability[2]. This further highlights the topic's relevance. With intensified involvement in prudential regulation it becomes increasingly important for the ECB to ensure that monetary and macroprudential policy are harmonised (Smets, 2014). In this regard, the ECB identifies conditions under which they expect conflicting as well as aligned goals of the two policy measures. In case of a synchronised financial and business cycle, monetary policy is expected to reinforce financial stability. Without matching cycles, undesirable side effects may occur (European Systemic Risk Board, 2014). In case of a financial crisis it is crucial to know whether expansionary monetary policy will mitigate or amplify systemic risk, revealing a potential conflict of goals between monetary and macroprudential policy.

Empirically, the effect of monetary policy on systemic risk is less than clear. For one, there is substantial evidence of a risk-taking channel, suggesting that expansionary monetary policy leads to more individual risk-taking in the financial sector (e.g. Altunbas et al., 2010; Buch et al., 2014; Smets, 2014). However, they only allow for insufficient inference about systemic risk, since the literature focuses on bank level liquidity and default risk (Colletaz et al., 2018). In fact, the exposure of financial institutions to similar risks might lead to amplified effects of risk-taking at the systemic level (Benoit et al., 2017). Even though empirical literature investigating the effect of monetary policy on risk at a systemic level generally suggests that expansionary monetary policy leads to increased systemic risk, these results are less substantiated. Some publications assess systemic risk by relying on risk indicators that have a strong emphasis on the micro-level dimension of risk such as ΔCoVAR[3] and SRisk[4] (e.g. Faia & Karau, 2019; Kapinos, 2018) and often only focus on specific financial sectors (e.g. Deev & Hodula, 2016; Faia & Karau, 2019; Jin & De Simone, 2020). While most of these papers find evidence in support of the risk-taking channel, Kapinos (2018), who specifically look at the effect of Forward Guidance (FG), find that expansionary FG has calming effects on systemic risk. Literature that takes a more aggregate perspective and uses aggregate risk measures such as the CBOE Volatility Index (VIX) or the Composite Indicator of Systemic Stress (CISS) is sparser and less unanimous. Some find that expansionary unconventional monetary policy (UMP) decreases systemic risk (Boeckx et al., 2017; Gambacorta et al., 2014) whereas others find an increase in systemic risk (Faia & Karau, 2019) in the banking sector. Overall, different publications focus on different monetary policy instruments and financial sectors and rely

[1]The terms *systemic risk* and *systemic stress* are closely linked: stress measures are employed to measure systemic risk (Silva et al., 2017). We will follow the distinction by Hollo et al. (2012) who refer to systemic stress as an ex-post measure of systemic risk.

[2]see https://www.ecb.europa.eu/home/search/review/html/workstreams.en.html, retrieved last: 03.03.2021

[3]ΔCoVAR is defined as "the change in the value at risk of the financial system conditional on an institution being under distress relative to its median state" (Adrian & Brunnermeier, 2016, p.1705).

[4]The SRisk indicator is "defined as the total amount of capital that would be needed to bail out the financial system conditional on a financial crisis"(Colletaz et al., 2018, p.166).

on distinct econometric approaches which complicates obtaining comparable results. In general, there is a lack of clear evidence on the effect of distinct monetary policy instruments on systemic risk, and therefore, on financial stability, especially for the Euro area.

To the best of our knowledge, this article provides the first comparable analysis of the impact of CMP and UMP on aggregate systemic risk as well as systemic risk in five distinct financial sectors (Bond Market, Equity Market, Financial Intermediaries, Foreign Exchange (FX), Money Market) for the Euro area. Hence, our contribution lies in the empirical investigation of heterogeneous systemic risk effects of monetary policy. We make use of a structural vector autoregression and achieve identification by employing high-frequency monetary policy surprise factors, constructed by Altavilla et al. (2019). Our paper captures the reaction of aggregate systemic risk and systemic risk in specific financial markets through the CISS and its subindices, respectively. For the Euro area, this approach provides a novel combination of analysing the impact of monetary policy on systemic risk without relying on recursive identification as required with identification via commonly used Cholesky decomposition.

We find that aggregate systemic risk decreases in response to expansionary CMP. Also, short term guidance and FG have mitigating effects on financial turmoil. Quantitative Easing (QE), on the other hand, significantly increases systemic stress. These results are heterogeneous across financial markets. For example, the increase in systemic stress in response to a QE shock is mainly driven by elevated risk captured by the Bond Market, Financial Intermediaries and FX subindices. While the CISS displays significantly reduced risk in reaction to expansionary CMP, this is not the case for all subindices. In fact, a modest (insignificant) risk increase is found for the Equity Market. The effect of FG on systemic stress is most pronounced in the Money Market. Overall, we cannot find evidence for a risk-taking channel of CMP but provide clear empirical support for a risk-taking channel of QE. One reason for this could be that increased *search for yield* behaviour is relevant for QE especially, given that it reduces long term interest rate. Furthermore, our results illustrate that the impact of monetary policy on systemic risk cannot be extrapolated from results on individual risk-taking or results obtained from individual markets. The heterogeneous reactions across financial markets could contribute to explain diverging results throughout different publications.

The remainder of this paper is structured as follows. Section 2 discusses existing literature, Section 3 outlines the econometric framework of our empirical analysis and Section 4 presents the data used. Section 5 contains detailed results as well as a discussion of our findings. Finally, Section 6 concludes.

2 Literature Review

Systemic risk can be broadly defined as "the risk that financial instability becomes so widespread that it impairs the functioning of a financial system to the point where economic growth and welfare suffer materially"(ECB, 2009, p.134). As this definition already suggests, the analysis of systemic risk and prevention possibilities is of crucial importance as imbalances in the financial market can have damaging impacts on economic growth and welfare (Constâncio et al., 2019). This highlights the importance of our research. By providing insights into how monetary policy influences systemic risk, we get one step closer towards a better understanding of how central banks can affect systemic risk and financial instability.

Transmission mechanisms of monetary policy on risk-taking with a specific focus on the banking sector have been studied extensively. For example Adrian et al. (2019) as well as Borio and Zhu (2012) discuss how monetary policy impacts the perception and pricing of risk through the so called *risk-taking channel*. To be specific lower interest rates strengthen asset values and thus, income and profits increase which enhances investors confidence, and therefore, increases risk tolerance. Moreover, a decreased interest rate with unaltered rate-of-return targets leads to search for yield effects and in turn to an increased risk tolerance (Borio & Zhu, 2012).

Building on the notion of the risk-taking channel, Martinez-Miera and Repullo (2017) provide a theoretical model analysing the search for yield effect as a reaction to low interest rates. In their model there are three types of agents, namely entrepreneurs, investors and a bank. The bank provides funding for the entrepreneurs' projects. To finance these projects, the bank is reliant on investors. The bank can choose at a given cost how intensely the entrepreneurs are monitored. More intense monitoring will decrease the likelihood of the projects' defaults. The model suggests that a decrease in the real interest rate as a reaction to an exogenous drop in demand for investment will drive banks, on the one side, to invest in more and riskier projects, i.e. there will be search for yield behaviour. On the other side, the decrease in investment reduces the credit spread, i.e. "the spread between the bank's lending rate and the expected return required by investors" (Martinez-Miera & Repullo, 2017, p.352). This will lead to banks finding it more optimal to reduce their monitoring intensity. With less monitoring, however, the probability of default increases and thus a higher chance of financial instability arises.

After the introduction of the risk-taking channel by Borio and Zhu (2012), there has been a large increase in literature focusing on the effect of CMP on individual risk-taking in the banking sector (e.g. Altunbas et al., 2010; Buch et al., 2014, etc.). Smets (2014) provides a literature review for the Euro area. The common result supports the risk-taking channel (Smets, 2014). While this literature strand makes use of individual bank risk indicators and thus focuses on the micro-level, we put our focus on the macro-level by concentrating on systemic risk, as this is not as thoroughly researched.

In fact, most of the recent empirical literature focusing on the macro-level concentrates only on the real economy. This is done primarily by studying consumer prices and output as main research objects without explicitly focusing on systemic risk (Boeckx et al., 2017; Gambacorta et al., 2014, etc.). While Boeckx et al. (2017) study the Euro area, Gambacorta et al. (2014) examine individual countries, like Japan, Sweden and the United States. Both include a composite risk indicator as control variable and find that expansionary monetary policy has a reducing effect on systemic risk. This is not in line with the literature concerned with individual risk-taking.

There has been some literature concentrating on the effect of CMP on systemic stress using composite risk indicators, like the CBOE Volatility Index (VIX), the SRisk Indicator (Acharya et al., 2012; Brownlees & Engle, 2016) or ΔCoVAR (Adrian & Brunnermeier, 2016). However, except for the VIX indicator all of the named stress measures again focus on a micro-level dimension (Constâncio et al., 2019). Even though systemic stress is partly captured by these indicators the main focus still lies on the individual contribution of institutions to systemic risk. Focusing on this micro dimension to analyse the systemic risk-taking channel Colletaz et al. (2018) use the SRisk indicator. The authors find a significant causal relationship from monetary policy to systemic risk only in the long run and agree with the other literature on a risk increase as a reaction to expansionary monetary policy. Both the ΔCoVAR indicator and the long run marginal expected shortfall (LMRES)[5] are used by Faia and Karau (2019). Conforming with other studies, they find a significant negative effect on risk in the banking sector when the interest rate is increased. Bekaert et al. (2013), on the other hand, analyse CMP and its impact on the components of the VIX and

[5]The LMRES is a firm's "expected equity loss conditional on the market decline" (Adrian & Brunnermeier, 2016, p.49). This measure is used to construct the SRisk indicator (Brownlees & Engle, 2016).

find that expansionary monetary policy reduces risk aversion as well as the expected stock market volatility (uncertainty). Interestingly, the risk aversion effect is found to be stronger, which is in support of the risk-taking channel. Building on this research using the VIX indicator, Jang (2020) find that contractionary CMP and UMP shocks increase risk aversion as well as uncertainty. For expansionary MP this would translate to more certainty that mitigates the effect of increased risk-taking. These effects are marginal for CMP and more pronounced for UMP. The relative size of the impact on risk aversion and uncertainty is similar for all monetary policy shocks. Hence, the results are supportive of the risk-taking channel. At the same time, the impulse responses presented in the paper display marginally larger uncertainty effects, which would suggest reduced systemic risk in reaction to expansionary monetary policy. This division in two distinct effects illustrates how observations of specific micro-level behaviour (e.g. risk-taking) can deviate from systemic risk at an aggregate level. To the best of our knowledge, comparable macro stress analyses for the Euro area using the CISS have only been carried out by Kremer (2016). However, in contrast to our research Kremer (2016) concentrates on how monetary policy reacts to a change in the CISS.

Further research examining UMP and systemic risk has been rare and mostly focused on one specific financial market. Deev and Hodula (2016), for example, only concentrate on the banking sector and find that a decrease in the interest rate as well as QE increases the level of systemic stress. The impact on bond funds, mixed funds and equity funds is analysed by Jin and De Simone (2020). In their paper several systemic risk indicators are used. Depending on the systemic risk indicator different results are found. Focusing on systemic risk overall, Kapinos (2018) finds that expansionary forward guidance reduces systemic stress at the zero lower bound. In conclusion, different results are found in different market segments. Adding to this literature, we concentrate on the MP effect in five different financial markets in a comparable manner.

3 Econometric Framework

We apply a structural vector autoregression (SVAR) to investigate the potential causal effect of CMP and UMP shocks on the CISS and its subindices. In order to identify structural shocks we rely on the high-frequency identification (HFI) approach put forward by Gertler and Karadi (2015). As instruments we use monetary policy surprise factors extracted by Altavilla et al. (2019).

Already Beaudry and Saito (1998) employed the same identification strategy using the periods of monetary contractions that were identified by Romer and Romer (1989) to serve as external instruments. However, caused by the scarcity of suitable datasets of monetary policy events, the number of studies using this approach has been rare. Only relatively recently a literature strand analyzing the impact of monetary policy on the economy by utilizing data on high-frequency monetary policy surprises as an external instrument has emerged. Two noteworthy examples are Stock and Watson (2008) as well as Mertens and Ravn (2013). Since the provision of the *Euro Area Monetary Policy Event-Study Database* (EA-MPD) by Altavilla et al. (2019) the number of studies relying on the proxy-VAR approach for the Euro area has increased. Blot et al. (2020), for example, take a look at the influence on stock price imbalances and Andrade and Ferroni (2021) use the approach to analyse Forward Guidance. The clear advantage of this method is that it does not impose any zero- or sign restrictions on the economy which would be necessary for the Cholesky decomposition used in previous research (e.g. Gambacorta et al., 2014). In fact, these restrictions have been shown to overlook that changes in financial variables affect CMP and UMP endogenously (Caldara & Herbst, 2019). Hence, the high-frequency approach is especially attractive for VARs incorporating financial variables.

As common in the empirical literature concerned with macroeconomic effects of monetary policy the main building block is a SVAR which is given by

$$SY_t = \alpha + C_1 Y_{t-1} + \cdots + C_l Y_{t-l} + e_t, \qquad e_t \sim \mathcal{N}(0, I) \tag{1}$$

where Y_t denotes the endogenous variables, S captures the contemporaneous relations of Y_t, α denotes a vector of constants, C_i, for $i = 1, \ldots, l$ capture the autoregressive effects in the structural VAR up to lag l and e_t denotes the orthogonal structural errors which are assumed to be normally distributed around 0. The variance-covariance matrix of the structural errors e_t is normalized such that we have

$$\mathbb{E}[e_t e_t'] = I. \tag{2}$$

Premultiplying equation (1) with S^{-1} yields the reduced form which can be directly estimated

$$Y_t = \tilde{\alpha} + A_1 Y_{t-1} + \cdots + A_l Y_{t-l} + u_t, \qquad u_t \sim \mathcal{N}(0, \Sigma_u) \tag{3}$$

where $\tilde{\alpha} = S^{-1}\alpha$ denotes the transformed vector of constants, $A_i = S^{-1}C_i$ capture the autoregressive effects and $u_t = S^{-1}e_t$ denote the reduced form residuals centered around 0 with variance-covariance matrix

$$\mathbb{E}[u_t u_t'] = \mathbb{E}[S^{-1}(S^{-1})'] = \Sigma_u. \tag{4}$$

See Kilian and Lütkepohl (2017) for further details. Equation (3) will be estimated by applying Bayesian estimation techniques and employing commonly used prior specification of Litterman (1986) for $A_1, \ldots, A_l$ as well as Σ_u.

In order to identify the system we employ the proxy-VAR methodology using external instruments since a Cholesky decomposition of Σ_u via zero- or sign restrictions on S^{-1} is hard to justify in the monetary policy setting as mentioned before. See for example Gertler and Karadi (2015) who compare the results retrieved with external instruments to those from a Cholesky identification. The latter leads to some inconsistent results due to the endogeneity problem of the central bank influencing and reacting to financial variables simultaneously. Hence, following Gertler and Karadi (2015) we need to define the policy indicator, which is a specific time series $Y_t^p \in Y_t$ that indicates the monetary policy effect. In our application the policy indicators are different interest rates. We denote e_t^p as the column in e_t that corresponds to this specific policy indicator. In our case it can be interpreted as an exogenous monetary policy shock. For each VAR estimated in our analysis, we are only interested in identifying e_t^p. Thus, it is sufficient to compute the column s^p of S corresponding to this shock. This can be achieved by finding an instrument Z_t that is *valid* and fulfills the *exclusion restriction* similarly to a Two-Stage Least Square regression. That is,

$$\mathbb{E}[Z_t(e_t^p)'] = \theta \neq 0 \tag{5}$$

$$\mathbb{E}[Z_t(e_t^{-p})'] = 0 \tag{6}$$

where e_t^{-p} denotes all other exogenous shocks not concerning the policy indicator. In a next step, a first stage regression of u_t^p on Z_t is performed, where u_t^p denotes the column in u_t corresponding to Y_t^p. The thereby obtained fitted values $\hat{u}_t^p$ are cleaned from variation of u_t^{-p}. Their variation only results from the exogenous policy shock. Then the second stage regression

$$u_t^{-p} = \beta \hat{u}_t^p + \eta_t \qquad \eta_t \sim \mathcal{N}(0, \sigma_\eta) \tag{7}$$

is estimated, where given that Z_t fulfill the *exclusion restriction* we have

$$\mathbb{E}[\hat{u}_t^p \eta'] = 0. \tag{8}$$

The coefficient β then measures the effect of an exogenous policy shock in u_t^{-p}. Having estimated this coefficient β and using equation (4) one can find an analytical solution for s, therefore, we are able to identify a shock in e_t^p. For the analytical details we refer to Gertler and Karadi (2015). Having found s and given that Z_t is indeed *valid* and *fulfills the exclusion restriction* we can compute structural impulse-response functions (IRF) with causal interpretation. As instruments we use monetary policy factors (see Section 4) created by Altavilla et al. (2019)

4 Data

The majority of the data used is obtained on a monthly basis from the ECB Statistical Data Warehouse. Only the instruments (see Section 4.1) are drawn from the replication files of Altavilla et al. (2019). In general, the period investigated starts in January 2007 and lasts until November 2018, as the instruments used are not available afterwards.

4.1 High-Frequency Instruments

As policy instruments for our proxy-VAR we use monetary policy surprise factors created by Altavilla et al. (2019), which we obtain from the replication files available online.[6]

Altavilla et al. (2019) collect data on high-frequency asset price- and yield changes within narrow time windows around monetary policy announcements of the ECB. The data can be found in the EA-MPD. Included are price changes for a broad class of different assets and maturities including overnight index swaps (OIS), sovereign yields, stock prices and exchange rates. Using this data they extract four orthogonalised and independent factors where each of them describes the variance of the yield and price changes in a specific maturity segment. As a result, each indicator captures a different type of monetary surprise and can be interpreted independently from the other factors. The first factor is called the *Target* factor and captures the change in market expectations about the current setting of the policy rates. The Target factor influences the 1-month maturity interest rates the strongest and only affects short term rates. Second, the *Timing* factor captures the shifts in short term market expectations over the next few monetary policy announcements, which to a large extent leaves long term interest rates unchanged. It impacts the 6-month maturity most heavily. This is why Altavilla et al. (2019) argue that this factor captures short term guidance surprises. Third, the so called *Forward Guidance* factor captures the revision in midterm market expectations about the future path of policy rates. The FG factor affects the mid range of the yield curve most heavily peaking at about two years, but still strongly impacting up to five years. Last, but not least, from 2014 onwards the factor *Quantitative Easing* is found to be significant.[7] The QE factor captures the revised market expectations of changes to the Quantitative Easing program of the ECB. QE effects become larger as maturity increases and its influence is peaking at the 10-year maturity (Altavilla et al., 2019).

[6] http://refet.bilkent.edu.tr/research.html, retrieved on: 23.02.2021

[7] Before that, the QE factor is not significant. The fact that it is active from 2014 onwards might be due to the ECB not running any QE programs before 2015. That is, the ECB started buying assets from commercial banks in March 2015. See https://www.ecb.europa.eu/explainers/show-me/html/app_infographic.en.html, retrieved on: 23.02.2021.

As a result, the factors are capturing different monetary policy surprise shocks. Furthermore, Altavilla et al. (2019) ensure that the key assumption for the interpretation in high-frequency event studies, that changes in asset prices and yields within the policy window only happen due to the monetary policy announcement, is fulfilled. From the qualities of the factors, we can assume that they are suitable instruments for our research purpose. That is, they are *relevant* since they describe variance of the changes of different yield maturities caused by monetary policy surprises. Furthermore, they fulfill the *exclusion restriction*, as Altavilla et al. (2019) have shown, implying that they can be interpreted as random (exogenous) monetary policy surprises.

Since the factors capture changes in different maturities we use different policy indicators for each CMP and UMP shocks of interest. First, the *one-month Euribor* index (Euribor 1M) on a monthly basis is used in combination with the Target instrument. Second, the *six-month Euribor* index (Euribor 6M) is used for the Timing instrument. Third, when using the FG instrument, we use the *Generic Eurozone 5 Year Government Bond* index (5Y Bond Yield). Finally, for the QE instrument we use the *Generic Eurozone 10 Year Government Bond* index (10Y Bond Yield).

In the estimation of our models the instruments are used in levels whereas the policy indicators are used in monthly first differences to obtain stationarity.

4.2 Composite Indicator of Systemic Stress and Subindices

To capture and quantify systemic stress in the financial system in the Euro area we use the CISS and the respective subindices. These indices are constructed by the ECB and are specifically designed for the Euro area. It allows us to focus on systemic risk in the entire financial system in contrast to the individual contribution of institutions to systemic risk measured by most other risk measures such as SRisk or ΔCoVAR as explained above. Moreover, one new and core element of our research is investigating systemic risk not only using the CISS, but zooming in more closely looking at the effects on each subindex which enables the analysis of heterogeneous effects of monetary policy on instability in different financial markets (Hollo et al., 2012). Data used on the CISS and the subindices is obtained on a weekly basis. However, in order to transform weekly to monthly data we use monthly averages. Furthermore, monthly first differences are used to obtain stationary time series data.

In general, the CISS consists of five market specific subindices which are again created by 15 different systemic stress measures. The first subindex *Bond Market* is composed of a realized volatility measure and a yield and swap rate spread measure. Second, the so called *Equity Market* subindex consists of a measure for stock-bond correlation, some realized volatility and the CMAX[8] of the Datastream non-financial sector stock market index. Third, the *Financial Intermediaries* subindex reflects systemic stress of three sectors, namely banks, insurance companies and hedge funds or others. In this subindex a measure of realized volatility of the Datastream bank sector, the yield spread between A-rated financial and non-financial corporations and the CMAX interacted with the inverse price-book ratio for the financial sector equity market index is included. Fourth, the *Foreign Exchange* subindex contains the realised volatility of the euro exchange rate against the US Dollar, the Japanese Yen and the British Pound, respectively. Last but not least, the *Money Market* subindex consists of the realised volatility of the 3-month Euribor rate, some interest rate spread and the Monetary Financial Institution's emergency lending at Eurosystem central banks (Hollo et al., 2012).

[8]CMAX defines the maximum cumulated index losses over a moving period of two years. See Hollo et al. (2012) for a detailed mathematical definition.

The aggregation of the 15 different stress factors to the subindices and finally to the CISS can be roughly described as follows. First, the samples of all raw indicators are standardized and transformed by means of order statistics. Then, each of the stress factors is given equal weight to the corresponding subindex. Next, the subindices are aggregated to the CISS using portfolio theory, hence, taking into account the cross-correlations between the subindices and not only their variances. Moreover, it is allowed for time-varying cross-correlations. As a result, the CISS puts relatively more weight on situations in which stress is present in several market segments at the same time, which captures the idea that systemic stress is high if financial instability is widely spread across the whole financial system. In order to determine the subindex weights Hollo et al. (2012) use the relative importance of each subindex for real economic activity. The resulting subindex weights are: Money Market (15%), Bond Market (15%), Equity Market (25%), Financial Intermediaries (30%) and FX Market (15%).

Figure 1 shows the CISS and its subindices for the whole sample period. It is clearly visible that these indices capture stress in the financial system. This becomes apparent when first looking at the low risk period at the beginning of the sample when the global Financial Crisis was ahead. Shortly after, around the beginning of 2009, the indices reach their maximum in our sample period reflecting high systemic stress. The second peak (late 2010) reflects the Greek government debt crisis followed by the European Sovereign Debt Crisis.

When looking closely at the Financial Intermediaries subindex we see that it stays at an elevated level after its peak in 2009 until 2014 reflecting the destructive impact of the Financial Crisis on financial institutions. During the same time other indices, such as the Money Market do not seem to be influenced as strongly.

Summary statistics in Table 2 in Appendix A.2 show the Financial Intermediaries and Equity indices to be riskier (higher movement) than the Bond, Foreign Exchange, or Money Market indices.

4.3 Control Variables

Apart from the instruments and policy indicators described in Section 4.1 and the CISS and its subindices explained in Section 4.2 we also include control variables. First, we use the total *Industrial Production (excl. construction)* (PROD) of the Euro area as a proxy for real activity since the gross domestic product is not available on monthly frequency. Second, we take the *Harmonised Index of Consumer Prices* (HICP) in order to control for inflation in the Euro area. Using the X13 filter (Sax, 2018) we check for any seasonal patterns included in the PROD or HICP data and remove it. PROD and HICP are both used in log monthly first differences to obtain growth rates and to assure stationarity.

Interested readers can find all data and transformations used in our research in Table 1 in the Appendix.

5 Results

In order to uncover the interaction of monetary policy and financial stability at the aggregate level we estimate a baseline specification in which each of the models incorporates the CISS as well as PROD and HICP as control variables. To investigate whether these risk effects are distinct in different parts of the financial system, we also estimate a second specification in which we replace the CISS with all its subindices.

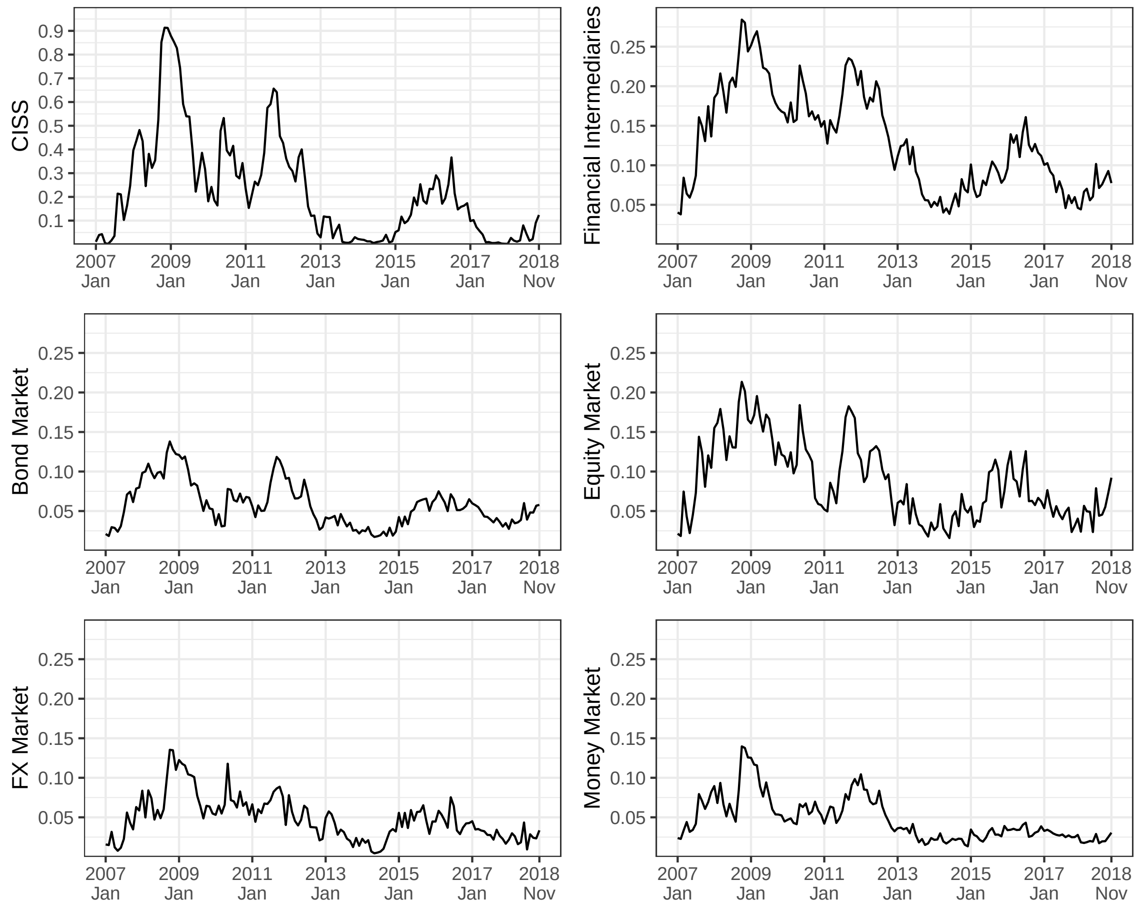

Figure 1: CISS and the respective subindices from 2007 to 2018. Note: the scale of the ordinate of the CISS differs to the scale of the subindices.

The models of both specifications feature one of the four different policy indicators which are identified with its corresponding instrument. Therefore, each specific model captures the effect of a different kind of monetary policy shock. The shocks are normalized such that they represent a one percentage point decrease of the policy indicators. Therefore, the results can be interpreted as a reaction to an expansionary monetary policy.

In general, each of the models incorporates two lags and the results are obtained by using 10,000 draws from the Gibbs Sampler of which 5,000 draws are discarded as burn-in.

5.1 Systemic Stress Effects of Monetary Policy

First, we focus on the overall reaction of systemic stress proxied by the CISS. Figure 2 shows the results of the four models of our baseline specification, each row presenting the IRFs of a specific model. The first column displays the shock of the specific policy indicator. The first row in Figure 2 shows the IRFs of a Target shock that decreases the Euribor 1M. It can, therefore, be interpreted as an expansionary CMP shock. We see that production as well as prices increase which is in accordance with standard macroeconomic theory. The reaction of prices is particularly remarkable. In fact, we find no price puzzle (e.g. Sims, 1992) which is reassuring of a well identified CMP shock. With respect to the financial stability effects of CMP, we find that the CISS decreases significantly, indicating a calming effect of CMP on overall systemic stress.

Next, we examine the effect of a Timing shock which, as stated, captures shifts in short term market expectations, and can, thus, be interpreted as short term guidance factor (Altavilla et al., 2019) and classifies as a UMP shock. While no clear reaction of PROD is visible, prices are estimated to decline on impact. This effect, however, is barely significant. Systemic stress is also estimated to decline. Furthermore, when comparing the median posterior IRF of the CISS across all four model specifications, we see that the Timing shock has the strongest impact on systemic stress. However, this result remains quite uncertain with respect to the significance of this reduction. This is displayed by the blue area in the IRF plot always being close to zero.

The next UMP shock under consideration shown in the third row of Figure 2 is an expansionary FG shock, indicated by a decrease in the 5Y Bond Yield. We find that PROD as well as HICP increases, which is in line with the findings of Andrade and Ferroni (2021) for *Delphic* FG[9] in the Euro area. Turning to the effects of FG on financial stability, we see that FG reduces the CISS significantly which implies that FG has a mitigating effect on financial turmoil. The effect is smaller compared to the Timing and Target shock. However, the confidence bands are comparably smaller, indicating that the calming systemic stress effects estimated for FG are more clearly pronounced.

The last model of the baseline specification investigates the effects of QE. The results show no significant impact on production. Prices, on the other hand, are estimated to increase significantly as expected. For an expansionary QE shock, we find a significant increase in the CISS which implies that QE increases systemic stress significantly. However, the estimated effect seems rather small as can be inferred when comparing the magnitude to the CISS effects of the previous specifications.

Taking all the results of our baseline specifications together, we see that QE explicitly can be distinguished from the other forms of CMP and UMP. While Target, Timing and FG shocks reduce the CISS, QE increases systemic stress. This reveals a transmission of the risk-taking channel of monetary policy via QE. Hence, if there is a threat to financial stability stemming from expansionary monetary policy, it is a negative side effect of QE.

5.2 Heterogeneous Systemic Stress Effects in different Financial Sectors

Having seen that monetary policy has direct effects on systemic stress within the Euro area, we now try to uncover whether these effects are equally transmitted through different financial markets. For this reason, we again estimate our models as discussed before, but now replace the CISS with all its subindices at once. Figure 3 presents the corresponding results[10], in which some heterogeneity across the different subindices is immediately visible.

[9] For details on the concept of Delphic and Odyssean FG we refer to Campbell et al. (2012) who introduced this notion. Andrade and Ferroni (2021) argue that the ECB's FG policy is understood as being *Delphic* for most of the time period in our sample. However, Altavilla et al. (2019) also asses their FG factor in a proxy-VAR featuring financial variables. They obtain reactions typical for *Delphic* shocks for the period 2008-2014 but *Odyssean* patterns for the period 2014-2018.

[10] The reaction of PROD and HICP are qualitatively similar to the baseline specification and have been excluded from the figure for brevity.

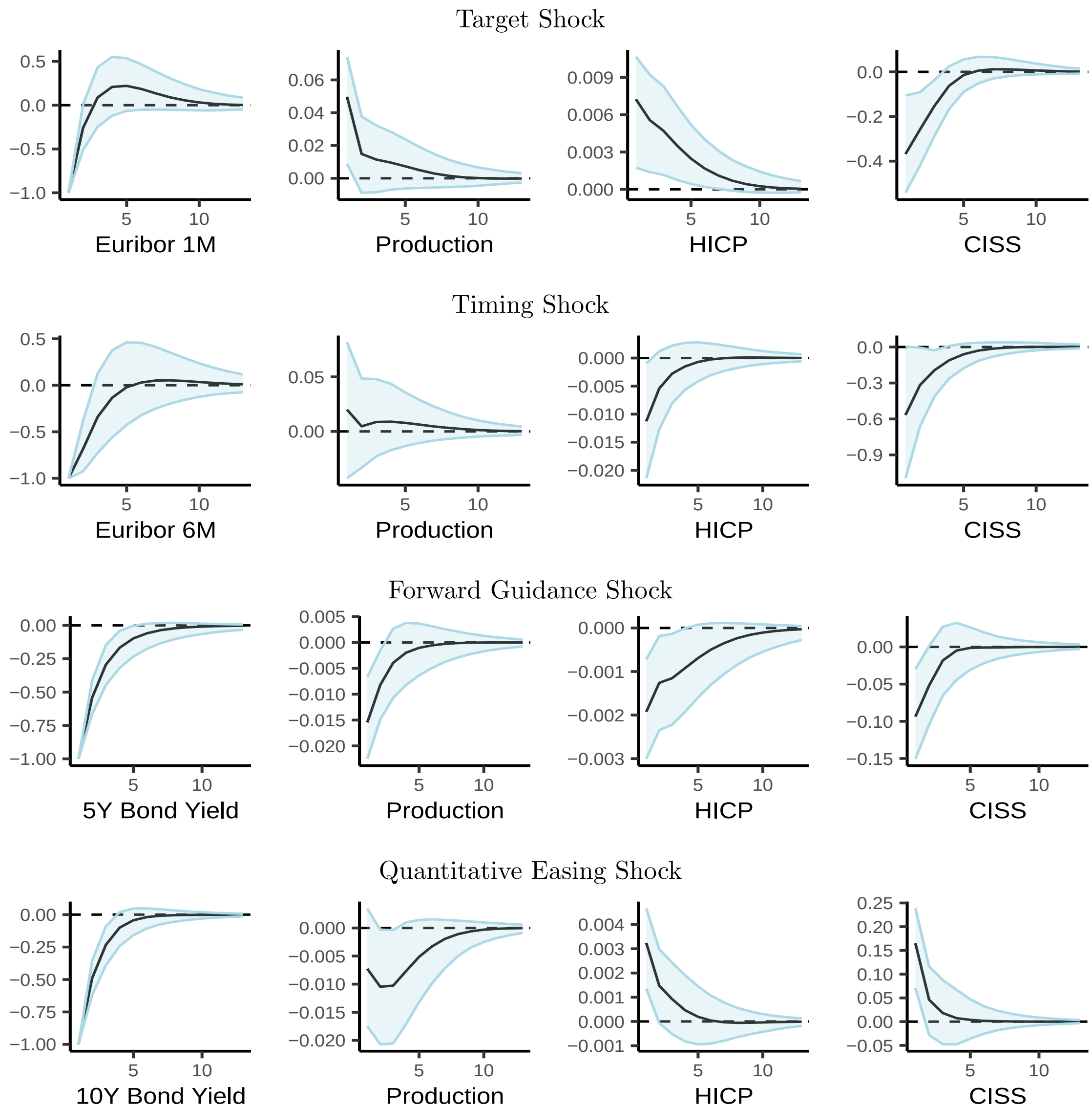

Figure 2: Impulse Response Functions to the specified One Unit Expansionary Monetary Policy Shock

Note: The MP shocks consist of a Target, Timing, Forward Guidance and Quantitative Easing shock. The black line represents the median posterior IRF of the specified variable, the blue shaded area the 80% Bayesian credible interval. The black dashed line marks the zero line.

First, we examine the Target shock shown in the first row of Figure 3. We see that the calming effect of CMP seems to be transmitted through the Bond Market, Money Market and FX Market. However, it is important to note that the effects are barely significant at the 80% level. In fact, they are only significant for the Bond Market on impact and for the Money- and FX Market after

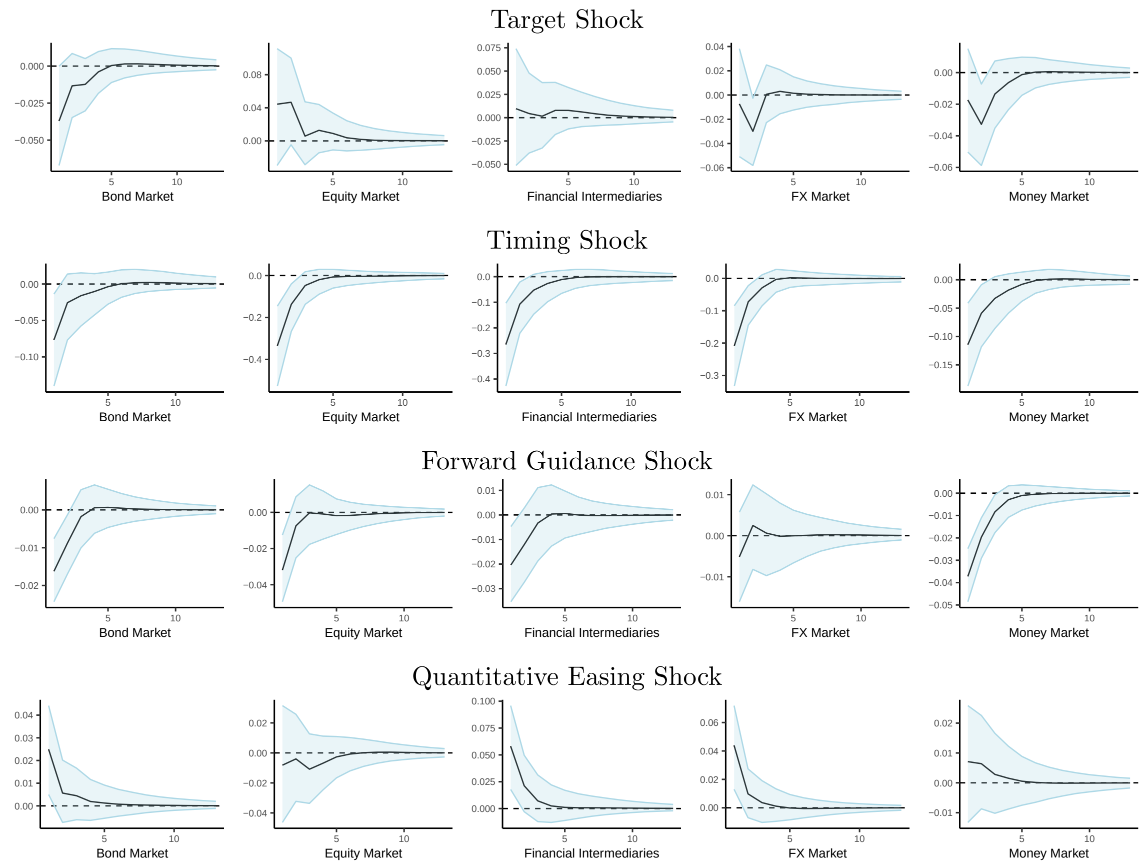

Figure 3: Impulse Response Functions of the CISS Subindices to the specified One Unit Expansionary MP Shock

Note: The MP shocks consist of a Target, Timing, Forward Guidance and Quantitative Easing shock. The black line represents the median posterior IRF of the specified CISS subindices, the blue shaded area the 80% Bayesian credible interval. The black dashed line marks the zero line.

two months.[11] There are no significant effects in the Equity Market, for Financial Intermediaries and in the FX Market. However, the results concerning Equity Markets are still very important. In fact, CMP seems to increase the respective subindex. This implies that CMP tends to increase systemic stress in Equity Markets hinting at a transmission of the risk-taking channel of CMP only through the Equity Market. This result, however, is not significant and should be taken with a grain of salt. For Financial Intermediaries, CMP does not have any significant direct systemic stress implications. Focusing on the magnitude of the effects we see that they are equally pronounced for

[11] When comparing financial stability effects of this specification with our baseline specification which features the CISS, it becomes visible that the effects are less significant. This indicates that model uncertainty increases for this specification, i.e. when all subindices are included instead of the CISS. One reason for this could be that the CISS takes into account cross-correlations of all its subindices, and therefore, especially emphasizes situations in which risk is increased in multiple markets simultaneously. This specific information is not captured by the second specification.

all subindices indicating that no specific financial market is particularly strongly influenced.

For the Timing shock, we see a significant reduction of systemic stress in all sectors of the financial market. This implies that near term guidance is effective in reducing systemic stress and, therefore, fosters financial stability over all segments of the financial markets. It is again visible, as in the CISS setting, that the size of all systemic stress effects is also considerably larger for the Timing shock compared to the other shocks. This again confirms that systemic stress reacts the strongest to short term guidance. The impacts are particularly pronounced for the Equity Market and for Financial Intermediaries.

A similar picture is shown when looking at the third row of Figure 3 which shows the reaction of systemic stress to FG. Systemic stress is reduced significantly in all segments of the financial market, but the FX Market. The effects are strongest for the Money Market and Equity Market. However, in general the magnitude of the effects is rather small. Thus, FG is able to reduce systemic stress in almost all financial sectors but not as effectively and pronounced as near term guidance.

Finally, turning to the QE effects, we find that the risk increase, that has been shown in the baseline specification, is not transmitted through all segments of the financial market. Indeed, when looking at the last row of Figure 3, we see that there are no significant reactions in the Equity and Money Market subindices. In all the remaining segments, however, systemic stress is increased. Therefore, the risk-taking channel of QE is transmitted through the Bond Market, Financial Intermediaries and FX Markets. The strongest effects are found for Financial Intermediaries. However, again compared to the magnitude of systemic stress effects to the other types of MP before, we find that the effects are rather small, i.e. similar in magnitude to the ones of the Target and FG shock.

5.3 Discussion

Overall, our results clearly suggest that CMP as well as UMP have an impact on systemic stress within the Euro area. However, there is strong heterogeneity in the risk transmission through different sectors of the financial market and via different types of MP shocks. Our results are robust against changing the lag structure, using different policy indicators for each instrument and considering different time periods (see Appendix A.1 for more information).

Diving deeper into our findings, we discover that while FG reduces stress modestly, near term guidance (Timing) has a stronger decreasing effect on systemic risk. Kapinos (2018) also studies the systemic risk reaction to a monetary news shock, i.e. FG shock, and suggests in line with our results that expansionary FG decreases systemic risk at the zero lower bound. Our results hint at more pronounced reduction of uncertainty compared to risk-taking effects in reaction to FG, as indicated by Jang (2020). It could be the case that near term guidance and FG both reduce uncertainty in the markets but FG being more long-term oriented leads to increased risk-taking which mitigates the calming impact on systemic risk. More research is required to uncover the mechanisms that trigger the aggregate effect found in this paper.

In contrast to QE which increases the CISS suggesting a risk-taking channel, all other shocks decrease composite systemic stress. The findings for the Target shock differ compared to research finding evidence for the risk-taking channel of CMP (e.g. Altunbas et al., 2010; Buch et al., 2014). However, it has to be noted that this literature strand mainly focuses on the banking sector using micro-level risk measures.[12] In contrast to this literature strand, we use the CISS, which focuses on the whole financial system. Hence, we need to put our attention towards the CISS subindices. And

[12] Research focusing on the individual institutions' contribution to systemic risk, i.e. SRisk or ΔCoVAR, find opposing results concerning CMP, i.e. the Target shock (e.g. Colletaz et al., 2018; Faia & Karau, 2019).

in fact, we find qualitatively conforming results suggestive of the theoretical risk-taking channel in the banking sector when focusing on the Financial Intermediaries, i.e. a drop in the interest rate slightly increases systemic risk.[13] However, we do not find this result to be significant.

Interestingly, when analysing the CISS subindices more closely, we only find heterogeneity in reaction to the Target and the QE shock. In more detail, the QE shock increases systemic risk in all but the Equity and Money Market. This provides clear evidence of the risk-taking channel of QE in the Bond Market, the FX Market and for Financial Intermediaries. The reason for this could be increased *search for yield*: The prevailing low interest rate environment paired with further downward pressure on long term maturity assets due to QE may cause financial agents to shift their portfolios into more profitable investment opportunities which comes at the cost of higher risk. Our results show that the Financial Intermediaries subindex is affected strongest by QE suggesting that the *search for yield* effect is particularly emphasized within this sector. This does not come as a surprise as *risk-free* long term financial products such as government bonds are important components of banks' and insurance companies' investment portfolios. Lower long term interest rates may force them to reallocate their portfolios to riskier assets in order to keep income cash-flows steady. This is line with Deev and Hodula (2016), who find that QE increases risk in the banking sector. Furthermore, our results show that QE increases systemic risk in the Bond Market. One reason for this could be that the former mentioned *search for yield* triggers portfolio re-balancing, and therefore, greater trading-activity in bond markets leading to increased volatility in bond prices. [14] Interestingly, we do not find a risk increase in the Equity Market caused by QE. However, we do find some weaker evidence on increasing systemic stress in the Equity Market as response to expansionary CMP. This suggests that the risk-taking channel concerning CMP is mainly transmitted through equity markets.

While the heterogeneity in risk transmission of CMP and QE across different financial markets is an interesting empirical result, we are only able to provide some rough arguments on the reasons for this issue. Rigorous theoretical considerations remain out of scope of this paper. In fact, to the best of our knowledge there is no theoretical research concerned with the heterogeneity in the risk transmission of MP.

Overall, our results provide important information for central bankers and policymakers concerned with financial stability. First, we find that QE indeed bears negative side-effects on systemic stress. This suggests a possible trade off between price and financial stability. The relevance of this issue is pointed out by the current situations with CMP being limited due to the zero lower bound and QE having become one of the main monetary policy instruments of the ECB to stabilise inflation. However, with respect to this issue, our results also provide some good news: We find that near term guidance (Timing shock) as well as FG are capable of reducing systemic stress over all segments of the financial market significantly. Furthermore, we find that the magnitude of the calming effect of near term guidance is quite sizable. In fact, it is considerably stronger than the negative impact impact of QE. Thus, our results offer the conclusion that the negative side effects of QE on financial stability could be mitigated if not even neutralised by near term guidance and FG actions. However, since monetary policy's official mandate is to serve price stability, such financial stability considerations do not necessarily have to be reflected in MP decision making. There-

[13]It should be pointed out that the banking and the Financial Intermediaries can only be partially compared, as in addition to banks, also insurance companies, hedge funds and others are included in the Financial Intermediary subindex.

[14]The realized volatility of the German 10 year benchmark government bond index is a component of the Bond Market subindex.

fore, macroprudential policy should have a watchful eye on financial stability threats stemming from QE and potentially consider developing countermeasures to build up resilience. However, for such considerations, more research on the theoretical background on the risk transmission of QE is needed.

6 Conclusion

In this paper we have studied how monetary policy in the Euro area has affected systemic risk and financial stability since the beginning of the Financial Crisis. Using a Bayesian proxy-VAR estimation method, we add to previous research by analysing the effect of CMP and UMP shocks on systemic stress at the aggregate level as well as in five different sectors of the financial market. We find that near term guidance and Forward Guidance reduce systemic stress significantly and sizably across the whole financial market while CMP only modestly reduces stress in specific sectors but tends to increase turmoil in the Equity Market. On the other hand, our results suggest that QE increases systemic risk in the Bond Market, FX Market and for Financial Intermediaries. Therefore, we find significant evidence for a risk-taking channel for QE in these financial segments and also some modest evidence for a risk-tanking channel of CMP transmitted through Equity Markets.

Our results show that MP measures have a direct implication on financial stability, and therefore, provide some empirical evidence for the ongoing discussion of the possible conflict between price and financial stability. According to our results, we can conclude that an extensively one-sided concentration of MP on QE could create a considerable threat to financial stability. However, we see the potential for near term and forward guidance to mitigate if not even neutralize this negative side effect.

Still, it needs to be mentioned that our results come with a few limitations. First, given the nature of our empirical strategy, we are not able to shed light on the long-run effects of MP on financial stability. Second, having seen that there is pronounced heterogeneity in the risk transmission of MP across different financial segments, one could potentially go into more detail within these sectors. Performing such an analysis on a more granular level, would even better uncover heterogeneity and also link the results more closely to established micro-focused literature concerned with risk effects of MP. Finally, our analysis does not aim at uncovering theoretical arguments on why there is heterogeneity in the risk transmission of MP across different financial segments. This, however, would be very useful for (macroprudential) policy aiming at mitigating the negative side effects of MP and should, therefore, be taken up by future research. So, how risky is monetary policy? Even though we find calming effects of CMP and FG, risk is increased by QE. This highlights the fact that the impact of MP on systemic risk should be carefully considered. In general, however, MP is not bound to be risky.

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A Appendix

A.1 Robustness

We run several robustness checks in our model to verify our results. First, we test different lag structures. Second, we re-estimate our model using the full sample period where the instruments provided by Altavilla et al. (2019) are available. To be specific, starting in January 2002 until November 2018. Overall, our results did not change. To check for robustness related to the chosen policy indicators we used different indicators for each instrument. Specifically, for each of the factors of Altavilla et al. (2019) in use, we consider interest rates of different maturity periods in accordance with the strongest loading of each factor. For instance for estimating FG we used two, three and five year yield indices, the same was done for the other factors. Other than minor changes in variances, our results were qualitatively unchanged. To keep this paper compact, we do not present any of the outputs from the performed robustness checks. They are available from the authors upon request.

A.2 Data

Table 1: Data and Transformation

Variable	Description	Transformation	Source
Timing	Instrument: Timing Factor	Levels	Altavilla et al. (2019)
Target	Instrument: Target Factor	Levels	Altavilla et al. (2019)
FG	Instrument: Forward Guidance Factor	Levels	Altavilla et al. (2019)
QE	Instrument: Quantitative Easing Factor	Levels	Altavilla et al. (2019)
Euribor 1M	one-month Euribor	First Differences	ECB
Euribor 6M	six-month Euribor	First Differences	ECB
5Y Bond Yield	Generic Eurozone 5 Year Government Bond	First Differences	ECB
10Y Bond Yield	Generic Eurozone 10 Year Government Bond	First Differences	ECB
Bond Market	CISS Subindex of Bond Market	First Differences	ECB
Equity Market	CISS Subindex of Equity Market	First Differences	ECB
Financial Intermediaries	CISS Subindex of Financial Intermediaries	First Differences	ECB
FX Market	CISS Subindex of Foreign Exchange Market	First Differences	ECB
Money Market	CISS Subindex of Money Market	First Differences	ECB
PROD	Total Industrial Production (excl. construction)	Log Differences	ECB
HICP	Harmonised Index of Consumer Prices	Log Differences	ECB

Table 2: Summary Statistics of the CISS and its Subindices

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
CISS	143	0.222	0.221	0.002	0.033	0.335	0.913
Bond Market	143	0.058	0.028	0.017	0.036	0.072	0.138
Equity Market	143	0.088	0.049	0.016	0.049	0.124	0.213
Financial Intermediaries	143	0.130	0.063	0.038	0.073	0.177	0.284
FX Market	143	0.049	0.028	0.004	0.028	0.064	0.135
Money Market	143	0.047	0.028	0.013	0.026	0.064	0.140