Monetary Policy during Financial Crises: Is the Transmission Mechanism Impaired?*

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The effects of monetary policy during financial crises differ substantially from those in normal times. Using a panel VAR for twenty advanced economies, we show that monetary policy has larger and quicker effects during financial crises on output and inflation, and also on various other macroeconomic variables like credit, asset prices, uncertainty, and consumer confidence. The effects on output and inflation are particularly strong during the acute phase of financial crises when the economy is also in recession, while they are weaker during the subsequent recovery phase. We find differences in the size and the timing of monetary policy actions during the global financial crisis of 2008/09 across countries that may have contributed to the different macroeconomic performance across countries.

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1. Introduction

During the global financial crisis that started in 2007, many central banks eased monetary policy aggressively in order to alleviate financial market distress, boost output, and stabilize inflation. Monetary

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policy was largely successful in mitigating financial market distress, but output growth and inflation remained lower than expected in many advanced economies and the recoveries were widely perceived as disappointingly sluggish (see, e.g., Pain et al. 2014). These observations led to a broad-based debate on whether the transmission channels of monetary policy were impaired due to the global financial crisis and whether monetary policy is in general less effective during financial crises and their aftermath (see, e.g., Bouis et al. 2013).

The relevance of this debate goes beyond the central banks' general need for assessing the effectiveness of their policies. It is crucial for defining a policy mix that can stabilize the economy during financial crises. If monetary policy is less effective in such crises, the questions arise whether larger monetary stimulus needs to be provided in order to achieve the desired effects; whether other policies, such as fiscal policy, need to be used more extensively; or whether sluggish recoveries after financial crises must be tolerated given that there is little scope for monetary policy. In this regard, the question of monetary policy effectiveness during financial crises is also relevant for the assessment of undesirable side effects, such as excessive risk-taking and asset price bubbles, that can occur if monetary policy remains highly expansionary for an extended period of time (see, e.g., Rajan 2005; Altunbasa, Gambacorta, and Marques-Ibanez 2014; Jiménez et al. 2014).

Financial crises exhibit several characteristics that can influence the transmission of monetary policy: high financial market distress, macroeconomic volatility and uncertainty, low confidence of market participants, and substantial balance sheet adjustments of firms and households. All these adverse characteristics might impair the transmission of monetary policy. In particular, banks might be unwilling to extend their credit supply, because they face higher credit default risk and because they need to adjust their balance sheets after previous losses (Bouis et al. 2013; Buch, Buchholz, and Tonzer 2014; Valencia 2017). Also, financial crises are typically preceded by asset price bubbles and credit and consumption booms and, as a consequence, are typically followed by deleveraging of households and firms and increasing risk aversion (Reinhart and Rogoff 2008). Hence, in such periods, credit supply and demand may remain weak, irrespective of the interest rate set by the monetary authority, thus hampering the credit channel of monetary policy. The interest rate channel of monetary policy may be impaired, because in times of high uncertainty investors may postpone irreversible investment decisions until more information arrives (see, e.g., Bernanke 1983; Dixit and Pindyck 1994). Uncertainty then becomes a major determinant of investment decisions, whereas monetary policy loses its impact (Bloom, Bond, and Reenen 2007). Similarly, the interest rate responsiveness of investment may decline when firms and consumers have low confidence in their business or employment prospects (Morgan 1993). Finally, it may become more difficult for central banks to stabilize output because in times of high macroeconomic volatility firms tend to adjust their prices more often (Vavra 2014).

On the other hand, a monetary policy intervention could also be particularly effective, if it can mitigate some of the adverse financial crisis characteristics and thus prevent adverse feedback loops between the financial sector and the real economy, thereby restoring the functioning of the credit and interest rate channel (see, e.g., Mishkin 2009). In particular, credit constraints are more likely to bind during financial crises, leading to an increase in the external finance premium. Monetary policy may in this situation be able to decrease the external finance premium by easing credit constraints, so that the financial accelerator of Bernanke, Gertler, and Gilchrist (1999) would make monetary policy particularly effective. Moreover, while being less effective in the presence of high financial market distress and uncertainty, monetary policy can be all the more powerful if it is able to significantly alleviate financial market distress and reduce uncertainty (Bekaert, Hoerova, and Lo Duca 2013; Basu and Bundick 2017). Similarly, monetary policy can be more effective if it is able to raise confidence from very low levels, by providing signals about future economic prospects (Barsky and Sims 2012), by decreasing the probability of worst-case outcomes, and by improving the ability of agents to make probability assessments about future events (Ilut and Schneider 2014).[1]

It is therefore a priori ambiguous whether monetary policy is more or less effective during financial crises than during normal

[1] Bachmann and Sims (2012) provide evidence that the confidence channel is important for the effectiveness of fiscal policy in stimulating economic activity. Similar effects are conceivable in the context of monetary policy.

times. This ambiguity is further enhanced as crisis characteristics may vary over the course of a financial crisis (Borio and Hofmann 2017). Financial market distress and high uncertainty are primarily present in the initial and most acute phase of a financial crisis, when the economy is typically in a recession. In contrast, balance sheet adjustments may gain importance when financial market distress and uncertainty abate and the economy begins to recover.

Given the mixed theoretical predictions, the effectiveness of monetary policy during financial crises becomes an empirical question. However, such an analysis is made difficult, because financial crises are rare events and there is no unique definition of a financial crisis. We attempt to overcome these issues by exploiting the panel dimension of the data for twenty advanced economies over the period from 1984 to 2016 and by employing as measure of financial crises the widely used data set of Laeven and Valencia (2013), which identifies systematic banking crises via a transparent narrative approach. This approach captures systemic disruptions in the banking system, but it excludes periods during which financial stress is high for other reasons, such as political events or natural catastrophes. Our sample covers twenty financial crisis episodes that last 4.5 years on average. With fifteen out of twenty financial crisis episodes, our sample reflects to a large extent the global financial crisis that started in 2007, but also includes five earlier more regionally bounded crises.

We analyze differences in the transmission of monetary policy during financial crises and normal times using the interacted panel VAR (PVAR) methodology of Sá, Towbin, and Wieladek (2014), in which we interact the endogenous variables with a financial crisis indicator variable. This panel approach exploits the cross-section dimension of the data to improve the precision of the estimation, while allowing for a large degree of heterogeneity across countries. The PVAR model includes GDP and CPI as the main variables of interest and, in the baseline specification, the three-month interest rates as monetary policy instrument. We include several additional macroeconomic and financial variables, which are potentially important for the monetary policy transmission mechanism, such as credit, exchange rates, house prices, and stock market volatility as a proxy for uncertainty. We identify monetary policy shocks using a recursive identification.

In the baseline model, all variables in the VAR are interacted with financial crisis dummies in order to analyze differences in the transmission of monetary policy shocks between *financial crises* and *normal times*. In an extended model, we further investigate potential heterogeneity between different phases of financial crises: the *acute phase*, where the financial crisis is accompanied by a recession, and the *recovery phase*, where the financial crisis is ongoing but the economy is already in expansion. We use the Bry-Boschan algorithm to identify recession episodes, which is the most commonly used algorithm in the literature. The extended model can provide a more comprehensive understanding of monetary policy transmission during financial crises. However, it is also more prone to methodological limitations due to the reduced number of observations in each regime resulting from splitting financial crisis episodes into different phases, and due to the uncertainty inherent to the dating of recessions, on which our phase definition is built.

We find that the effects of monetary policy shocks on output and inflation are significantly larger and occur faster during financial crises than during normal times. Monetary policy shocks also explain a larger share of business cycle fluctuations during financial crises, according to forecast error variance decompositions. The effects of monetary policy shocks on uncertainty, credit, consumer confidence, and share prices are significantly larger compared with normal times, suggesting that these variables may play an important role in the transmission of monetary policy in financial crises. Further, we find that distinguishing between the acute and the recovery phases of financial crises can provide a more comprehensive picture of differences in the effects of monetary policy over the course of a crisis. An expansionary monetary policy shock has large and very quick positive effects on output and inflation during the acute phase of a financial crisis. On the other hand, during the recovery phase of a financial crisis the effects of monetary policy shocks occur at longer lags and have rather small effects on output and inflation, while the effects of financial variables are sizable. Finally, we find heterogeneity across countries with respect to the size and the timing of monetary policy actions during the global financial crisis. In the United States, monetary policy was eased quickly in 2008, mitigating the biggest drop in GDP at the end of 2008 and the beginning of 2009. By contrast, interest rates in the euro area were lowered about one year later, so that monetary policy shocks in many member states appear to have been contractionary in 2008 through the lens of our model and not to have mitigated the drop in GDP, as we show using counterfactual simulations. Euro-area monetary policy shocks became expansionary only at a later stage for most member states, in particular during the second recession in 2012/13, thus likely contributing to the final recovery.

We carefully check whether our results are affected by the zero lower bound and by unconventional monetary policies that have become relevant during the global financial crisis of 2008/09. In an alternative specification, we use estimated shadow interest rates from Wu and Xia (2016) to account for the zero lower bound and the effects of unconventional monetary policy for the United States, the United Kingdom, and the euro area. We also apply a more deterministic approach by excluding all observations in which the three-month interest rate is lower than 30 basis points.

Our finding that the effects of monetary policy are strong during financial crises and in particular during the acute phase, but less so in the recovery phase, are in line with findings of related empirical studies. Ciccarelli, Maddaloni, and Peydró (2013) analyze the effects of monetary policy in the euro area. They extend the end of their sample recursively from 2007 until 2011 and find, in line with our results, that monetary policy became more effective at stimulating economic activity during the global financial crisis, mainly via the credit channel. Dahlhaus (2017) focuses on the United States and finds that monetary policy is more effective in stimulating the economy during a high financial stress regime. By contrast, Bech, Gambacorta, and Kharroubi (2014) focus on the recovery period of financial crises by studying the effects of the monetary policy stance during recession episodes on the strength of the subsequent recovery for a panel of twenty-four advanced economies. They find that monetary policy is not very effective in stimulating GDP growth during the recovery phase of a financial crisis.[2]

[2]Other studies on monetary policy transmission during financial crises have focused on the effects of unconventional monetary policy (see, e.g., Gambacorta, Hofmann, and Peersman 2014 for a panel analysis or Williams 2014 for a survey). However, it is not possible to conclude whether monetary policy is more or less effective during financial crises compared with non-crisis times based on

The remainder of the paper is organized as follows. Section 2 describes the data set. Section 3 explains the econometric methodology. Section 4 presents and discusses the estimation results including various robustness checks. Finally, section 5 concludes.

2. Data

We first describe the panel data set of the endogenous variables for the PVAR and then our identification of financial crisis episodes, as well as the two phases of financial crises.

2.1 Data on Endogenous Variables

Our panel data set covers twenty advanced economies.[3] We use quarterly data for the period from the first quarter of 1984 to the fourth quarter of 2016, which provides us with a total of 2,640 observations.[4] Our baseline PVAR includes nine variables: real GDP, CPI, real house prices, the short-term interest rate, bank credit to the private non-financial sector, the effective exchange rate, consumer confidence, share prices, and stock price volatility.

GDP, CPI, three-month interest rates, effective exchange rates, and share prices data are taken from the OECD.[5] For the eleven countries in our sample that are members of the euro area, the aggregate euro-area three-month interest rates are used from 1999 onwards (from 2001 onwards in the case of Greece), accounting for their common monetary policy. Real house prices data come from

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these studies because of the limited comparability of shocks to unconventional and conventional monetary policy measures.

[3]These are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

[4]The year 1984 was also chosen in previous studies that used panel models similar to ours (see, e.g., Sá, Towbin, and Wieladek 2014). Moreover, some of the endogenous variables, such as consumer confidence, are not available for several countries for longer samples. Starting our sample in 1970 instead of 1984 would only have added one financial crisis to our sample, i.e., the crisis in Spain between 1977 and 1981. Indeed, our results are robust when we estimate a model without consumer confidence from 1970 to 2016.

[5]Table A1 in the online appendix (available at http://www.ijcb.org) provides an overview of our data set and our data sources.

the International House Price Database from the Federal Reserve Bank of Dallas. Data for bank credit to the private non-financial sector are taken from the Bank for International Settlements. The consumer confidence measure is based on survey data and is obtained from various national sources via Thomson Financial Datastream. For example, for economies in the European Union, data stem from the Business and Consumer Surveys of the European Commission. Consumer confidence data are standardized to ensure an identical scale across countries. Finally, we follow Bloom (2009) and Cesa-Bianchi, Pesaran, and Rebucci (2018) and use stock market volatility as a measure of uncertainty. We calculate this measure as the average realized volatilities of daily stock returns for each quarter. The stock market indicators used represent the major stock indexes in each country and are obtained from Thomson Financial Datastream. We take logs of all variables except interest rates and consumer confidence indexes. Data not available in seasonally adjusted form are adjusted using a stable seasonal filter.

2.2 Financial Crises

We use the systematic banking crises identified by Laeven and Valencia (2013) to date financial crises. The data set is provided in annual frequency for the period from 1970 to 2011 for the twenty economies in our panel. Laeven and Valencia (2013) define the starting year of a banking crisis as when the two following criteria are met in the same year for the first time:

(i) Significant signs of financial distress in the banking system (as indicated by significant bank runs, losses in the banking system, and/or bank liquidations).

(ii) Significant banking policy intervention measures in response to significant losses in the banking system.

They consider the first criterion as a necessary and sufficient condition for a banking crisis. The second criterion is added as an indirect measure because financial distress is often difficult to quantify. They define the end of a banking crisis as the year before both real GDP growth and real credit growth remain positive for at least two consecutive years. In addition, they truncate financial crises after a maximum duration of five years.

We make two adjustments to the data set of Laeven and Valencia (2013) in order to make it applicable for our analysis. First, we transform their annual data set to a quarterly frequency. We follow the simplest and least restrictive approach and assume that a financial crisis begins in the first quarter of its first year and ends in the last quarter of its last year.[6] Second, the data set of Laeven and Valencia (2013) only covers up to 2011 and does not include the end of some of the financial crises that started in 2008. Therefore, we extend the database until the year 2016. We use the same criteria as Laeven and Valencia (2013) to define the end of financial crises, based on real GDP and credit data and a maximum duration of financial crises of five years.[7]

On the basis of this data set, we construct a financial crisis dummy $D_{i,t}$, which takes a value of one when there is a financial crisis in country i at period t, and a value of zero otherwise. In our main analysis, we distinguish between two regimes on the basis of this dummy: financial crises and normal times.

In an extended analysis, we further distinguish between an acute and a recovery phase of a financial crisis. We understand the acute phase of a financial crisis as a period during which the immediate impact of the crisis on the economy is most noticeable, e.g., via high volatility and weak economic activity. The recovery phase is understood as the period when this immediate impact of the crisis has largely disappeared but the legacy of the crisis may still impact the economy, e.g., via balance sheet adjustments. As there is no single indicator available that allows for a sharp distinction

[6] As shown in the online appendix, results are very similar when using a more restrictive approach for the transformation to the quarterly frequency, where financial crises are set to begin in the fourth quarter of their first year and end in the first quarter of the last year.

[7] We make one exception to the truncation scheme of Laeven and Valencia (2013). In seven countries in our sample, the recession which began during the financial crisis in 2008 was still ongoing for some quarters in 2013. In these countries, we assume that the financial crisis ends together with the recession in 2013 instead of truncating it at the end of 2012. This extension only affects twelve quarterly observations in total and does not drive our results, but it assures a more consistent treatment of recessions that arise during financial crises, as opposed to normal recessions.

Table 1. Summary Statistics: Financial Crisis and Recession Episodes

	Quarters	Share	Episodes	Average Length (Quarters)
Financial Crises				
Total	367	14%	20	18
Acute Phase (FC + Recession)	190	7%	30	6
Recovery Phase (FC + Expansion)	177	7%	34	5
Normal Times				
Total	2,273	86%		
Recession	196	7%	56	4
Expansion	2,077	79%		

Note: The table shows data for 2,640 total observations over twenty countries between 1984:Q1 and 2016:Q4.

between these two phases, we follow the literature on asymmetric effects of monetary policy over the business cycle and use business cycle phases to distinguish between acute phases and recovery phases of financial crises. For this purpose, we use the Harding and Pagan (2002) version of the Bry-Boschan algorithm, which is the most frequently applied business cycle dating algorithm in the literature, to define—similarly to the financial crisis dummy indicator—a recession dummy.[8] Based on the financial crisis dummy and the recession dummy, we define four regimes: the acute phase of a financial crisis (financial crisis and recession), the recovery phase of a financial crisis (financial crisis and expansion), and recessions and expansions in normal times.

Table 1 shows some summary statistics regarding the number of observations, and the length and frequency of financial crisis

[8]This algorithm identifies local peaks and troughs in real GDP and defines a recession as the period from the peak to the trough and an expansion as the period from trough to peak.

episodes. There are twenty financial crisis episodes in our sample. With an average length of eighteen quarters, financial crises are rather persistent. The episodes cover 367 quarters in the sample and thus about 14 percent of the total 2,640 observations. In addition, there are eighty-six recession episodes in the sample, of which thirty occur during financial crises and fifty-six during normal times. Recession episodes are much less persistent than financial crises, with an average length of six quarters when they occur during a financial crisis and a length of four quarters in normal times. Within financial crisis episodes, there is a roughly similar number of acute and recovery episodes of a length of five to six quarters, as about half of the financial crisis quarters are recessionary. All twenty financial crisis episodes are accompanied by at least one recession, which usually occurs at the beginning of a financial crisis. However, in some cases—in particular, during the global financial crisis that started in 2007—two separate recessions occurred during the financial crisis, with a recovery phase in between.

In terms of the regional distribution, two financial crises occurred in Sweden and the United States, no financial crises occurred in Australia and Canada, whereas each of the other economies experienced one financial crisis. The number of recessions per economy ranges from two (Canada, Australia, Netherlands, and Ireland) to seven (Greece). Our sample of financial crises is dominated by the global financial crisis that started in 2007, as fifteen out of twenty financial crises took place in this period. Apart from that, one financial crisis occurred in the United States during 1988; three during the early 1990s in Finland, Norway, and Sweden; and one in Japan around the year 2000.

3. Methodology

We base our empirical model on the Bayesian interacted PVAR methodology developed in Sá, Towbin, and Wieladek (2014), which extends the model of Towbin and Weber (2013) using cross-country heterogeneous coefficients. The model exploits the cross-country dimension of the data, accounts for the dynamics between the main macroeconomic variables, and allows for interactions between macroeconomic variables and exogenous terms, i.e., financial crisis and recession dummy variables in our study.

3.1 Interacted PVAR Model

We start by describing the simple PVAR model without interaction terms.[9] The PVAR in structural form is given by

$$J_i Y_{i,t} = \tilde{A}_{i,0} + \sum_{k=1}^{L} \tilde{A}_{i,k} Y_{i,t-k} + \tilde{u}_{i,t}, \tag{1}$$

where $t = 1, \ldots, T$ denotes time, $i = 1, \ldots, N$ denotes the country, $Y_{i,t}$ is a $q \times 1$ vector of endogenous variables, $\tilde{A}_{i,0}$ is a vector of country-specific intercepts, and $\tilde{A}_{i,k}$ is a $q \times q$ matrix of autoregressive coefficients up to lag L.[10] The $q \times q$ matrix of contemporaneous effects J_i is lower triangular with a vector of ones on the main diagonal. The $q \times 1$ vector of structural residuals $\tilde{u}_{i,t}$ is assumed to be normally distributed with a mean of zero and with a diagonal $q \times q$ covariance matrix $\tilde{\Sigma}$.

We follow Sá, Towbin, and Wieladek (2014) by allowing for heterogeneous intercepts $\tilde{A}_{i,0}$ and heterogeneous slope parameters $\tilde{A}_{i,k}$ across countries. Moreover, we also allow the parameters of the contemporaneous coefficients matrix J_i to vary across countries by estimating the model recursively, i.e., directly in its structural form. Country-specific coefficients result from adding dummy variables for each country into the model. In order to compute the average effect over countries, we assign the value of $1/N$ to each of the country-specific dummies. For the PVAR without interaction terms, this approach is equivalent to the mean group estimator of Pesaran and

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[9] PVARs have been used in various empirical analyses of monetary policy to improve the precision of the estimation and to detect common country dynamics. For example, see Assenmacher-Wesche and Gerlach (2008), Goodhart and Hofmann (2008), Carstensen, Hülsewig, and Wollmershäuser (2009), Calza, Monacelli, and Stracca (2013), and Gambacorta, Hofmann, and Peersman (2014).

[10] We assume that there are no dynamic interdependencies across countries, i.e., the endogenous variables of country i are not affected by other countries' variables and residuals are uncorrelated across countries. This can be a rather strong assumption in a cross-country framework, but it drastically reduces the number of parameters that need to be estimated, and thus it is used frequently in PVAR applications.

Smith (1995) and it gives consistent estimates for dynamic panels in the presence of cross-country heterogeneity.[11]

The PVAR is then augmented with interactions between the endogenous variables and an exogenous indicator variable. The structural interacted PVAR (IPVAR) model with a single interaction term is given by

$$J_{i,t}Y_{i,t} = \tilde{A}_{i,0} + \sum_{k=1}^{L} \tilde{A}_{i,k}Y_{i,t-k} + \tilde{B}_0 D_{i,t} + \sum_{k=1}^{L} \tilde{B}_k D_{i,t} Y_{i,t-k} + \tilde{u}_{i,t}, \tag{2}$$

$$J_{i,t}(w,q) = J_i(w,q) + J(w,q)D_{i,t}, \tag{3}$$

where $\tilde{A}_{i,0}$, $\tilde{A}_{i,k}$, and $\tilde{u}_{i,t}$ are defined as in equation (1). $D_{i,t}$ is the financial crisis dummy variable, which takes a value of one if there is a financial crisis in country i during period t, and a value of zero otherwise. $\tilde{B}_0$ are intercepts and $\tilde{B}_k$ is a $q \times q$ matrix of autoregressive coefficients up to lag L, which correspond to the financial crisis regime, respectively. The matrix of contemporaneous coefficients $J_{i,t}$ is again lower triangular with a vector of ones on the main diagonal.

The coefficients that capture the dynamics in normal times, $\tilde{A}_{i,0}$ and $\tilde{A}_{i,k}$, remain country specific through the addition of country dummies. By contrast, the coefficients that capture changes in the dynamics during financial crises, $\tilde{B}_0$ and $\tilde{B}_k$, are assumed to be homogeneous across countries. We make a similar assumption for the contemporaneous coefficients $J_{i,t}$. Equation (3) shows that each lower triangular element (w, q) of $J_{i,t}$—where w indicates the row, q indicates the column, and $q < w$—comprises a country-specific part, $J_i(w, q)$, for the non-crisis regime and a regime-specific part, $J(w, q)D_{i,t}$, which does not vary across countries.

[11]Pesaran and Smith (1995) estimate separate VAR models for each country and then calculate averages over the estimated coefficients, whereas Sá, Towbin, and Wieladek (2014) introduce cross-country heterogeneity by augmenting parameters with country dummies. The latter approach allows the combination of cross-country heterogeneous coefficients and country-invariant interaction terms in the interacted PVAR model.

Pre-multiplying the recursive-form IPVAR in equation (2) with $J_{i,t}^{-1}$ yields the reduced-form version of the model:

$$Y_{i,t} = A_{i,0} + \sum_{k=1}^{L} A_{i,k} Y_{i,t-k} + B_{i,0} D_{i,t} + \sum_{k=1}^{L} B_{i,k} D_{i,t} Y_{i,t-k} + u_{i,t}, \tag{4}$$

with the reduced-form coefficient matrices defined as, e.g., $A_{i,0} = J_{i,t}^{-1} \tilde{A}_{i,0}$. Note that the reduced-form coefficients corresponding to the financial crisis regime, $B_{i,0} = J_{i,t}^{-1} \tilde{B}_0$ and $B_{i,k} = J_{i,t}^{-1} \tilde{B}_k$, as well as the residuals $u_{i,t} = J_{i,t}^{-1} \tilde{u}_{i,t}$ and their covariance matrix $\Sigma_{i,t} = J_{i,t}^{-1} \tilde{\Sigma} (J_{i,t}^{-1})'$, will also vary across countries and regimes due to the variation in $J_{i,t}$. Thus, estimating the model recursively across different regimes allows for heteroskedasticity of residuals and for country- and regime-specific contemporaneous correlations.

Using the above approach, we exploit the panel structure of our data and address the problem of the small number of financial crisis observations per country. In addition, we allow for as much cross-country heterogeneity as possible and we assume that only the recursive-form coefficients that capture the dynamics during financial crises are homogeneous across countries. By contrast, the reduced-form coefficients in financial crises vary across countries via country-specific contemporaneous effects.[12] In this, our approach allows for more cross-country heterogeneity than a fixed-effect estimator does and therefore provides estimates that are less likely to suffer from inconsistency.[13] At the same time, the use of country

[12] Georgiadis (2014) shows that the heterogeneity of monetary policy transmission is quite large across advanced economies and it can be explained mainly by differences in the financial structure, labor market rigidities, and the industry mix.

[13] When we estimate the IPVAR with fixed effects (i.e., only allowing for country-specific intercepts), the impulse responses to a monetary policy shock are highly persistent and the responses of CPI exhibit signs of the price puzzle. This may be attributable to the fixed-effects estimator being biased in dynamic panels when the time dimension is small (Nickell 1981) as well as when the time dimension is large, but the coefficients of lagged endogenous variables are heterogeneous across countries (Pesaran and Smith 1995). The pooled mean group estimator used by Pesaran and Smith (1995) is only biased if the time dimension is small. In our case, $T = 120$, so the bias from this source should be

dummies to allow for cross-country heterogeneity is more flexible than the mean group estimator of Pesaran and Smith (1995). It allows us to combine country-specific and pooled effects within a PVAR when facing a tradeoff between heterogeneity in the data and the aim of pooling information across countries in order to increase the precision of estimated parameters.

The impulse responses of endogenous variables to a monetary policy shock can be computed from the reduced form of the VAR and the identified structural monetary policy shocks. In the IPVAR model, the impulse responses depend on the values of the interaction terms, and thus on the regime. We assume that the economies remain in the regime that prevailed when the monetary policy shock occurred. Thereby, we follow most previous studies that analyze asymmetries in monetary policy transmission during recessions and expansions and during periods of high financial stress using VAR methods.[14]

In the second part of the analysis, we extend model (2) to distinguish between four regimes. For this purpose, we define $D_{i,t}$ not as a single dummy variable but as a vector of three dummy variables, $D_{i,t} = [D_{i,t}^{FC}, D_{i,t}^{R}, D_{i,t}^{FCR}]$, where $D_{i,t}^{FC}$ is the financial crisis dummy, $D_{i,t}^{R}$ is the recession dummy, and $D_{i,t}^{FCR} = D_{i,t}^{FC} * D_{i,t}^{R}$ is the interaction term between the first two dummies, taking a value of one when there is a financial crisis *and* a recession in country i at time t, and zero otherwise. These dummies allow us two distinguish between the following regimes:

- $D_{i,t}^{FC} = 1$, $D_{i,t}^{R} = 1$, $D_{i,t}^{FCR} = 1$: acute phase of a financial crisis (crisis and recession),

negligible. The introduction of interaction terms that are assumed to be homogeneous across countries introduces some bias to the extent that the homogeneity assumption is violated by the data. However, we consider our setup as a good solution to the tradeoff between minimizing bias and enabling the estimation of financial crisis effects.

[14]An exception is Fry-McKibbin and Zheng (2016), who calculate regime-independent, non-linear impulse responses in a threshold VAR model for the United States. They find that only large monetary policy shocks of two standard deviations or more are able to endogenously move the economy from a low to a high financial stress regime or vice versa, while small shocks do not increase the probability of regime switches. Hence, imposing the regimes exogenously rather than allowing for regime switches in response to monetary policy shocks does not seem to be a very restrictive assumption.

- $D_{i,t}^{FC} = 1$, $D_{i,t}^{R} = 0$, $D_{i,t}^{FCR} = 0$: recovery phase of a financial crisis (crisis, no recession),
- $D_{i,t}^{FC} = 0$, $D_{i,t}^{R} = 1$, $D_{i,t}^{FCR} = 0$: normal recession (no crisis, recession),
- $D_{i,t}^{FC} = 0$, $D_{i,t}^{R} = 0$, $D_{i,t}^{FCR} = 0$: normal expansion (no crisis, expansion).

3.2 Estimation and Inference

We follow Uhlig (2005) and Sá, Towbin, and Wieladek (2014) and estimate the model with Bayesian methods. As argued by Uhlig (2005), the Bayesian approach has the advantage that it is computationally simple and that it allows us to draw error bands for impulse responses and variance decompositions using Monte Carlo simulations. At the same time we use a flat prior, which does not impose any shrinkage on the parameters. The only additional prior information we incorporate is that of a stable VAR, as we discard explosive draws.

In particular, we apply a conjugate normal-Wishart prior which allows us to obtain joint draws from the posterior distribution by direct Monte Carlo sampling of all recursive-form parameters (Uhlig 1994, 2005; Koop and Korobilis 2010; Del Negro and Schorfheide 2011). The normal-Wishart distribution specifies that Σ^{-1} follows a Wishart distribution $\mathcal{W}_m(S^{-1}/\nu, \nu)$, where S is the mean covariance matrix and ν are the degrees of freedom describing the uncertainty about $(\mathbf{B}, \Sigma)$ around the mean coefficients $(\bar{B}, S)$. Conditionally on Σ, the matrix of vectorized recursive coefficients $vec(\mathbf{B})$ follows a normal distribution $\mathcal{N}(vec(\bar{B}), \Sigma \otimes K^{-1})$, where $\bar{B}$ is an $l \times m$ dimensional matrix of mean coefficients and K is an $l \times l$ positive definite matrix.

The normal-Wishart posterior has a closed-form solution. As we use a flat prior, the posterior mean of the normal distribution corresponds to the maximum-likelihood estimator of the recursive coefficient matrix $\hat{B}$, and the posterior covariance matrix corresponds to $\hat{S}$, i.e., the sum of squared residuals from the maximum-likelihood estimation of equation (2). The number of degrees of freedom is set to equal the number of observations over time and countries (excluding missing values). We choose two lags in the baseline IPVAR specification according to the Akaike information criterion.[15]

For each draw from the posterior, we evaluate the interaction terms $D_{i,t}$ at their values of interest. We then compute the reduced-form parameters according to equation (4) by pre-multiplying the structural parameters with the inverted lower-diagonal matrix of contemporaneous coefficients, $J_{i,t}^{-1}$, and we calculate the impulse responses for each regime. Here, we impose the additional prior that responses are non-explosive, as in Uhlig (1994) and Cogley and Sargent (2005), i.e., we discard draws that lead to explosive parameters. We continue drawing from the posterior until we have 1,000 non-explosive draws, which we use to compute the median and 90 percent probability bands.

3.3 Identification of Monetary Policy Shocks

We estimate the interacted PVAR in its recursive form. Hence, monetary policy shocks are identified implicitly by the ordering of the variables in the VAR. We order GDP, CPI, and house prices before the short-term interest rate and we assume that these variables do not react to a monetary policy shock on impact. This assumption has been employed in a large number of VAR studies and agrees with the theoretical predictions from DSGE models, i.e., a delayed response of output and prices to monetary policy. We order banks' credit to the private sector, the exchange rate, consumer confidence, share prices, and stock market volatility after the interest rate, and thus allow these variables to react to monetary policy shocks on impact. This is consistent with the view that financial market variables or variables of market confidence are less rigid, so they can react to monetary policy shocks contemporaneously. Nonetheless, our results are robust when we choose alternative orderings, such as ordering house prices after the interest rate or ordering banks' credit to the private sector and consumer confidence before the interest rate.

As a robustness check, we also identify monetary policy shocks using the sign-restrictions approach developed in Canova and De Nicoló (2002) and Uhlig (2005), which was applied in a PVAR

[15] Two lags are also used in comparable PVAR models; see Calza, Monacelli, and Stracca (2013) and Sá, Towbin, and Wieladek (2014).

context in Carstensen, Hülsewig, and Wollmerhäuser (2009), Gambacorta, Hofmann, and Peersman (2014), and Sá, Towbin, and Wieladek (2014). This approach has the advantage that identification is independent of the ordering in the VAR and no zero contemporaneous restrictions need to be imposed. Instead, the sign of the impulse responses of a subset of endogenous variables is restricted in line with theoretical predictions. However, the latter can also be restrictive, particularly in the analysis of financial crises, when the economy might behave very differently from the predictions of standard theoretical models. We only restrict the impulse response of the short-term interest rate to be negative during the first four quarters and the response of CPI to being positive between the second and fourth quarter, whereas we remain agnostic about the responses of GDP and the other variables in the VAR.

4. Results

In this section, we describe our results for the baseline model that differentiates between financial crises and normal times, followed by the results of the extended model, where we distinguish between the acute and the recovery phases of financial crises. Subsequently, we discuss our results in light of related empirical and theoretical findings of the literature, and we provide some robustness checks.

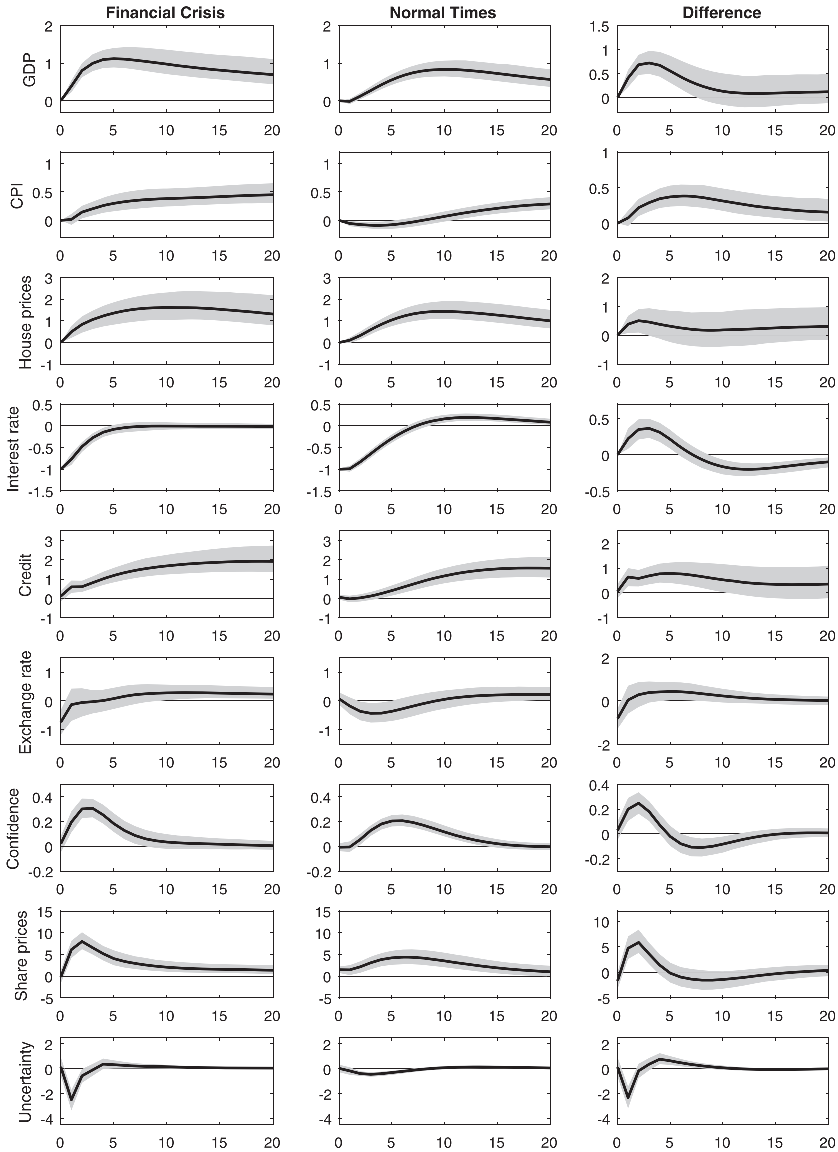
4.1 Monetary Policy Transmission in Financial Crisis and Normal Times

We analyze differences in monetary policy transmission during financial crises and normal times based on an impulse response analysis, a forecast error variance decomposition, plots of identified monetary policy shocks, and a counterfactual scenario that shows trajectories of macroeconomic variables during financial crises based on the assumption of a constant interest rate.

4.1.1 Panel Impulse Response Analysis

Figure 1 shows the impulse responses and the 90 percent probability bands to a 1 percentage point expansionary monetary policy shock in the baseline model. The first column shows the effects of

Figure 1. Effects of a Monetary Policy Shock during Financial Crises and Normal Times



Notes: Median impulse responses to a 100 basis point expansionary monetary policy shock together with 90 percent probability bands, in percent. For each draw from the posterior, impulse responses are computed for the different regimes. Column 3 shows median differences between the two regimes and the corresponding probability bands in percentage points.

a monetary policy shock during financial crises, the second column shows the effects during normal times, and the third column shows the difference between the two. All impulse responses correspond to average effects across all twenty countries in our sample.

During normal times, our results for output and prices are in line with the results of previous empirical studies (see, e.g., Christiano, Eichenbaum, and Evans 1999). The response of output is hump shaped and is faster than the response of prices, which start increasing after about two years. Monetary policy shocks have permanent effects on the price level, whereas the effect on output returns to zero in the long run.

However, during financial crises the responses of output and prices are significantly stronger and occur faster. Within the first two years after an expansionary monetary policy shock, the response of output is up to 0.8 percentage point higher compared with normal times; subsequently, there is no significant difference between the two regimes. Prices increase within the first few quarters after the shock during financial crises. The differences in the responses between the regimes are rather persistent: over the entire horizon, the increase in prices is about 0.3 percentage point higher than that during normal times. The impulse responses of the interest rate shows that the larger effects of monetary policy shocks on output and prices during financial crises are not driven by differences in the systematic part of monetary policy: in financial crises, an expansionary monetary policy shock has a less persistent effect on the interest rate during the first two years.

We also find significant differences between the two regimes for most of the other variables. After a monetary policy shock, credit increases more instantaneously and, for about two years, significantly stronger during financial crises. Similar patterns are observed for the other variables, but differences between the responses in the two regimes are rather short-lived, lasting for up to one year. Uncertainty exhibits a marked decline of up to 2.5 percent after an expansionary monetary policy shock during financial crises, whereas it barely reacts during normal times. Share prices increase by up to 6 percentage points stronger in financial crises. Consumer confidence also increases stronger, but the effect returns to zero faster than in normal times. House prices and the exchange rate react slightly stronger during financial crises for the first two quarters after

Table 2. Forecast Error Variance Explained by the Monetary Policy Shock, Two Regimes

	Financial Crisis		
	One Year	**Two Years**	**Five Years**
GDP	22.9 (14.6, 32.6)	35.1 (24.9, 46.5)	39.9 (30.6, 53.8)
CPI	6.6 (2.7, 13.3)	15.7 (7.6, 26.7)	33.4 (21.0, 47.2)
House Prices	7.3 (3.5, 14.0)	18.1 (9.5, 28.5)	29.5 (16.9, 42.1)
Interest Rates	70.8 (61.2, 78.0)	59.6 (51.2, 69.6)	52.7 (44.2, 63.6)
Credit	11.2 (4.1, 19.9)	24.1 (11.8, 33.7)	42.4 (29.6, 55.5)
Exchange Rate	2.3 (0.7, 6.5)	2.7 (0.9, 8.5)	4.0 (1.7, 11.2)
Confidence	22.0 (15.1, 30.3)	22.9 (15.9, 29.5)	21.8 (15.0, 28.6)
Share Prices	25.3 (15.8, 34.2)	27.9 (18.8, 38.6)	28.4 (20.0, 39.1)
Uncertainty	14.0 (8.1, 22.2)	13.9 (7.9, 22.5)	14.1 (8.3, 22.5)
	Normal Times		
	One Year	**Two Years**	**Five Years**
GDP	4.1 (1.5, 8.2)	16.0 (7.6, 26.1)	28.0 (14.6, 39.0)
CPI	0.4 (0.0, 2.4)	0.8 (0.3, 3.0)	11.1 (4.8, 21.5)
House Prices	5.5 (2.3, 9.3)	15.4 (7.9, 24.1)	26.4 (14.7, 37.2)
Interest Rates	85.7 (80.1, 89.9)	74.8 (65.8, 81.0)	69.1 (60.0, 74.8)
Credit	1.1 (0.3, 2.7)	7.8 (2.0, 14.5)	25.8 (13.1, 37.2)
Exchange Rate	1.0 (0.1, 3.9)	1.8 (0.2, 7.8)	2.9 (0.9, 8.7)
Confidence	9.2 (5.2, 15.4)	20.6 (12.8, 30.6)	21.6 (13.0, 32.5)
Share Prices	2.9 (0.7, 7.7)	7.8 (2.4, 17.9)	12.2 (3.9, 24.5)
Uncertainty	2.5 (0.9, 5.3)	3.1 (1.4, 6.8)	3.6 (1.7, 7.9)

Notes: Median share of the forecast error variance explained by the monetary policy shock, in percent. The sixteenth and eighty-fourth credibility sets are shown in parentheses.

the shock, but differences between the regimes turn insignificant thereafter.

Our main finding that the effects of monetary policy shocks are larger during financial crises is reflected in the forecast error variance decompositions shown in table 2. Our results for normal times are in line with the common finding in the literature that monetary policy shocks explain only relatively small fractions of forecast errors of output and inflation (see, e.g., Bernanke, Boivin, and Eliasz 2005; Coibion 2012). However, during financial crises this fraction is considerably higher for output and prices, and the differences between the regimes are particularly pronounced at low horizons. For example, the monetary policy shock explains about 4 percent of the forecast error of output at the one-year horizon during normal times, but more than 20 percent in the financial crisis regime. For prices, the shares of forecast errors explained by monetary policy shocks in normal times are still close to zero at the one- and two-year horizons and only increase at higher horizons, while during financial crises the share is at above 6 percent at the one-year horizon. Also for all other variables—most notably credit, share prices, uncertainty, and confidence—the monetary policy shock explains considerably larger fractions of the total forecast error, particularly at low horizons, in the financial crisis regime compared with normal times.

4.1.2 Cross-Country Heterogeneity

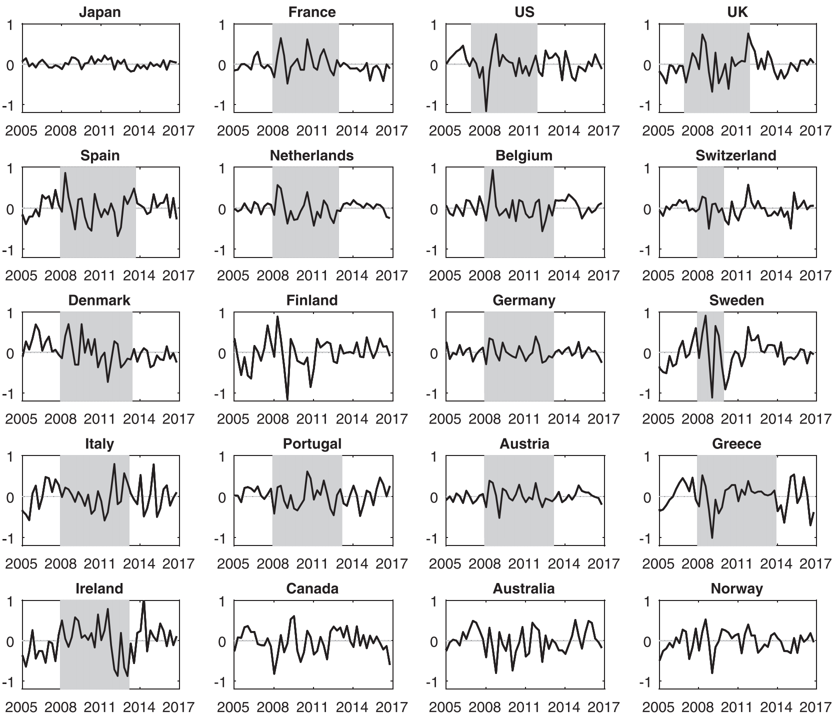
The results presented until now refer to the average effects across twenty economies. However, to the extent that monetary policy reacted differently during financial crisis episodes in individual countries—for instance, by intervening more or less aggressively or at different points in time—cross-country heterogeneity can be important and potentially helpful for the interpretation of the results. We therefore show the series of the identified monetary policy shocks for individual countries in order to assess whether and to what extent monetary policy surprises were expansionary or contractionary during financial crisis episodes. Further, for selected countries, we compute counterfactual paths of the endogenous variables under the assumption of a constant interest rate over financial crisis episodes and compare them with actually observed paths.[16]

Figure 2 shows the identified monetary policy shocks for each of the twenty countries in the sample.[17] We restrict the plots to the

[16]In principle, the PVAR model also allows us to compute impulse responses on a country-by-country basis, as the reduced-form coefficients in the model vary across countries. However, such results are subject to instability and a high degree of estimation uncertainty due to the very low number of observations per country during financial crises.

[17]While all euro-area member states in the sample were subject to a common monetary policy and thus similar short-term interest rate paths since 1999, the PVAR model estimates separate interest equations for each country. We can interpret the identified monetary policy shocks in the individual euro-area countries

Figure 2. Estimated Monetary Policy Shocks: 2005–17



Notes: Residuals corresponding to the interest rate equation of each country from the structural form of the IPVAR of equation (2). Gray bars show the financial crisis episodes for each country.

2005–17 subperiod to focus on cross-country differences during the global financial crisis and its aftermath. The shock series are by their nature quite volatile, typically exhibiting alternating expansionary and contractionary movements. They add up to zero for each country over the total sample period, but can deviate from zero during subperiods, and thus also during financial crisis episodes.

as country-specific monetary policy surprises, given the economic conditions of each country according to the model. This is in line with Barigozzi, Conti, and Luciani (2014) and Corsetti, Duarte, and Mann (2018), who show that euro-area monetary policy shocks transmit heterogeneously across member states.

The United States exhibits the largest expansionary shock directly at the beginning of the financial crisis, and it took some time until that expansionary movement was followed by a contraction, which was likely related to the zero lower bound. The United Kingdom shows a similar pattern, although the respective shocks were much smaller. By contrast, monetary policy shocks were contractionary for most euro-area member states at the onset of the global financial crisis, reflecting the delayed reduction in common euro-area interest rates compared with the United States. Given the large effects of monetary policy shocks during financial crises documented above, these differences in the direction of monetary policy surprises may have partially contributed to the differences in macroeconomic performance between the United States, the United Kingdom, and the euro area. While the United States was the epicenter of the global financial crisis, there was only one recession in 2008 and 2009 associated with this crisis. The global financial crisis spread to Europe, causing a recession of similar length in the euro area and the United Kingdom as in the United States, but then the euro area fell into a longer second recession related to the European sovereign debt crisis in 2011 that lasted for two years, while there was no such second recession in the United States and the United Kingdom. During that time, the monetary policy surprises became expansionary for most euro-area member economies, contributing to the final recovery.

Finally, we complement our analysis with a counterfactual exercise based on a constant interest rate scenario.[18] We compute a series of consecutive one-step-ahead forecasts on a country-by-country basis for the main macroeconomic variables in our model for specific financial crisis episodes, conditional on a predetermined counterfactual constant interest rate path for the short-term interest rate using the approach by Lütkepohl (2013).[19]

[18]Chen et al. (2016) apply similar counterfactual forecasts to evaluate the global effects of U.S. quantitative easing measures within a global vector autoregressive (GVAR) model. Giannone et al. (2012) use a similar counterfactual exercise to gauge the effects of non-standard monetary policy measures in the euro area by conditioning on different paths of interest rate spreads.

[19]We evaluate the PVAR model for each country individually. For each financial crisis episode in a particular country, we define the time period t^* as the quarter when the episode started. From that point in time onwards, we restrict

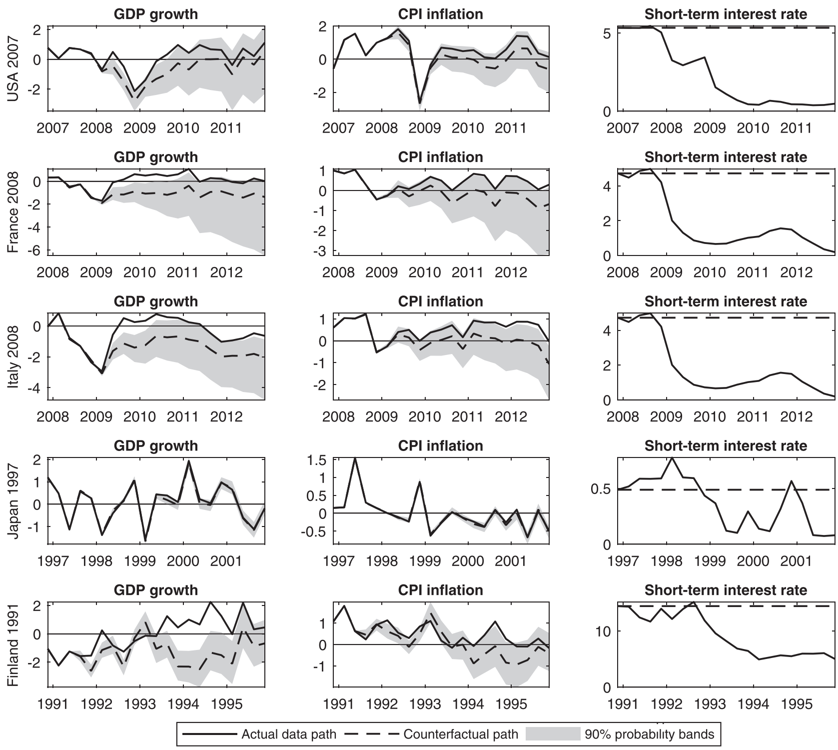
By comparing the counterfactual paths with the actual data, we can assess the effects of interest rate adjustments during financial crisis episodes. To the extent that monetary policy is in control of the short-term interest rate and that our model reflects the monetary policy reaction function of central banks, the counterfactual analysis provides information on changes in the interest rate due to the systematic monetary policy of central banks (according to their reaction function) as well as due to monetary policy shocks. However, the Lucas critique implies that endogenous relations between macroeconomic variables might change relative to our baseline model, as the interest rate path is now fixed instead of reacting endogenously. We thus interpret the results of this counterfactual exercise with caution.

Because a discussion of the results for all countries in our sample is beyond the scope of this exercise, we focus on five countries. We look at the United States and two euro-area economies (France and Italy) during the global financial crisis and also study two earlier more regionally bounded crises in Japan (1997–2001) and Finland (1991–95). Figure 3 presents the counterfactual paths (dashed lines) of the main variables for the years of the financial crisis episode in the respective country and 90 percent probability bands, together with the actual outcomes (solid lines) of the respective variables.

For the United States, we find that GDP growth and inflation are considerably lower in the counterfactual scenario of no change in the interest rate (interest rate remains at about 5 percent) compared with the actual paths. GDP growth (quarter-on-quarter) is 1 to 2 percentage points lower in this scenario from 2008 onwards, and inflation remains in negative territory for most of this period. The differences between the actual and the counterfactual paths are even larger in France and, in particular, in Italy from mid-2009 onwards. Hence, expansionary monetary policy, given its large effects during

the short-term interest rate of the respective country to remain unchanged at the level it assumed at time $t^* - 1$, i.e., $\{int_{i,t}\}_{t=t*}^{t=T} = int_{i,t^*-1}$, while all other variables in the VAR are endogenous. We then compute one-step-ahead forecasts of the endogenous variables $\tilde{y}_{i,t}^{t^*}$, given their values up to time $t^* - 1$ and the lagged value of the short-term interest rate. Further one-step-ahead conditional forecasts $\tilde{y}_{i,t}^{t^*+1}$ up to $\tilde{y}_{i,t}^{t^*+20}$ are computed on the basis of the previous forecasts and the exogenous interest rate path.

Figure 3. Counterfactual Paths for Selected Financial Crisis Episodes



Notes: Black solid lines show actual paths of the series during selected financial crisis episodes in the United States (financial crisis 2007–11), France and Italy (2008–12), Japan (1997–2001), and Finland (1991–95). Dashed lines show counterfactual paths based on consecutive one-step-ahead forecasts from the interacted PVAR model, starting from the first quarter of the financial crisis ($t = t^*$), where the short-term interest rate is held fixed for $t \geq t^*$, together with 90 percent probability bands.

financial crises as indicated by our model, may have helped to prevent a much longer recession. At the same time, differences in timing might have mattered. In the United States, the interest rate already decreased considerably in 2008, mitigating the adverse effects of the crisis on GDP during that time. By contrast, in France and Italy the decrease in the interest rate started only at the end of 2008, and the downturn of GDP in 2008 is therefore equally pronounced in the counterfactual scenario as in the actual data. An earlier cut in interest rates could have possibly mitigated the large drop in GDP in 2008 and the beginning of 2009 in particular, given that monetary policy transmits quickly and strongly to the economy according to our results.

The large effects of monetary policy hold not only for the recent global financial crisis but also for earlier financial crisis episodes, as shown for the example of Finland. On the other hand, for the Japanese crisis starting in 1997, there are basically no differences in GDP growth and inflation between the counterfactual and the actual data paths, most likely because the short-term interest rate was already close to zero at the beginning of the crisis, so there was little room for further interest rate cuts.

4.2 Acute and Recovery Phases of Financial Crises

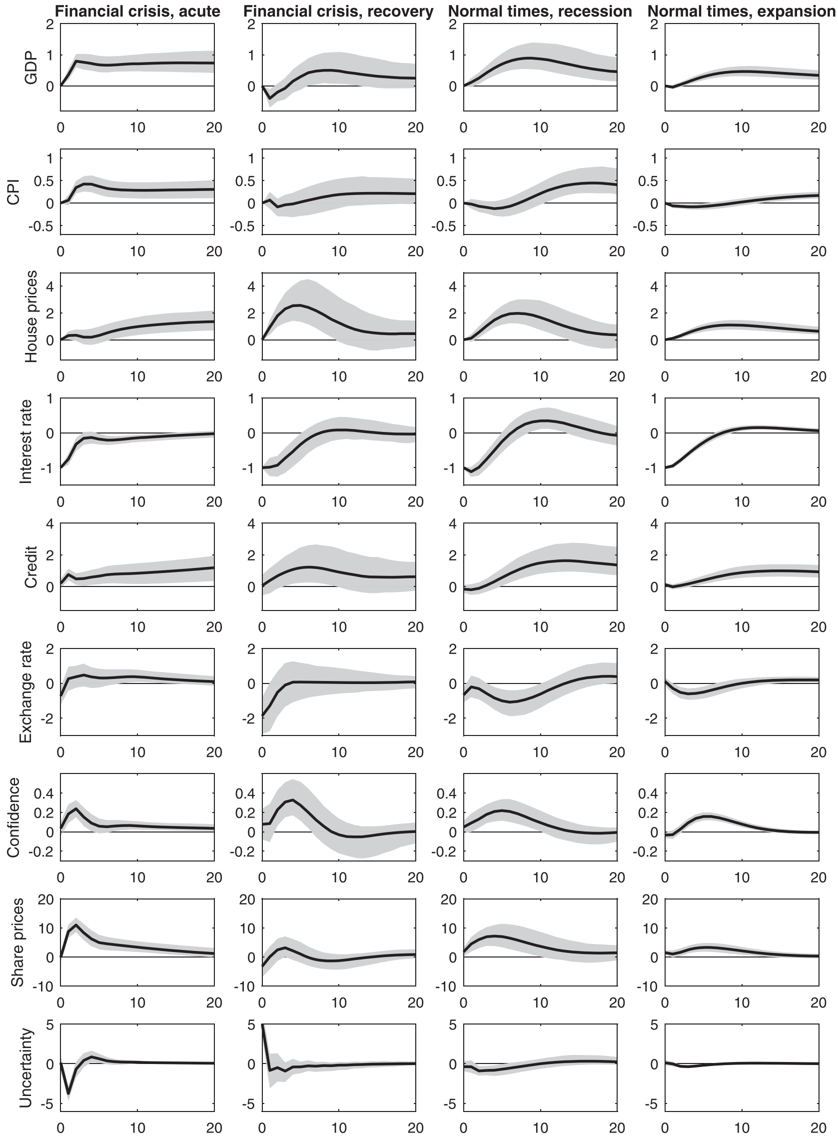
Figure 4 shows the impulse responses to an expansionary monetary policy shock in the model that differentiates between four regimes: acute phase of financial crises, recovery phase of financial crises, recessions in normal times, and expansions in normal times. The effects of monetary policy shocks differ between the different regimes, particularly between the acute and recovery phases of financial crises.

The effects of an expansionary monetary policy shock during the acute phase of a financial crisis are roughly similar to the results for financial crises in the model with two regimes: an expansionary monetary policy shock leads to a rapid and persistent increase in output and prices. Also, share prices increase while uncertainty decreases strongly in this regime.

By contrast, during the recovery phase of a financial crisis, a monetary policy shock has significantly lower and more-delayed effects on output and prices.[20] The effect on output becomes significantly positive only after about two years, according to the 90 percent probability bands. The response of prices becomes positive after two years, but is not significantly different from zero. Share prices

[20]Figure A2 in the online appendix illustrates the differences in the impulse response functions.

Figure 4. Effects of Monetary Policy Shocks in Four Regimes



Notes: Median impulse responses to a 100 basis point expansionary monetary policy shock together with 90 percent probability bands, in percent. For each draw from the posterior, impulse responses are computed for the different regimes.

increase only moderately and not significantly, while uncertainty even increases on impact before the effect dies out. On the other hand, house prices, credit, exchange rates, and consumer confidence respond more strongly to a monetary policy shock compared with the acute phase. Nonetheless, the strong responses of these financial variables apparently do not markedly transmit to the real economy, i.e., output and prices, during the recovery phase.

The responses during normal recessions and expansions both show similar dynamics and are comparable to those of the normal-times regime presented in figure 1, but the responses of most variables turn out stronger in recessions than in expansions.[21] The effects in both normal-times regimes set in with larger delays and are often smaller than those in the acute phase, while being in parts stronger and more significant than those in the recovery phase of financial crises.

These differences in the role of monetary policy shocks across regimes are largely reflected in the forecast error variance decompositions, presented in table 3. Again, we observe that monetary policy shocks typically explain a larger share of forecast error variance for horizons of up to two years during financial crises compared with normal times, but differences across subperiods emerge. During the acute phase of financial crises, monetary policy shocks explain large fractions of forecast error in GDP, consumer prices, confidence, uncertainty, and particularly share prices. The shares are higher at a one-year horizon than in all other regimes, reflecting our result that the effects of monetary policy shocks set in rapidly during the acute phase. During the recovery phase, monetary policy shocks explain high shares of forecast error variation in house prices, exchange rates, confidence, and uncertainty, but less so in real variables. In normal recessions, monetary policy shocks explain considerably higher shares of forecast error variances compared with normal expansions for most variables, but somewhat lower shares compared with financial crises.

[21] Weise (1999), Garcia and Schaller (2002), Peersman and Smets (2002), and Lo and Piger (2005) also find that monetary policy is more effective during recessions than expansions, whereas more recent studies by Caggiano, Castelnuovo, and Groshenny (2014) and Tenreyro and Thwaites (2016) find the opposite.

Table 3. Forecast Error Variance Explained by the Monetary Policy Shock, Four Regimes

	Financial Crisis			
	Acute Phase		Recovery Phase	
	One Year	Two Years	One Year	Two Years
GDP	19.3 (11.6, 28.9)	23.9 (14.1, 35.8)	5.8 (2.1, 14.8)	11.0 (4.3, 25.6)
CPI	11.8 (4.6, 21.7)	15.7 (5.0, 29.6)	2.0 (0.3, 9.5)	3.3 (0.6, 14.6)
House Prices	1.2 (0.1, 5.6)	3.7 (0.6, 12.5)	24.9 (9.3, 41.4)	34.0 (13.7, 55.6)
Interest Rates	55.2 (44.6, 65.4)	52.6 (42.7, 62.2)	82.3 (67.7, 90.7)	71.0 (54.8, 83.3)
Credit	6.5 (1.6, 15.5)	7.9 (1.3, 20.0)	8.3 (1.3, 26.1)	15.5 (2.2, 37.9)
Exchange Rate	4.2 (1.4, 10.0)	5.4 (1.8, 12.9)	15.0 (3.9, 32.7)	15.9 (4.3, 32.3)
Confidence	14.9 (6.6, 25.0)	15.9 (7.4, 25.9)	22.9 (9.2, 40.4)	26.8 (12.4, 44.9)
Share Prices	38.7 (29.0, 48.5)	41.6 (31.5, 51.0)	10.6 (2.8, 24.3)	11.8 (4.3, 25.7)
Uncertainty	19.7 (12.2, 27.7)	20.2 (12.6, 27.7)	37.6 (23, 51.2)	37.5 (23.2, 51.1)
	Normal Times			
	Recession		**Expansion**	
	One Year	**Two Years**	**One Year**	**Two Years**
GDP	8.7 (2.4, 18.5)	25.2 (10.3, 42.0)	1.2 (0.4, 2.9)	6.4 (2.8, 11.6)
CPI	1.4 (0.1, 6.3)	2.2 (0.4, 8.2)	1.2 (0.2, 3.2)	1.2 (0.2, 4.0)
House Prices	10.2 (3.8, 19.6)	26.7 (13.5, 42.9)	2.9 (1.1, 5.5)	9.3 (4.8, 14.9)
Interest Rates	72.7 (59.9, 82.7)	60.4 (46.6, 73.2)	85.2 (80.4, 89.4)	74.0 (66.9, 80.3)
Credit	1.8 (0.4, 6.0)	9.9 (2.5, 24.1)	0.6 (0.2, 2.4)	3.5 (1.1, 8.3)
Exchange Rate	5.1 (1.3, 13.2)	13.6 (4.2, 28.1)	2.2 (0.6, 5.5)	2.9 (0.8, 7.4)
Confidence	11.5 (3.8, 23.3)	23.5 (10.9, 37.5)	4.0 (2.1, 7.0)	12.7 (7.6, 18.7)
Share Prices	16.9 (6.5, 29.8)	24.6 (10.2, 42.2)	2.9 (0.8, 7.0)	6.3 (2.0, 13.1)
Uncertainty	6.2 (1.6, 13.9)	8.0 (2.3, 18.2)	1.6 (0.5, 3.2)	1.8 (0.6, 3.6)

Notes: Median share of the forecast error variance explained by the monetary policy shock, in percent. The sixteenth and eighty-fourth credibility sets are shown in parentheses.

The series of identified monetary policy shocks from the extended model look very similar to those from the baseline model and are shown in the online appendix. They indicate that expansionary monetary surprises occurred at different stages of the global financial crisis when compared across countries. Again, the United States shows a large expansionary shock which occurred at the beginning of the acute phase of the global financial crisis, and also the mean value of U.S. monetary policy shocks was expansionary during this period. By contrast, in most euro-area member states, monetary policy surprises were on average contractionary during the acute phase, with large contractionary shocks occurring at its beginning of the global financial crisis. In those euro-area countries which exhibited double-dip recessions, the monetary surprises tend to be on average contractionary during the recessionary period in 2008 and 2009, but expansionary during the period 2011 to 2013. Hence, monetary policy shocks as identified in our model might have constituted additional adversary factors to euro-area economies during the financial crisis in 2008, while during the second recession these shocks have likely contributed to the recovery in the euro area.

4.3 Discussion of the Results

Overall, we find that monetary policy has larger and quicker effects on the economy during financial crises than during normal times, and that monetary policy shocks are more important for macroeconomic dynamics during financial crises, as indicated by forecast error variance decompositions. Further, there is some heterogeneity over the course of financial crises. During the acute phase of a crisis, the effects of monetary policy shocks are particularly large and quicker than during other times.

The results suggest that it is advisable to ease monetary policy quickly during financial crises. The counterfactual results show that indeed in the United States—where this strategy was pursued—the downturn in GDP was significantly mitigated, while this was not the case in the euro area, where interest rate cuts started one year later than in the United States. At the beginning of the financial crisis, euro-area monetary policy shocks were contractionary for many member economies according to our model and only became expansionary during the second recession in 2012/13 contributing to the final recovery. In contrast to the large effects during the acute phase of financial crises, we observe only weak effects of monetary policy on output and prices, such that the possibilities to stabilize macroeconomic variables appear limited during this phase. However, monetary policy shocks are not entirely without effect during this period, as financial market variables—like house prices, credit, and exchange rates—do react significantly. Macroeconomic uncertainty even significantly increases for a short period following an expansionary monetary policy shock. Hence, an early tightening of monetary policy would run the risk of financial markets destabilization.

Our finding that the effects of monetary policy are strong during the acute phase of financial crises, but less so in the recovery phase, is in line with findings of related empirical studies. Ciccarelli, Maddaloni, and Peydró (2013) analyze the effects of monetary policy in the euro area in the period from 2002 to 2011. By extending the end of their sample recursively from 2007 until 2011, they assess the evolution of the effects of a monetary policy shock when moving from a non-crisis period to the global financial crisis. In line with our results, they find that monetary policy became more effective at stimulating economic activity during the acute phase of the global financial crisis, mainly via the credit channel. Dahlhaus (2017) focuses on the United States and studies the effects of monetary policy conditional on financial stress, which shows that monetary policy is more effective in stimulating the economy during a high-stress regime. By contrast, Bech, Gambacorta, and Kharroubi (2014) focus on the recovery period of financial crises by studying the effects of the monetary policy stance during recession episodes on the strength of the subsequent recovery for a panel of twenty-four advanced economies. They find that monetary policy is not effective in stimulating GDP growth during the recovery phase of a financial crisis, whereas it is effective outside financial crises.

In a broader sense, the results of our study relate to numerous contributions in the literature that deal with the transmission of monetary policy under conditions typically prevailing during financial crises, such as credit constraints, high levels of uncertainty and financial stress, or the presence of large shocks. In the following, we discuss the potential mechanisms underlying our results in light of the findings in this literature.

Larger effects of monetary policy during financial crises and, in particular, during the acute phase are plausible if the central bank is able to ease the adverse effects of financial crises. In particular, firms and private households are more likely to be credit constrained during financial crises because of a decrease in the value of their financial assets and losses of collateral. In this situation, monetary policy may reduce the external finance premium by easing these constraints via the financial accelerator (Bernanke and Gertler 1995; Bernanke, Gertler, and Gilchrist 1999).

Further, our results suggest that the large responses of output during financial crises might relate to the strong effects monetary policy has on uncertainty, confidence, and share prices during this regime. Indeed, various contributions in the literature argue in favor of monetary policy transmission channels via these variables. Basu and Bundick (2017) show in a DSGE model with countercyclical markups and sticky prices that monetary policy can play a key role in offsetting the negative impact of uncertainty shocks. Bekaert, Hoerova, and Lo Duca (2013) provide empirical evidence for the effectiveness of expansionary monetary policy in decreasing risk aversion and uncertainty. By reducing uncertainty, monetary policy can stimulate output and inflation in various ways. First, lower uncertainty can lead to higher output because investment revives as investors receive new information (Bloom 2009). Second, a lower degree of uncertainty can stimulate credit supply and thus restore the credit channel of monetary policy. In particular, a lower degree of uncertainty should decrease liquidity risk and ease refinancing in interbank markets, which improves lending conditions for banks (Buch, Buchholz, and Tonzer 2014). Banks also have less need to retain capital for reasons of self-insurance and can thus extend their lending (Valencia 2017). Third, a reduction in uncertainty can improve consumer sentiment by enhancing the ability of agents to make probabilistic assessments about future events (Ilut and Schneider 2014). A monetary policy expansion can also raise consumer confidence directly by providing signals about future economic prospects (Bachmann and Sims 2012; Barsky and Sims 2012). In this context expansionary monetary policy might be interpreted as a sign that the central bank will prevent a further deepening of the crisis. An increase in consumer confidence can then restore the interest rate responsiveness of borrowing, investment, and spending on durables. Finally, an increase in share prices driven by a monetary policy expansion can increase the value of collateral, thereby contributing to a softening of credit constraints and to higher credit demand. An increase in share prices also makes it easier to finance investment by retaining profits.

Our finding that the co-movement between output and prices is much larger during financial crises than during normal times and in particular during the acute phase of financial crises is in line with the empirical literature on the Phillips curve. Several studies find a significant Phillips-curve relationship only when shocks are large. Roberts (2006) documents a flattening of the Phillips curve in the mid-1980s. This can potentially explain why it has become difficult since the mid-1980s to improve upon simple univariate inflation forecasts models, as documented by Atkeson and Ohanian (2001), Fisher, Liu, and Zhou (2002), and Orphanides and van Norden (2005). Stock and Watson (2007) systematically analyze reasons for the decline in the performance of activity-based inflation forecasts since the mid-1980s and argue that the decrease in the variance of activity measures during the Great Moderation is the reason for this. Further, Clark and McCracken (2006) argue that the sampling variability of inflation forecast comparison statistics is so large that evidence for a breakdown of the Phillips curve is not clear, despite the low accuracy of Phillips-curve-based inflation forecasts between the mid-1980s and the mid-2000s. All these studies use data prior to the 2008/09 Great Recession. However, the Great Recession might be a new episode of large macroeconomic shocks with output and inflation being highly volatile, so that a reemergence of a Phillips-curve relationship is plausible. Large monetary policy shocks can be one factor causing the increased co-movement between output and inflation according to our results, but other shocks—in particular, those that caused the Great Recession—are likely to be important as well.

Finally, the low effects on output and prices during the recovery phase of financial crises might be related to balance sheet adjustments and deleveraging by firms and financial institutions (Reinhart and Rogoff 2008). Monetary policy usually works via intertemporal substitution, but fewer people might be willing to increase their credit exposure in such periods. Hence, even highly expansionary monetary policy might not have a large effect on credit, output, and inflation.[22] Our result that share prices even decline and uncertainty even increases on impact following an expansionary monetary policy shock in this phase may mirror that such a shock may be regarded as confirmation of financial difficulties when the recovery is ongoing already for some time (Hubrich and Tetlow 2015). Continuous

[22]Agarwal et al. (2018) show that also monetary policy measures that were implemented during the Great Recession with the aim of stimulating household borrowing and spending by reducing banks' cost of funds have limited effects, because banks pass through credit expansion least to households that want to borrow the most.

monetary policy interventions could then be interpreted as signaling weak future fundamentals, thereby increasing uncertainty. This explanation would also be in line with the observation that exchange rate depreciation in response to an expansionary monetary policy shock is largest in the recovery phase of a financial crisis, but without leading to an increase in output.

Further, during the recovery phase of a financial crisis, factors that are important for the high effectiveness of monetary policy during the acute phase, such as the reduction of uncertainty and the stabilization of asset prices, may lose ground. At this late stage of a financial crisis, uncertainty has typically been mitigated and asset prices have stabilized substantially, with financial stress being much lower than during the acute phase. Thus, potential acceleration mechanisms in monetary policy transmission have already been exhausted.

4.4 Robustness Checks

We check the sensitivity of our results to a number of alternative specifications. In the following, we present the results for specifications which investigate the relevance of the zero lower bound and unconventional monetary policies. We also describe results of specifications, where we differentiate between euro-area and non-euro-area countries and where we use sign restrictions to identify monetary policy shocks. We show figures only for the baseline model with two regimes and for the three main variables output, prices, and the short-term interest rate. Figures for all variables and the extended model with four regimes are contained in the online appendix.

4.4.1 Zero Lower Bound and Quantitative Easing

The majority of the financial crises in our sample are associated with the global financial crisis that started in 2007: fifteen out of twenty financial crisis episodes took place around that period. In this crisis, several central banks reached the zero lower bound on nominal interest rates and therefore switched to unconventional monetary policy measures such as quantitative easing, for which we do not account in our baseline model.

We check whether our results are sensitive to accounting for unconventional monetary policy measure in two different ways. First, we use the shadow rate by Wu and Xia (2016) instead of the money market short-run interest rate for the United States, the United Kingdom, and the euro area as monetary policy instrument in our model. This measure is an estimate of the level of the short-term interest rate that would prevail in the absence of the zero lower bound. It is estimated based on forward rates and a Nelson-Siegel-Svensson yield-curve model, so it also reflects quantitative easing and other unconventional monetary policy measures.[23] The results of this specification are shown in figure 5, as dotted lines. The responses of both output and prices remain stronger during financial crises than during normal times, although the responses of both variables during financial crises are slightly weaker when using shadow interest rate estimates compared with the baseline. A similar pattern holds for the other six variables in the model. In the estimation over four regimes, results when using the shadow interest rate as monetary policy instrument are very similar to the baseline, as shown in the online appendix.

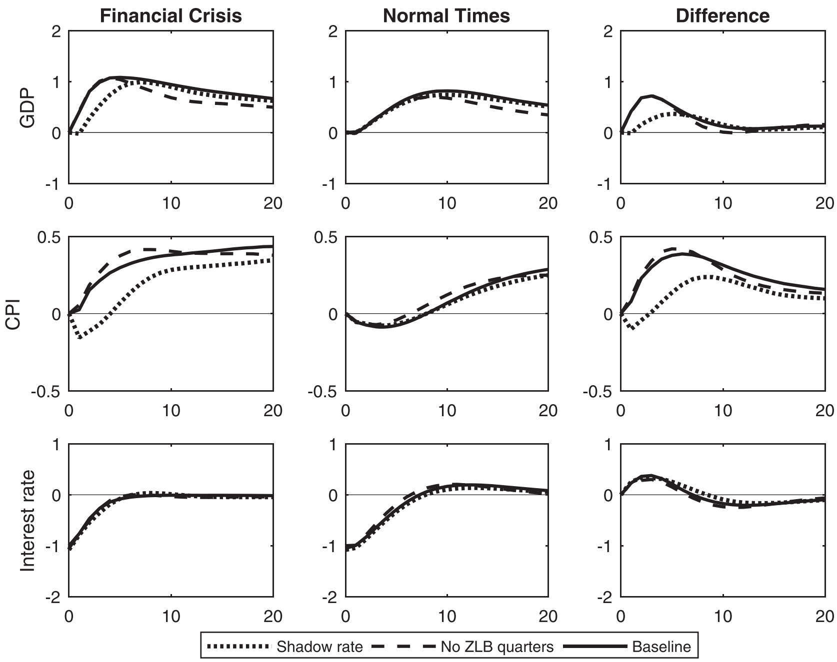
Second, we perform a more agnostic robustness check with respect to the zero lower bound and unconventional monetary policy measures. We identify all observations in which monetary policy reaches the zero lower bound, i.e., when the interest rate of the main monetary policy instrument is smaller than or equal to 0.3 percent. This definition yields 298 observations where monetary policy reaches the zero lower bound, among which 33 occur in financial crises. When we exclude these observations from our sample, our results are basically unchanged, as shown by the dashed lines in figure 5.

4.4.2 Euro-Area and Non-euro-area Samples

Eleven out of the twenty countries in our sample are members of the euro area. In our data set, the aggregate euro-area short-term

[23] Shadow interest rates are not available for other economies; therefore, we do not control for unconventional monetary policy measures in Japan, which is the only remaining economy in our sample where such measures have been applied for a longer period. However, our results do not change when we also exclude Japan from our sample.

Figure 5. Accounting for the Zero Lower Bound

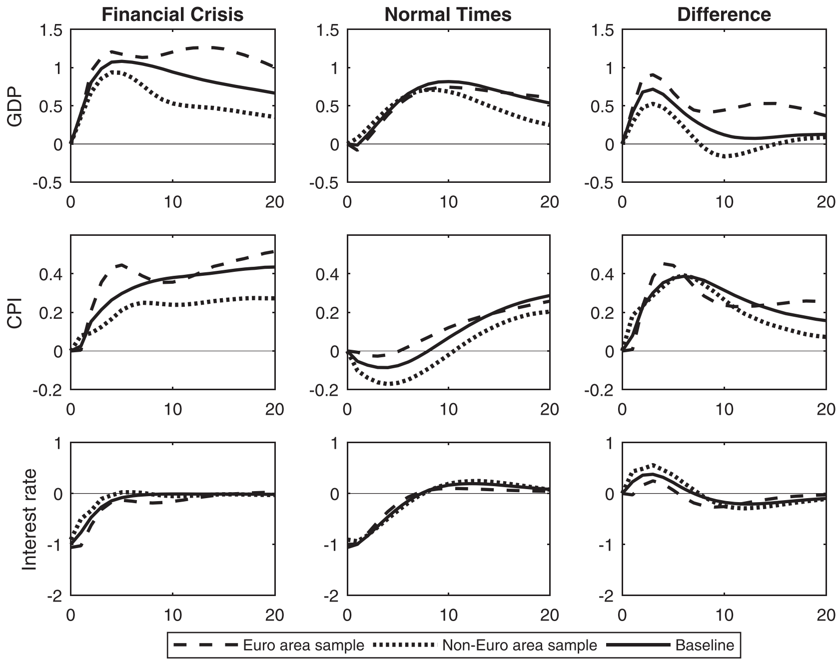


Notes: Solid lines show baseline estimation; dotted lines show estimation with the shadow interest rate as the monetary policy variable; dashed lines show results for the estimation where the 298 observations in which the zero lower bound was reached were excluded. See also notes of figure 1.

interest rate is thus used for all euro-area members from 1999 onwards (from 2001 in the case of Greece). While we opt for including these countries separately in order to exploit the cross-country dimension of the data and to be able to analyze differences across euro-area member states in section 4.1.2, the information that can be drawn from including individual euro-area countries in our panel might be limited given that they share a joint monetary policy.[24]

[24]The existing empirical literature analyzing monetary policy transmission within a panel VAR context typically follows a similar approach and includes euro-area countries as individual economies in the panel (Assenmacher-Wesche and Gerlach 2008; Goodhart and Hofmann 2008; Carstensen, Hülsewig, and Wollmerhäusen 2009; Calza, Monacelli, and Stracca 2013). Only Gambacorta, Hofmann, and Peersman (2014) take a different approach and consider the euro

Figure 6. Euro-Area and Non-euro-area Samples



Notes: Solid lines show baseline estimation; dashed (dotted) lines show estimation for the euro area (non-euro-area) subsample. See also notes of figure 1.

To assess whether our results are dominated by euro-area dynamics, we run two separate PVAR regressions for euro-area countries and for countries outside the euro area, respectively. We only have about half of the total observations for each subgroup, so estimation is only feasible for the baseline case with two regimes. Figure 6 shows the median impulse responses and probability bands for the euro-area sample (dashed lines) and the non-euro-area sample (dotted lines), together with the baseline estimates for the full sample, depicted as solid lines. The results are comparable to the baseline estimation and mostly similar for both subgroups. Output and prices

area as aggregate, at the cost of having only eight countries in their panel VAR, which for our purposes of pooling financial crisis episodes and distinguishing between different regimes would not provide enough data points.

react stronger and faster during financial crises in both the euro-area countries and the non-euro area countries. Differences between euro-area and non-euro-area countries are small for all other variables.

We also check whether our results are affected by the sovereign debt crisis that become severe in 2011 in several euro-area countries, leading to a double-dip recession in these economies. To exclude the sovereign debt crisis, we restrict our estimation period to the subsample from 1984 to 2010 and our results remain strongly robust, as shown in the online appendix.

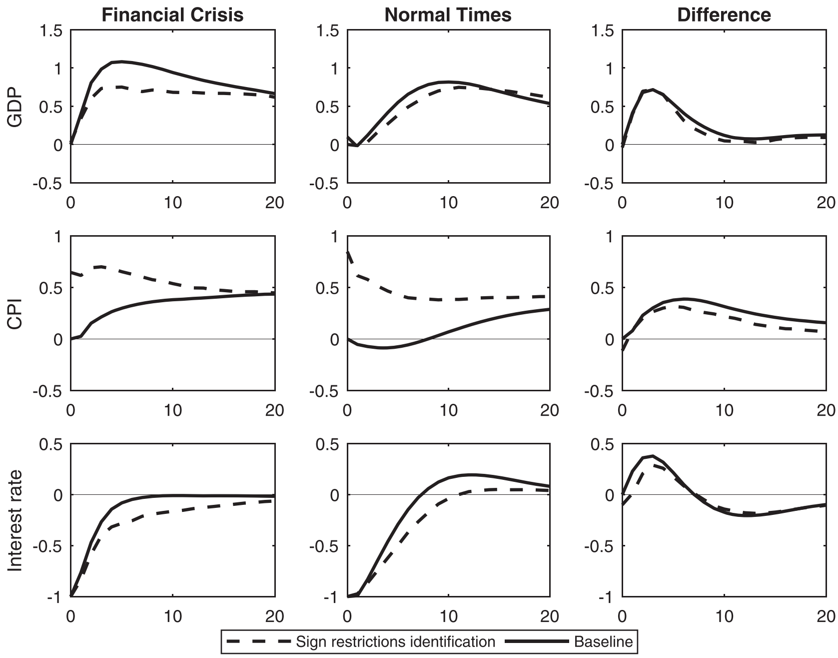
4.4.3 Sign Restrictions

Finally, we check whether our results are robust when we use sign restrictions instead of the recursive identification to identify monetary policy shocks. The sign-restriction approach has the advantage that it allows for non-zero contemporaneous responses by all variables in the VAR. We remain agnostic about the response of output, and we restrict the impulse response of the short-term interest rate to being negative during the first four quarters and the response of prices to being positive between the second and fourth quarter. We follow Sá, Towbin, and Wieladek (2014) and do not restrict the CPI response in the first quarter to allow for a sluggish response by this variable. Figure 7 shows that the results are similar to the results obtained based on the recursive identification. Output and prices react faster and stronger during financial crises. The results for the other six variables are similar to our baseline results as well: we find a stronger increase in confidence and share prices as well as a larger reduction in uncertainty during financial crises. Also in the estimation over four regimes, results are very similar when using sign-restriction identification, as shown in the online appendix.

5. Conclusion

In this paper, we analyze the effects of monetary policy shocks during financial crises. We find that monetary policy shocks have significantly larger effects on output and prices during financial crises than during normal times and that these effects occur more instantaneously. We also observe significantly larger effects on several other variables, including credit, asset prices, uncertainty, and consumer

Figure 7. Identification via Sign Restrictions



Notes: Solid lines show baseline estimation; dashed lines show results for the estimation, where the monetary policy shock is identified via sign restrictions.

confidence, suggesting that these variables play an important role in the monetary policy transmission during financial crises. However, we find that there is time variation of the effects of monetary policy shocks during financial crises. While monetary policy shocks have large effects on output and prices during the acute phase of a financial crisis when the economy is in recession, the effects are significantly weaker during the subsequent recovery phase.

Further, we find some heterogeneity of monetary policy actions during the global financial crisis of 2008/09 across countries. In economies like the United States, in which interest rates were lowered directly at the beginning of the crisis, monetary policy was able to mitigate the biggest drop in output to some extent, but less so in other economies like the euro area, where the central bank reacted later. Our results suggest that monetary policy is highly effective during financial crises, probably because it can reduce some of the adverse characteristics of financial crises like high uncertainty, low confidence, and low asset prices. We discuss several papers that support this view, but leave a more detailed analysis of the relevance of different transmission channels of monetary policy during financial crises for future research.

References

Agarwal, S., S. Chomsisengphet, N. Mahoney, and J. Stroebel. 2018. "Do Banks Pass through Credit Expansions to Consumers Who Want to Borrow? *Quarterly Journal of Economics* 133 (1): 129–90.

Altunbasa, Y., L. Gambacorta, and D. Marques-Ibanez. 2014. "Does Monetary Policy Affect Bank Risk?" *International Journal of Central Banking* 10 (1, March): 95–135.

Assenmacher-Wesche, K., and S. Gerlach. 2008. "Monetary Policy, Asset Prices and Macroeconomic Conditions: A Panel-VAR Study." Working Paper No. 149, National Bank of Belgium.

Atkeson, A., and L. E. Ohanian. 2001. "Are Phillips Curves Useful for Forecasting Inflation?" *Quarterly Review* (Federal Reserve Bank of Minneapolis) 25 (1): 2–11.

Bachmann, R., and E. Sims. 2012. "Confidence and the Transmission of Government Spending Shocks." *Journal of Monetary Economics* 59 (3): 235–49.

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

Barsky, R. B., and E. R. Sims. 2012. "Information, Animal Spirits, and the Meaning of Innovations in Consumer Confidence." *American Economic Review* 102 (4): 1343–77.

Basu, S., and B. Bundick. 2017. "Uncertainty Shocks in a Model of Effective Demand." *Econometrica* 85 (3): 937–58.

Bech, M., L. Gambacorta, and E. Kharroubi. 2014. "Monetary Policy in a Downturn: Are Financial Crises Special?" *International Finance* 17 (1): 99–119.

Bekaert, G., M. Hoerova, and M. Lo Duca. 2013. "Risk, Uncertainty and Monetary Policy." *Journal of Monetary Economics* 60 (7): 771–88.

Bernanke, B. S. 1983. "Irreversibility, Uncertainty, and Cyclical Adjustment." *Quarterly Journal of Economics* 98 (1): 85–106.

Bernanke, B. S., J. Boivin, and P. Eliasz. 2005. "Measuring the Effects of Monetary Policy: A Factor-Augmented Vector Autoregressive (FAVAR) Approach." *Quarterly Journal of Economics* 120 (1): 387–422.

Bernanke, B. S., and M. Gertler. 1995. "Inside the Black Box: The Credit Channel of Monetary Policy Transmission." *Journal of Economic Perspectives* 9 (4): 27–48.

Bernanke, B. S., M. Gertler, and S. Gilchrist. 1999. "The Financial Accelerator in a Quantitative Business Cycle Framework." In *Handbook of Macroeconomics*, Vol. 1C, ed. J. B. Taylor and M. Woodford, 1341–93 (chapter 21). Elsevier.

Bloom, N. 2009. "The Impact of Uncertainty Shocks." *Econometrica* 77 (3): 623–85.

Bloom, N., S. Bond, and J. V. Reenen. 2007. "Uncertainty and Investment Dynamics." *Review of Economic Studies* 74 (2): 391–415.

Borio, C., and B. Hofmann. 2017. "Is Monetary Policy Less Effective when Interest Rates Are Persistently Low?" BIS Working Paper No. 628.

Bouis, R., L. Rawdanowicz, J.-P. Renne, S. Watanabe, and A. K. Christensen. 2013. "The Effectiveness of Monetary Policy since the Onset of the Financial Crisis." OECD Economics Department Working Paper No. 1081.

Buch, C. M., M. Buchholz, and L. Tonzer. 2014. "Uncertainty and International Banking." Mimeo.

Caggiano, G., E. Castelnuovo, and N. Groshenny. 2014. "Uncertainty Shocks and Unemployment Dynamics in U.S. Recessions." *Journal of Monetary Economics* 67 (October): 78–92.

Calza, A., T. Monacelli, and L. Stracca. 2013. "Housing Finance and Monetary Policy." *Journal of the European Economic Association* 11 (s1): 101–22.

Canova, F., and G. De Nicoló. 2002. "Monetary Disturbances Matter for Business Fluctuations in the G-7." *Journal of Monetary Economics* 49 (6): 1131–59.

Carstensen, K., O. Hülsewig, and T. Wollmershäuser. 2009. "Monetary Policy Transmission and House Prices: European Cross-Country Evidence." CESifo Working Paper No. 2750.

Cesa-Bianchi, A., M. H. Pesaran, and A. Rebucci. 2018. "Uncertainty and Economic Activity: A Multi-country Perspective." NBER Working Paper No. 24325.

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

Christiano, L. J., M. Eichenbaum, and C. L. Evans. 1999. "Monetary Policy Shocks: What Have We Learned and to What End?" In *Handbook of Macroeconomics*, Vol. 1A, 1st Edition, ed. J. B. Taylor and M. Woodford, 65–148 (chapter 2). Elsevier.

Ciccarelli, M., A. Maddaloni, and J.-L. Peydró. 2013. "Heterogeneous Transmission Mechanism: Monetary Policy and Financial Fragility in the Eurozone." *Economic Policy* 28 (75): 459–512.

Clark, T. E., and M. W. McCracken. 2006. "The Predictive Content of the Output Gap for Inflation: Resolving In-Sample and Out-of-Sample Evidence." *Journal of Money, Credit and Banking* 38 (5): 1127–48.

Cogley, T., and T. J. Sargent. 2005. "Drifts and Volatilities: Monetary Policies and Outcomes in the Post WWII US." *Review of Economic Dynamics* 8 (2): 262–302.

Coibion, O. 2012. "Are the Effects of Monetary Policy Shocks Big or Small?" *American Economic Journal: Macroeconomics* 4 (2): 1–32.

Corsetti, G., J. B. Duarte, and S. Mann. 2018. "One Money, Many Markets—A Factor Model Approach to Monetary Policy in the Euro Area with High-Frequency Identification." CFM Discussion Paper No. 1805.

Dahlhaus, T. 2017. "Conventional Monetary Policy Transmission during Financial Crises: An Empirical Analysis." *Journal of Applied Econometrics* 32 (2): 401–21.

Del Negro, M., and F. Schorfheide. 2011. "Bayesian Macroeconometrics." In *The Oxford Handbook of Bayesian Econometrics*, ed. J. Geweke, G. Koop, and H. V. Dijk, 293–389. Oxford University Press.

Dixit, A., and R. Pindyck. 1994. *Investment under Uncertainty.* Princeton, NJ: Princeton University Press.

Fisher, J. D., C. T. Liu, and R. Zhou. 2002. "When Can We Forecast Inflation?" *Economic Perspectives* (Federal Reserve Bank of Chicago) 26 (1): 30–42.

Fry-McKibbin, R., and J. Zheng. 2016. "Effects of US Monetary Policy Shocks during Financial Crises — A Threshold Vector Autoregression Approach." *Applied Economics* 48 (59): 5802–23.

Gambacorta, L., B. Hofmann, and G. Peersman. 2014. "The Effectiveness of Unconventional Monetary Policy at the Zero Lower Bound: A Cross-Country Analysis." *Journal of Money, Credit and Banking* 46 (4): 615–42.

Garcia, R., and H. Schaller. 2002. "Are the Effects of Monetary Policy Asymmetric?" *Economic Inquiry* 40 (1): 102–19.

Georgiadis, G. 2014. "Towards an Explanation of Cross-Country Asymmetries in Monetary Transmission." *Journal of Macroeconomics* 39 (Part A): 66–84.

Giannone, D., M. Lenza, H. Pill, and L. Reichlin. 2012. "The ECB and the Interbank Market." *Economic Journal* 122 (564): F467–F486.

Goodhart, C., and B. Hofmann. 2008. "House Prices, Money, Credit, and the Macroeconomy." *Oxford Review of Economic Policy* 24 (1): 180–205.

Harding, D., and A. Pagan. 2002. "Dissecting the Cycle: A Methodological Investigation." *Journal of Monetary Economics* 49 (2): 365–81.

Hubrich, K., and R. J. Tetlow. 2015. "Financial Stress and Economic Dynamics: The Transmission of Crises." *Journal of Monetary Economics* 70 (March): 100–115.

Ilut, C., and M. Schneider. 2014. "Ambiguous Business Cycles." *American Economic Review* 104 (8): 2368–99.

Jiménez, G., S. Ongena, J.-L. Peydró, and J. Saurina. 2014. "Hazardous Times for Monetary Policy: What Do Twenty-Three Million Bank Loans Say about the Effects of Monetary Policy on Credit Risk-Taking?" *Econometrica* 82 (2): 463–505.

Koop, G., and D. Korobilis. 2010. *Bayesian Multivariate Time Series Methods for Empirical Macroeconomics.* Now Publishers Inc.

Laeven, L., and F. Valencia. 2013. "Systemic Banking Crises Database." *IMF Economic Review* 61 (2): 225–70.

Lo, M. C., and J. Piger. 2005. "Is the Response of Output to Monetary Policy Asymmetric? Evidence from a Regime-Switching Coefficients Model." *Journal of Money, Credit and Banking* 37 (5): 865–86.

Lütkepohl, H. 2013. "Vector Autoregressive Models." In *Handbook of Research Methods and Applications in Empirical Macroeconomics*, ed. N. Hashimzade and M. A. Thornton, 139–64 (part II, chapter 6). Edward Elgar Publishing.

Mishkin, F. S. 2009. "Is Monetary Policy Effective during Financial Crises?" *American Economic Review* 99 (2): 573–77.

Morgan, D. P. 1993. "Asymmetric Effects of Monetary Policy." *Economic Review* (Federal Reserve Bank of Kansas City) 78 (Second Quarter): 21–33.

Nickell, S. J. 1981. "Biases in Dynamic Models with Fixed Effects." *Econometrica* 49 (6): 1417–26.

Orphanides, A., and S. van Norden. 2005. "The Reliability of Inflation Forecast Based on Output Gap Estimates in Real Time." *Journal of Money, Credit and Banking* 37 (3): 583–600.

Pain, N., C. Lewis, T.-T. Dang, Y. Jin, and P. Richardson. 2014. "OECD Forecasts during and after the Financial Crisis: A Post Mortem." OECD Economics Department Working Paper No. 1107.

Peersman, G., and F. Smets. 2002. "Are the Effects of Monetary Policy in the Euro Area Greater in Recessions than in Booms?" In *Monetary Transmission in Diverse Economies*, ed. L. Mahadeva and P. Sinclair, 28–48 (chapter 2). Cambridge University Press.

Pesaran, M. H., and R. Smith. 1995. "Estimating Long-run Relationships from Dynamic Heterogeneous Panels." *Journal of Econometrics* 68 (1): 79–113.

Rajan, R. G. 2005. "Has Financial Development Made the World Riskier?" In *The Greenspan Era: Lessons for the Future.* Proceedings of the 2005 Economic Policy Symposium sponsored by the Federal Reserve Bank of Kansas City, held in Jackson Hole, Wyoming, August 25–27.

Reinhart, C. M., and K. S. Rogoff. 2008. "Is the 2007 US Subprime Financial Crisis So Different? An International Historical Comparison." *American Economic Review* 98 (2): 339–44.

Roberts, J. M. 2006. "Monetary Policy and Inflation Dynamics." *International Journal of Central Banking* 2 (3, September): 193–230.

Sá, F., P. Towbin, and T. Wieladek. 2014. "Capital Inflows, Financial Structure and Housing Booms." *Journal of the European Economic Association* 12 (2): 522–46.

Stock, J. H., and M. W. Watson. 2007. "Why Has U.S. Inflation Become Harder to Forecast?" *Journal of Money, Credit and Banking* 39 (s1): 3–33.

Tenreyro, S., and G. Thwaites. 2016. "Pushing on a String: US Monetary Policy Is Less Powerful in Recessions." *American Economic Journal: Macroeconomics* 8 (4): 43–74.

Towbin, P., and S. Weber. 2013. "Limits of Floating Exchange Rates: The Role of Foreign Currency Debt and Import Structure." *Journal of Development Economics* 101 (March): 179–94.

Uhlig, H. 1994. "What Macroeconomists Should Know about Unit Roots: A Bayesian Perspective." *Econometric Theory* 10 (3–4): 645–71.

———. 2005. "What Are the Effects of Monetary Policy on Output? Results from an Agnostic Identification Procedure." *Journal of Monetary Economics* 52 (2): 381–419.

Valencia, F. 2017. "Aggregate Uncertainty and the Supply of Credit." *Journal of Banking and Finance* 81 (August): 150–65.

Vavra, J. 2014. "Inflation Dynamics and Time-Varying Volatility: New Evidence and an Ss Interpretation." *Quarterly Journal of Economics* 129 (1): 215–58.

Weise, C. L. 1999. "The Asymmetric Effects of Monetary Policy: A Nonlinear Vector Autoregression Approach." *Journal of Money, Credit and Banking* 31 (1): 85–108.

Williams, J. C. 2014. "Monetary Policy at the Zero Lower Bound: Putting Theory into Practice." Working Paper No. 2 (January), Hutchins Center, Brookings Institution.

Wu, J. C., and F. D. Xia. 2016. "Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound." *Journal of Money, Credit and Banking* 48 (2–3): 253–91.