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One size may not fit all: Financial fragmentation and European monetary policies

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Abstract

This article investigates the impact of European Central Bank policies on credits considering financial and banking fragmentation. Using European data from the past decade, we estimate SVAR models to analyze the regional impact of conventional and unconventional measures on price and volume indicators of fragmentation. The risk-taking channel is studied using GVAR models to document the national consequences of this fragmentation. We find that unconventional measures increase credit in peripheral countries. Monetary policies alleviate fragmentation, but mostly in terms of price dispersion rather than credit volume. Finally, unconventional measures imply a rebalancing of European bank assets in favor of foreign currency denominated-assets.

KEYWORDS

banking fragmentation, financial fragmentation, monetary policy, risk-taking channel

JEL CLASSIFICATION

E44, E50, F36, F42, F45

1 | INTRODUCTION

This article studies the impact of monetary policies on financial and banking fragmentation in the Eurozone and their consequences on bank risk and credits at the country and regional level. This

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question is especially relevant in the Eurozone given the major role played by banking intermediation, representing 75% of external financing for the nonfinancial corporate sector (Colangelo et al., 2017). Moreover, the current context provides further relevance to the issue. In March 2020, the European Central Bank (ECB) increased its liquidity supply in order to limit the contagion of the crisis to the banking sector and to support long-term interest rates' stability and credit supply. In doing so, one of the ECB's stated objectives was "preventing financial fragmentation and distortions in credit pricing" (C. Lagarde, March 19, 2020).¹ More recently, the ECB stated in February 2022 that while asset purchases are to be reduced from March 2022, their objective is to maintain the flexibility of the monetary policy in order to avoid an increase in market fragmentation.

Fragmented markets entail different investment opportunities among countries and limited cross-border financial links and risk-sharing (Baele et al., 2014), associated with institutional differences between market segments, with differences in accounting and governance practices, as well as informational barriers that increase cross-border transaction costs. While in principle the European Monetary Union implies regional integration of financial markets and banking sectors, evidence of fragmentation persists in the Eurozone (Baele et al., 2014; Battistini et al., 2014; Coeuré, speech at Bank of France March, 2019; ECB, 2018; Gagnon & Gimet, 2020; Mayor-domo et al., 2015) and has increased since the 2007–2008 financial crisis (Claessens, 2017). In this context, the national banking sectors could react differently to a common monetary policy change. More specifically, financial and banking fragmentation implies heterogeneity based on geographical location beyond what can be inferred from national fundamentals. This fragmentation generates asymmetry in a country's exposure to friction and shocks (Baele et al., 2014). Therefore, it is not clear according to the current state of the literature that a single monetary policy can be successful at addressing the economic recovery of all the members of the union without first reducing financial and banking fragmentation.

In this context, the main objective of this article is to investigate whether conventional and unconventional monetary policies implemented by the ECB can both alleviate financial and banking fragmentation and increase credits in all euro area countries. We focus on monetary policies and their consequences on market risk, risk-taking at the bank level, and credit supply. While Bruno and Shin (2015) study the U.S. situation in a similar framework, we study the risk-taking channel inside the Euro monetary union in the presence of financial and banking fragmentation. Our hypothesis is that heterogeneity in the risk-taking channel in Europe could hinder European credits.

We use monthly European data from 2008 to 2018 on interest rates, LTROs and quantitative easing performed by the ECB, coupled with regional Bayesian structural VAR models and national Global VAR models. First, the Bayesian structural VAR (BVAR) models are used in order to obtain regional aggregate regional impulse response functions, which provide a starting point for our analysis. The BVAR is estimated with Sims and Zha's (1999) approach, which allows us to circumvent the traditional overfitting problem present in VARs by reducing the number of parameters that have to be estimated. Structural BVARs also provide good likelihood-based error bands (Sims & Zha, 1999) and are not affected by unit roots (Sims, 1988; Sims & Uhlig, 1991). Given these advantages, this method has been used extensively in the literature since Mackowiak (2007). Second, we are interested in desegregating these regional responses into country responses. Here, we introduce another methodology in order to account for the curse of dimensionality. The Global VAR (GVAR) approach introduced by Pesaran et al. (2004) is a two-step approach that first estimates country-specific models while treating foreign variable as weakly exogenous. Then, these country models are stacked and solved together considering the financial interdependencies across countries. We argue that GVAR models, originally designed to measure financial institutions losses, are well-suited to

account for the national source of European fragmentation and for a global European model encompassing the banking sector, explicitly considering different national macro financial supervision contexts.

Our analysis underscores three main results. First, while conventional monetary policy does not significantly improve credit through the risk-taking channel, unconventional monetary policies can increase loans in peripheral countries. Indeed, LTROs increase German banks' external credits in Europe. Quantitative easing entails a substitution effect from domestic to external loans in core countries. Second, monetary policies can lessen financial and banking fragmentation by reducing price dispersion indicators. Third, unconventional monetary policies have additional unintended consequences, such as a rebalancing of the European banks' asset mix in favor of USD denominated assets. This substitution is associated with fragmentation and limits the European impact on credit supply.

2 | EUROPEAN CONTEXT AND LITERATURE REVIEW

The Eurozone was expected to consolidate the unification of financial markets as well as involve cross-border risk-sharing. Government bonds were expected to become perfect substitutes. The endogenous synchronization of economic cycles and financial integration would offset national specificities. The equity market integration would reduce the home bias (De Grauwe, 2018). Despite the adoption of the Financial Services Action Plan (FSAP) in 1999, which aimed to support the European financial integration, fragmentation remains due to the persistence of national banking regulations (De Grauwe, 2018).

Indeed, free capital mobility and easing credit conditions generated by the monetary integration during the 2000–2007 period within the Eurozone entailed an increase in cross-border loans from surplus to deficit countries, as it was theoretically expected (Ingram, 1969). However, the rise in cross-border lending created a credit boom in certain countries (Cyprus, Ireland, Greece, Italy, Portugal, and Spain), increasing systemic risk, asset prices, and financial vulnerability, in a national context of information asymmetry and a lack of macro-prudential supervision (De Grauwe & Ji, 2013). Thus, the financial cycles became disconnected across the members of the monetary union, increasing sudden stops in financially vulnerable countries,² multiple equilibria, and credit freezes (De Grauwe & Ji, 2013; Merler, 2015). In fact, the trend toward financial integration was reversed after the 2011 sovereign debt crisis (Claessens, 2017; Coeuré, speech at Bank of France March, 2019; Colangelo et al., 2017), as underscored by a decrease in the ECB financial integration index (ECB, 2018). Cross-border bank claims dropped by about 20% in the Eurozone (Claessens, 2017). The reduction in cross-border flows was compensated by liquidity assistance of the ECB in favor of financially stressed economies at a higher interest rate (emergency liquidity assistance [ELA]) and by official public inflows (Fagan & McNelis, 2020). In addition, macroprudential policy supervised by the ECB through the single supervisory mechanism was implemented in order to limit the systemic risk in the Eurozone. However, these measures are asymmetric between countries. Whereas the measures that concern lenders' behaviors (capital requirements or leverage ratios) are common to euro area countries and included in European directives (Capital requirement regulation [CRR]/capital requirement directive [CRD IV]), borrower-based instruments (such as loans-to-value ratios or debt-to-income ratios) are left to national choices, creating heterogeneities in their implementation (Merler, 2015). The heterogeneity inside the Eurozone persists, with high levels of nonperforming loans (Table A1), insolvency (Table A3), and illiquidity risks in southern Europe (Tables A2 and A4), which limit

the banks' access to the interbank market (Gabrieli & Labonne, 2022). Moreover, even if the risk associated with Eurozone sovereign and bank assets has decreased since 2013, the vicious circle between banks and sovereign risk remains (Colozza & Barucci, 2021).

Studying financial and banking fragmentation in the context of monetary policy is both theoretically and empirically motivated. On the theoretical side, the relationship between monetary policies and risk-taking in the banking sector is crucial. Our article builds and expands on these contributions, summarized in Table B1 and in particular the findings in Bruno and Shin (2015), who elaborate a model of a risk-taking channel that connects banks' asset mix and risk-taking to currency expectations and monetary policies. They demonstrate that lower bank funding rates and higher liquidity increase risk-taking, credits and cross-border flows. In addition, Vari (2020) shows in a theoretical model how fragmentation can have an impact on monetary policy's effectiveness beyond what is intended by the central bank. Fragmentation generates liquidity and interest rate fluctuations between countries inside the Eurozone that deviate from the central bank targets. Unconventional monetary policy based on central bank liquidity supply decreases interbank market exchanges. There is a surplus of liquidity in core countries that is not compensated by an increase in peripheral banks' demands for liquidity from the central bank. The transmission of monetary policy is thus unsettled by banking fragmentation.

Empirically, the literature on this question concludes that the ECB's unconventional measures were successful in reducing some indicators of fragmentation. Al-Eyd and Berkmen (2013) find that conventional and unconventional early policies undertaken by the ECB helped improve funding in the banking sector, reduced sovereign risk, and mitigated extreme currency risks. Szczerbowicz (2015) concludes that asset repurchases were the most efficient measures for financing costs and these operations reduced the sovereign bond spread across the Eurozone. Mayordomo et al. (2015) document a significant decrease in financial segmentation, measured in the interbank markets in the short run following the announcement and implementation of an LTRO program. Von Borstel et al. (2016) find a significant decrease in yields and lending rates in Europe after repurchasing operations that contributed to decreasing market segmentation by about 50%. The reduction in lending rates after nonstandard monetary measures is also demonstrated by Altavilla et al. (2020), who show that this lowering is particularly significant in financially stressed European countries and for small illiquid and poorly capitalized banks between 2007 and 2017. They consider that these monetary measures participate in strengthening the banks' balance sheet in these economies in particular, which contributes to increasing their output as it shown by Pagliari (2021).

This article makes two important contributions to the literature. First, we measure fragmentation both at a regional and a national level, while accounting for financial interdependences among all the countries. Financial fragmentation has been previously documented at the European level (Claessens, 2017; ECB, 2018), but the consequences of fragmentation are not yet well-understood for the individual member countries. Moreover, Vari (2020) shows the existence of country specific risks in the European banking sector. In this context, our analysis goes beyond the aggregate assessment that we present as a starting point using a Bayesian VAR analysis, but also provides a detailed national analysis in order to underscore the local differences in reaction to these measures using a GVAR approach. Moreover, this article considers the international spillovers of the ECB policy to the U.S. and therefore highlights the role of international banks as a channel of transmission of European monetary policy, which previous studies have often overlooked. Our study empirically documents for the Eurozone the risk-taking channel identified in Bruno and Shin (2015), relating monetary policies to cross-border flows while accounting for European financial and banking fragmentation. Second, we assess fragmentation using not

only price variables, but also volume variables. In contrast, the existing literature focuses on price variables such as the lending rate (Al-Eyd and Berkmen, 2013; Altavilla et al., 2020; Von Borsstel et al., 2016). In fact, in the banking sector, fragmentation is generally measured by dispersion in bond, equity, and banking markets prices inside a financial integrated area. We argue that measuring fragmentation effectively requires the use and comparison of both price-based and quantity-based indicators. Indeed, mitigating fragmentation implies reducing price dispersion, but also increasing volumes traded.

3 | DATA

Our study is based on the Eurozone³ during the 10 years following the collapse of Lehman Brothers to the temporary end of net asset purchases by the ECB before the health crisis (2008M10–2018M12). This period of analysis is relevant for studying financial fragmentation and its regional consequences, as the post-crisis period has been associated with increasing fragmentation in the European banking system (Claessens, 2017). We chose our variables according to the risk-taking channel defined by the theoretical considerations in Bruno and Shin (2015) in a fragmented European context (Vari, 2020). Table 1 presents all the data in detail, their source, their motivation and references to include each variable in a specific context. Compared to the existing literature summarized in Table B1, the data in this article enables a more comprehensive analysis of monetary policies and fragmentation with respect to (i) providing a national analysis of all the Eurozone countries members⁴ as well as a regional analysis, and (ii) a more recent period of analysis as most studies focus on the period before and during the 2008 crisis.

3.1 | Monetary policies variables

Three types of shocks on ECB monetary policy are studied: a negative interest rate shock (BCELR), which corresponds to the ECB marginal lending facility rate, a positive long-term refinancing operations shock (LTRO), which is measured by the monthly ECB contributions to the Eurosystem consolidated financial statement, and a positive quantitative easing shock (QE), which is defined as the direct purchase of the European debt securities by the ECB.

3.2 | Regional data on fragmentation

Our variables are selected in the literature as reliable metrics of financial and banking fragmentation (Claessens, 2019; ECB, 2020; Vari, 2020). Six variables are chosen to represent the degree of homogeneity in the reaction of the banking and financial sectors of the Eurozone: *FINT*, which is the sub-index for the equity market of the price-based financial composite indicator proposed by the ECB with a high value that corresponds to a high financial integration and country index returns; *CDS* which represents the five-year dispersion of banks' credit default swap; *EONIA*, which is the interquartile range of Eurozone countries' average short-term interbank lending rates; *BOND*, which is the interquartile dispersion of Eurozone ten-year sovereign bond yields; *FCP* is the volume of assets in foreign currency held by the Eurozone banking sector and *EXL* which measured the *MFI*'s loans to non-*MFI* of other Eurozone member states. All the aggregate European data are extracted from the ECB website. The Bayesian inference used in the regional

TABLE 1 Variables of the model

Variable	Description	Motivation and previous evidence	Source
<i>ECB monetary policy variables</i>			
BCELR	ECB marginal lending facility rate, in percent. Series key: FM.D.U2.EUR.4F.KR.MLFI	Conventional monetary policy (Bruno & Shin, 2015)	ECB statistics
LTRO	Longer-term refinancing operations, monthly ECB contributions to the Eurosystem consolidated financial statement, in millions of Euros. Series key: ILM.W. U2.C.A050200.U2.EUR	Credit easing standard measure (Fratzscher et al., 2016)	ECB statistics
QE	Direct purchase of the European debt securities by the ECB, in millions of Euros. Series key: BSI.M.4F.N.N.A30.A.1.U2.2	Quantitative easing standard measure (Szczerbowicz, 2015)	ECB statistics
<i>Regional variables</i>			
FINT	Sub-index for the equity market of the price-based financial composite indicator. It is based on a price dispersion but it is transformed to ensure that higher values of the indicator represent higher financial integration	Price measure of financial fragmentation and risk-sharing measure (Baele et al., 2014)	ECB statistics ^a
CDS	Five-year dispersion of banks credit default swap premium	Banking risk fragmentation measure (Al-Eyd & Berkmen, 2013; Mayordomo et al., 2015)	ECB statistics ^a
BOND	Interquartile dispersion of euro area 10-year sovereign bond yields	Price measure of financial market fragmentation (Al-Eyd & Berkmen, 2013)	ECB statistics ^a

(Continues)

TABLE 1 (Continued)

Variable	Description	Motivation and previous evidence	Source
EONIA	Average interquartile range of euro area countries' average short-term interbank lending rates, in basis point	Price variable measure of banking fragmentation (Mayordomo et al., 2015; Vari, 2020)	ECB statistics ^a
FCP	Volume of assets in foreign currency held by the euro-area banking sector, in millions of Euros	International banking flows measure (Buch et al., 2019)	ECB statistics ^a
EXL	MFIs' loans to non-MFI of other euro area member states, percentage of total lending	Volume measure of banking fragmentation (Baele et al., 2014)	ECB statistics ^a
<i>National variables</i>			
SPNFC	MFIs' lending margins on loans to nonfinancial corporations, percentage points. Series key: RAI.M.AT.LMGLNFC. EUR.MIR.Z 5 (adapted to each country)	Price indicator of banking price behavior (Adrian et al., 2019; Altavilla et al., 2020; Von Borstel et al., 2016)	ECB statistics
CDS	Five-year average banks' credit default swap (in log)	Price indicator of bank default risk (Fratzschler et al., 2016)	Datastream
VOL	Realized volatility measured as the standard error of daily price indices for each country	Price indicator of, risk-sharing measure, (Baele et al., 2014; Bekaert et al., 2013; Miranda-Agrippino & Rey, 2020)	Datastream
LTR	Ten-year interest rate, in percent	Price indicator of sovereign risk (Von Borstel et al., 2016)	Datastream
FCP	Volume of assets in foreign currency held by domestic banks, in millions of euros (in log). Series key: RA6.M.N.AT.W0.S121. S122.LE.A.FA.RT.F2.T. EUR.X1.N.N (adapted to each country)	National banks' volume of assets denominated in foreign currency (Buch et al., 2019; García López & Stracca, 2021)	ECB statistics

(Continues)

TABLE 1 (Continued)

Variable	Description	Motivation and previous evidence	Source
EXL	Volume of loans from domestic banks to the other euro area member states (non-MFIs), in millions of euros (in log). Series key: BSI.M.AT.N.A.A20.A.1.U5. 2000.Z01.E (adapted to each country)	Indicator of banking fragmentation (Al-Eyd & Berkmen, 2013; Bruno & Shin, 2015)	ECB statistics
DOL	Volume of domestic loans to the private sector from domestic banks, in millions of euros (in log). Series key: BSI.M.AT.N.A.A20.A.1.U6.20 (adapted to each country)	Volume indicator of domestic credit supply (Adrian et al., 2019; Bruno & Shin, 2015)	ECB statistics

^a Indicator proposed by the ECB in Indicators of financial integration in the euro area, ECB Statistics database, 2020.

models is not affected by unit-root and cointegration (Sims, 1988; Sims & Uhlig, 1991). Thus, all the variables are taken in levels.

3.3 | Country-level data

Following Bruno and Shin (2015), our variables can be classified into two categories representing the transmission channels from monetary policies to banks' risks, credits, and cross-border flows. The first set of variables are price indicators measuring the impact of monetary policies on financial and banking risk: *SPNFC*, the MFIs' lending margins on loans to nonfinancial corporations, *CDS*, the 5-year average banks' credit default swap, *VOL*, the realized volatility of daily price indices, and *LTR* is the 10-year interest rate for each European country. These variables are introduced in order to identify the risk-taking channel relating monetary policies and credit supply, as well as the financial markets (Adrian et al., 2019). In particular, lending margins have been used as a proxy for bank-pricing behavior (Altavilla et al., 2020; Von Borstel et al., 2016). In the literature, the effect of monetary policies on bank margins is unclear. While Adrian et al. (2019) predict a positive sign, Von Borstel et al. (2016) and Borio and Zhu (2012) document a mixed effect depending on sluggish rate adjustment and market forces. Altavilla et al. (2020) document a negative sign following unconventional monetary policy, especially in financially stressed countries. Our model therefore provides an empirical evaluation of the theoretical predictions. *CDS* represents the bank's default risk or the bank funding risk (Von Borstel et al., 2016). *VOL* is a proxy for the level of market risk, as volatility (e.g. the VIX) is known to be affected by monetary policy (Bekaert et al., 2013; Miranda-Agrippino & Rey, 2020). *LTR* measures the sovereign risk in each country (Von Borstel et al., 2016).

The second set of variables are volumes capturing banks' asset mix with a focus on cross border flows. The *FCP* variable measures the volume of assets in foreign currency held by domestic banks and is added in order to investigate whether banks respond to monetary policies by substituting assets internationally (García López & Stracca, 2021; Vari, 2020), which could alleviate the effectiveness of the monetary policy to provide credit to the Eurozone. We add an additional variable measuring the volume of domestic loans to the real sector (*DOL*) by domestic banks in order to document the credit channel in each country and the volume of loans from domestic banks to the other Eurozone member states (*EXL*). These variables mirror the objective pursued by the ECB as well as the considerations presented in Bruno and Shin (2015). They find that lower bank funding rates increase risk-taking and cross-border flows, a finding we aim to verify in the European context with our choice of variables. In addition, *EXL* is a measure of banking fragmentation within the Eurozone, as an objective of monetary policies is to increase regional implication of national banks within the Eurozone.

4 | METHODOLOGY

4.1 | The regional response to common monetary shocks

4.1.1 | Structural VAR model

The first models aim at explaining the heterogeneity in the reactions of the European monetary union members to ECB unconventional policy shocks at a regional level. Structural Bayesian VAR models are estimated according to the method developed by Sims and Zha (1998, 1999) and based on the available code.⁵ Bayesian inference ensures the model is free from unit-root (Sims, 1988; Sims & Uhlig, 1991) and allows us to use all the variables in levels. The methodology further allows to study either negative or positive shocks.

Letting L be the lag operator, the reduced form of the vector auto-regression model VAR(q) is given as:

$$A(L)Y_t = e_t, \quad (1)$$

where Y_t is the vector of endogenous variables, A is the $n \times n$ parameter matrix, and e_t is the vector of errors whose variance-covariance matrix has no restrictions, that is

$$E(e_t e_t^T) = \Omega \text{ and } E(e_t) = 0. \quad (2)$$

The structural moving average representation is:

$$Y_t = \Theta(L)\varepsilon_t, \quad (3)$$

with

$$e_t = P\varepsilon_t, \quad (4)$$

where P is an invertible matrix $n \times n$ that must be estimated to identify the structural shocks. The short-run constraints are imposed directly on P and correspond to some elements of the

matrix set to zero. The Θ_j matrix represents the impulse response functions to shocks ε_t of the elements of Y_t . The different structural shocks are supposed to be non-correlated and have a unitary variance:

$$E(\varepsilon_t \varepsilon_t^T) = I_n. \quad (5)$$

Ω is the variance–covariance matrix of the canonical innovations e_t , thus

$$E(e_t e_t^T) = PE(\varepsilon_t \varepsilon_t^T)P^T = PP^T = \Omega. \quad (6)$$

4.1.2 | Identification restrictions for the regional models

Let $Y = (MP; FINT; CDS; BOND; EONIA; FCP; EXL)$ the vector of endogenous variables and $\varepsilon_t = (\varepsilon_{mp}; \varepsilon_{fi}; \varepsilon_{brisk}; \varepsilon_{srisk}; \varepsilon_{liq}; \varepsilon_{fc}; \varepsilon_{frag})$ the vector of structural shocks, where ε_{mp} represents the shock of the unconventional monetary, and ε_{fi} , ε_{brisk} , ε_{srisk} , ε_{liq} , ε_{fc} , ε_{frag} are, respectively, the financial dispersion, the banking sector risk dispersion, the sovereign risk dispersion, the liquidity dispersion, the volume of assets in foreign currency in the banking sector, and the fragmentation shocks. Our objective is to identify the n^2 elements of the P matrix. The Ω matrix is symmetric and $n(n+1)/2$ orthogonalization constraints have already been imposed. The remaining 21 contemporaneous constraints are chosen according to the theoretical literature. First, we consider that the monetary policy is exogenous in the short term (Kim & Roubini, 2000; Sims & Zha, 1999). Second, we suppose that price variables are faster to respond to a shock than variables in volume. Finally, we consider that an external loan shock affects the other variables with a monthly delay (Kim & Roubini, 2000).

4.2 | National impacts of common monetary policy shocks

In this section, we study the national impact of the ECB monetary shocks. We implement GVAR models (Dees et al., 2007),⁶ which allows for an assessment of the influence of the common ECB monetary shocks on each country in the Eurozone, while considering both the financial interdependencies among the economies as channels of transmission and their relative economic weight in the euro area. Our approach further documents the literature documenting the pass-through of monetary policy measures on (i) European banks (Altavilla et al., 2020), (ii) one or several European countries (Al-Eyd and Berkmen 2013), (iii) the Eurozone as a whole (Colozza & Barucci, 2021; Mayordomo et al., 2015), or (iv) different country groups (Altavilla et al., 2020; Von Borstel et al., 2016). In contrast with these contributions, our analysis assesses the simultaneous reaction to a common shock of each member country. This decomposition allows for precisely identifying the risk-taking channel for each individual country considering the potential heterogeneity sources within the Eurozone. The model also offers a joint analysis of the impacts of common monetary policy measures on financial fragmentation. Our sample includes 15 Eurozone members⁷ as well as the United States in order to measure the international spillovers of the ECB shock. In addition, the U.S. interest rate is included in order to account for the international economic context. Finally, the country-specific foreign variables are constructed considering financial links measured by relative capital flows between each country and its

partners. Specifically, the relative importance of country i to country j is measured by the share of inflows and outflows of portfolio investment relative to total investment in country i .⁸

The VARX(p_i, q_i) model for country i with p_i as the lag order of the domestic variables and q_i as the lag order of the foreign variables is written as follows⁹:

$$Y_{it} = a_{io} + a_{i1}t + \sum_{p=1}^{p_i} A_{i,p} Y_{i,t-p} + \sum_{q=0}^{q_i} B_{i,q} Y_{i,t-q}^* + \sum_{q=0}^{q_i} C_i \omega_{t-q} + e_{it}, \quad t = 1, \dots, T; i = 0, \dots, M \quad (7)$$

with $Y_{i,t}$ the $n_i \times 1$ vector of domestic variables, $Y_{i,t}^*$ the $n_i^* \times 1$ vector of foreign variables,¹⁰ a_{i1} the $n_i \times 1$ vector of linear trend coefficients, $A_{i,p}$ the $n_i \times n_i$ matrix of lagged coefficients, and $B_{i,q}$ the $n_i \times n_i^*$ matrices of fixed coefficients, ω_t is the vector of global shocks considered as weakly exogenous,¹¹ $e_{i,t}$ is the $n_i \times 1$ vector of country-specific shocks whose variance-covariance matrix has no restrictions. Let $Y = (MP; SPNFC; CDS; VOL; LTR; FCP; EXL; DOL; LTR; FCP; SPNFC; CDS; VOL)$ be the set of variables for a given country with MP being the ECB unconventional monetary shock (each three monetary shocks are studied independently).

$Y_{i,t}^* = \sum_{j=1}^M w_{ij} Y_{jt}$ and $w_{ii} = 0$, $w_{ij}, j = 0, \dots, M$ represent the fixed financial weights such as $\sum_{j=1}^M w_{ij} = 1$.

If we suppose that $Z_{it} = \begin{pmatrix} Y_{it} \\ Y_{it}^* \end{pmatrix}$ and $Z_{it} = W_i Y_t$ with W_i the $(n_i + n_i^*) \times n$ financial weights matrix

$$H_{io} Z_{it} = h_{io} + h_{i1}t + H_{i1} Z_{it-1} + \dots + H_{i,p_i} Z_{i,t-p_i} + \Omega_{i1} \omega_{t-1} + \dots + \Omega_{i,q_i} \omega_{t-q_i} + e_{it}, \quad (8)$$

where $H_{io} = (I_{ki} - B_{io})$, $H_{i1} = (A_{i1}, B_{i1})$, $H_{ij} = (A_{ij}, B_{ij})$, for $j = 1, \dots, p_i$.

The countries' specific models can be combined to form the GVAR(p) model with the $n \times 1$, $n = \sum_{i=0}^M n_i$, global vector $X_t = (Y_t', \omega_t')'$:

$$G_o X_t = h_o + h_1 t + G_1 X_{t-1} + \dots + G_p X_{t-p} + e_t, \quad (9)$$

$$X_t = G_0^{-1} h_{io} + G_0^{-1} h_{i1} t + G_0^{-1} G_1 X_{t-1} + \dots + G_0^{-1} G_p X_{t-p} + G_0^{-1} e_t, \quad (10)$$

$$X_t = b_o + b_1 t + F_1 X_{t-1} + \dots + F_p X_{t-p} + \varepsilon_t \quad (11)$$

with $b_o = G_0^{-1} h_{io}$, $b_1 = G_0^{-1} h_{i1}$, $F_1 = G_0^{-1} G_1 \dots F_p = G_0^{-1} G_p$, and $\varepsilon_t = G_0^{-1} e_t$. b_o and b_1 are $n \times 1$ vector of coefficients, F as the $n \times n$ matrix of coefficients and ε_t as the $n \times 1$ vector of reduced form shocks, which are linear functions of the country-specific shocks $e_{i,t}$. The orthogonalized impulse response functions (OIRFs) of a one standard error shock depend on the variables' ordering (we use lower triangular matrix based on a Cholesky decomposition) and allow us to study the impulse response function at time t to the l th equation of the model on the n th variable. Confidence intervals at a 90% level of significance are obtained using the bootstrapping procedure described in Dees et al. (2007). In order to measure the international spillovers of the ECB monetary policy, we also include equations to document the U.S. case using domestic loans (*DOL*), the long-term interest rate (*LTR*), and the realized volatility (*VOL*) in the U.S. Given that all variables are $I(1)$, we consider corresponding cointegrating VAR models. The lag orders depend on country-specific VARX models and are obtained via a traditional AIC tests procedure.

5 | RESULTS

5.1 | The regional fragmentation: SVAR models

Impulse responses and variance decompositions of banking and financial aggregated variables following a variation of a standard deviation of the monetary policy variables are reported in this section. The confidence intervals for the impulse response functions based on structural Bayesian VAR models are obtained from the procedure proposed by Sims and Zha (1999).¹²

Figure 1 presents the impulse response functions of regional variables to the three main measures implemented by the ECB. First, we document price dispersions' reactions to monetary policy shocks. Monetary policy shocks positively affect financial integration, *FINT*. The effects on interest rates and QE shocks are permanent, but limited with a variance decomposition under 10%, while *LTRO* shocks have a positive but temporary effect. In addition, interest rates and *LTRO* shocks also reduce dispersion in bank default risk across the EU (*CDS*) and have a positive effect on *EONIA* dispersion. Regarding the government bond market fragmentation, a positive shock in QE and a negative shock in interest rates decrease the dispersion of the long-term spread at the regional level (*BOND*). This finding extends the results of Al-Eyd and Berkmen (2013) and Szczerbowicz (2015), who demonstrate the positive impacts on money market instruments during the 2007–2012 period. Our results mirror the findings in Altavilla et al. (2020), who show a positive price effect of nonstandard measure on lending rate dispersion in the Eurozone. However, the variance decompositions show that these effects are limited (see Appendix C, Table C1).

Second, the volume of assets in foreign currency (*FCP*) increases after a negative *ECBLR* shock and a positive QE shock as demonstrated by Fratzscher et al. (2016). Finally, the impacts on the volume of external loans (*EXL*) are not significant after an *ECBLR* and a *LTRO* shock. There is a positive impact after a QE shock, but the variance decomposition remains low.

Our regional assessment leads us to conclude that the unconventional ECB measures implemented during the period of analysis contribute to the reduction of the heterogeneity between countries by decreasing strategic price spreads, but have a limited regional impact on aggregate volumes in the banking sector. Therefore, cross-country risk-sharing in the banking sector remains limited. A decrease in interest rates has an impact on both banking and financial risk dispersion. Our results thus extend Bruno and Shin's (2015) assessment of the relevance of interest rate policy on banking and financial risk to the question of banking and financial fragmentation, suggesting that the effects of unconventional monetary policies are more specific. Indeed, *LTRO* shocks have an impact on banking risk dispersion through a tightening of the *CDS* and *EONIA* spreads, whereas QE shocks mainly reduce financial fragmentation through stock and bond spreads.

5.2 | National responses

In this section, we present results for the disaggregated national approach using GVAR models that allows for the estimation of a national response to each shock. The OIRFs and their associated standard errors are obtained following the methodology presented in Dees et al. (2007).

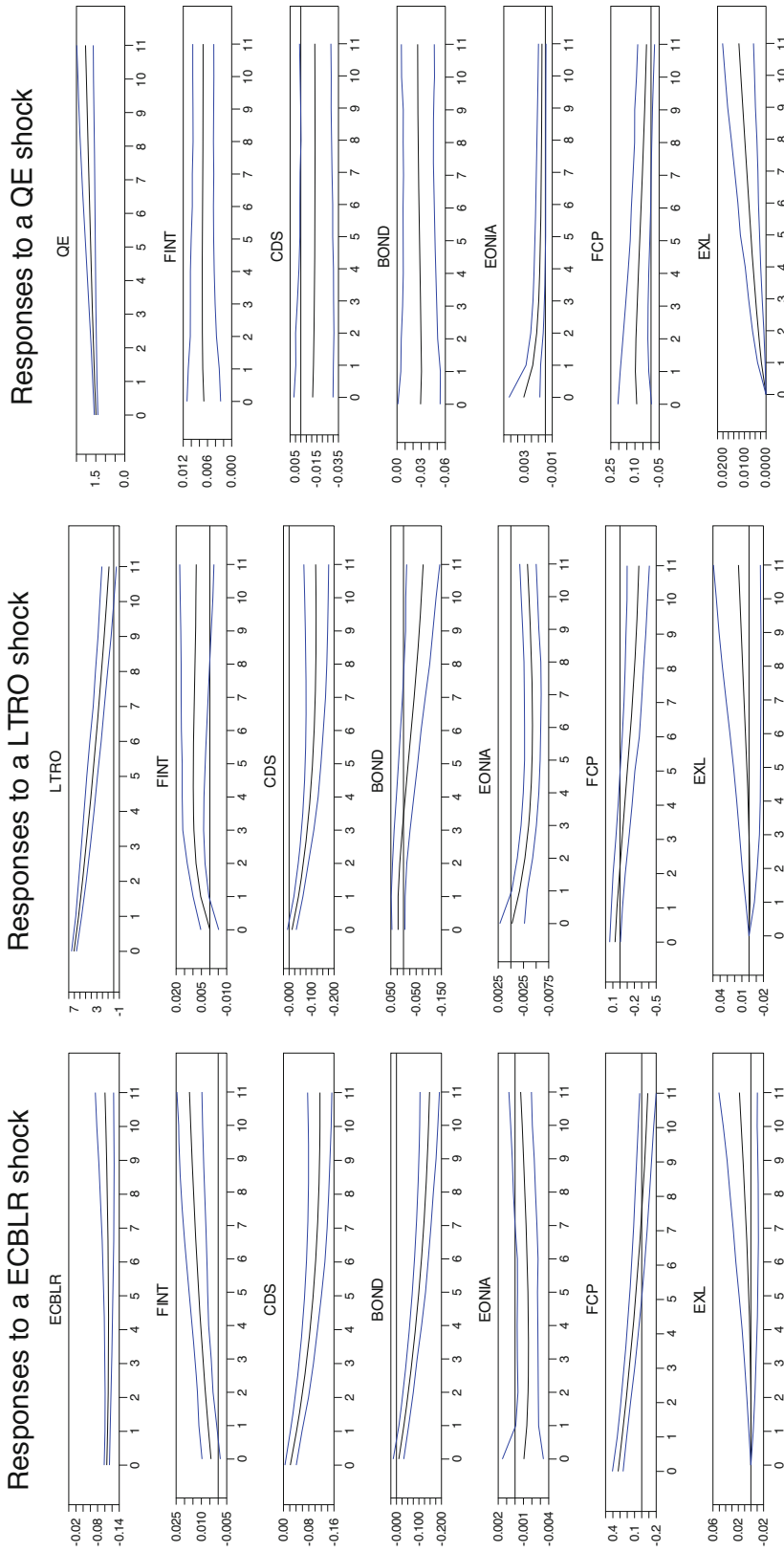


FIGURE 1 Impulse response functions for the Eurozone. Impulse response functions following (a) a negative shock in interest rates, (b) positive LTRO, and c) positive QE shock. Impulse response functions are obtained from the estimation of equation (3feq) and represent the adjustment monthly data over the 2008–2018 period. The results are displayed in columns, and variables are presented in order. The variable order is the monetary instrument (ECBLR, LTRO, QE), financial integration (FINT), banking sector credit default swap dispersion (CDS), 10-years BOND yields dispersion (BOND), EONIA dispersion (EONIA), long term bond dispersion across the Eurozone, volume of foreign currency assets in the banking sector (FCP), and volume of external loans (EXL). The response is the solid black line, and the associated confidence intervals (Sims & Zha, 1999) are the solid blue lines. [Colour figure can be viewed at wileyonlinelibrary.com]

5.2.1 | The impact of a negative interest rate shock

Figure 2 shows the impulse response functions for the European countries' variables following a decrease in the ECB interest rate (*ECBLR*). First, the interest rate shock affects the domestic lending spread (*SPNFC*) differently. In many countries (Germany, France, Malta, Austria, and

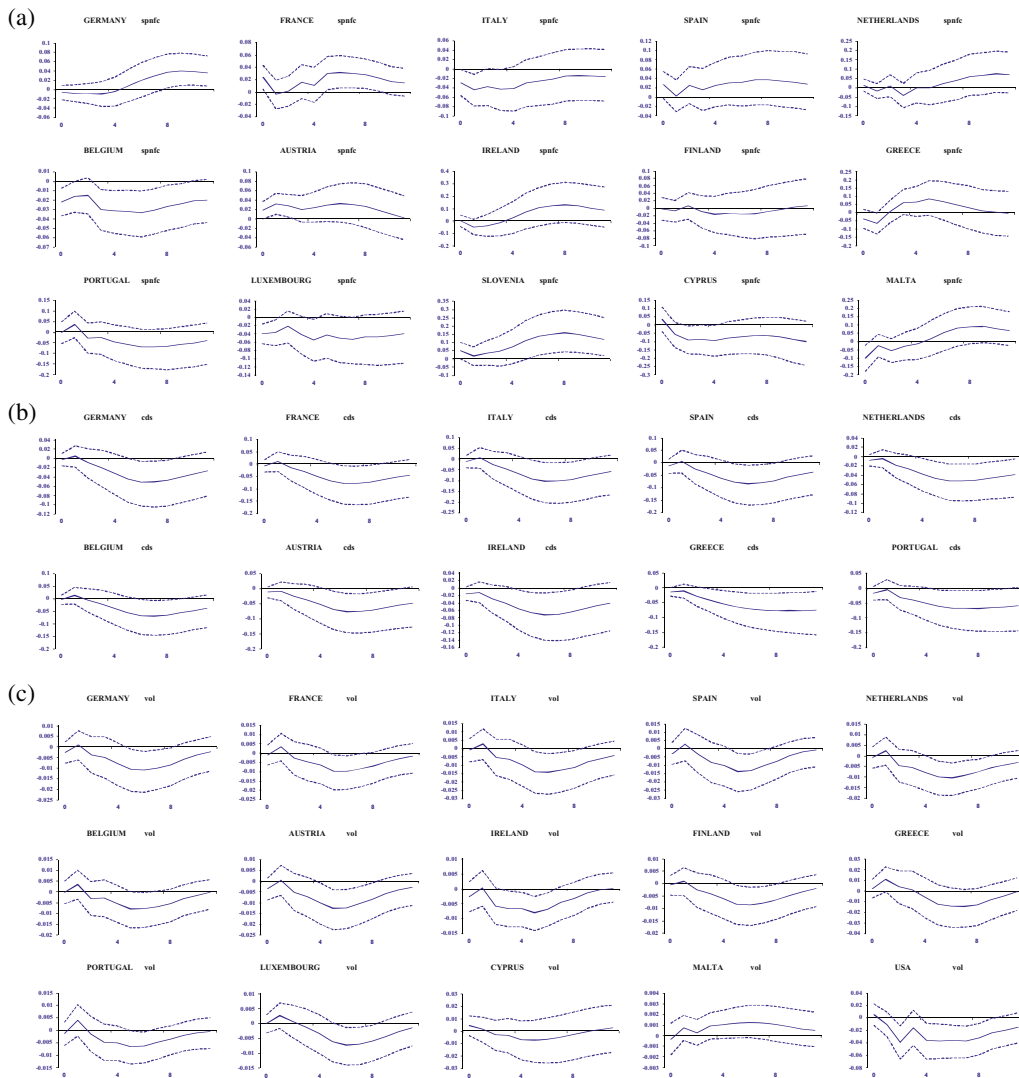


FIGURE 2 GIRFS following a negative interest rate shock. (a) Impact on national banks' lending rate spread. (b) Impact on national banks' CDS. (c) Impact on financial volatility. (d) Impact on national long-term interest rates. (e) Impact on national banks' assets in foreign currency. (f) Impact on national banks' domestic loans. (g) impact on national banks' external loans. This figure presents the OIRFs following a negative interest rate shocks. OIRFs are obtained following the estimation of the GVAR model presented in Equation (11). Each panel presents the effect of the shock for each countries' variables, if the variable is available. The solid line represents the OIRFs' estimates, and the dotted lines are the associated confidence intervals. Variables are classified from the most exogenous to the most endogenous ones. Countries are ranked according their weight in terms of GDP. [Colour figure can be viewed at wileyonlinelibrary.com]

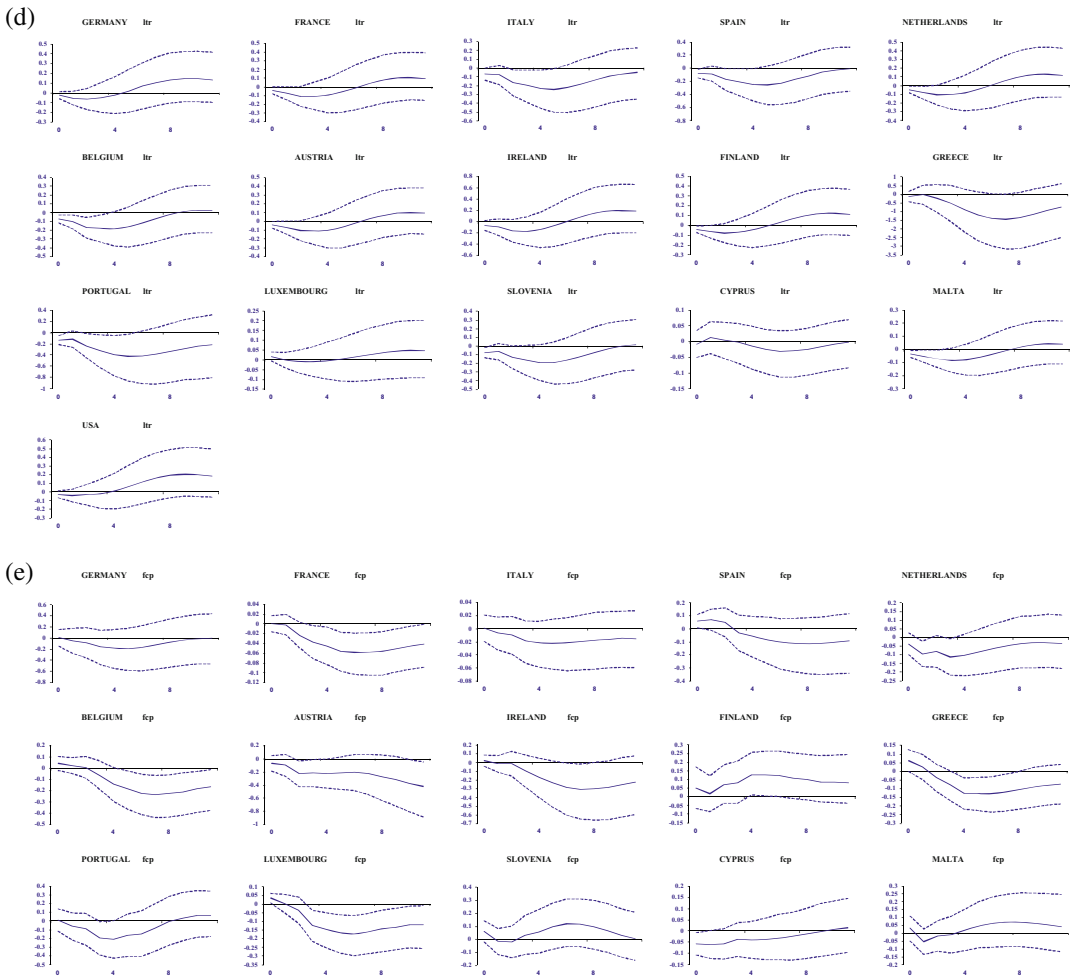


FIGURE 2 (Continued)

Slovenia), the domestic lending spread increases. This is mainly due to the banks' risk perception of the impact of a negative interest shock in a context of zero lower bound (Von Borstel et al., 2016). This is in line with the U.S. evidence presented in Bruno and Shin (2015), documenting that negative interest rate shock entails more risk-taking from U.S. banks. Our analysis, however, underscores that the impact of interest rate policies depends on the initial health of the banking sector. For instance, in Italy, the impact on domestic banks' funding costs and lending rates is significant and negative, as reported in Zoli (2013). Greece and Cyprus also benefit from lower funding cost due to European Financial Stability Mechanism programs. In Belgium and Luxembourg, countries with highly competitive banking sectors, banks transfer the official interest rate decrease to their lending rates and their margins accordingly decrease. Panel b shows that an interest rate decrease reduces banks' default risk measured as the decrease of banks' CDS. Panel c shows that the interest rate shock generates a growth in confidence on financial markets decreasing significantly the financial volatility (*VOL*), except in countries with significant macroeconomic risks such as Greece, Cyprus, and Malta. This result is reminiscent of the

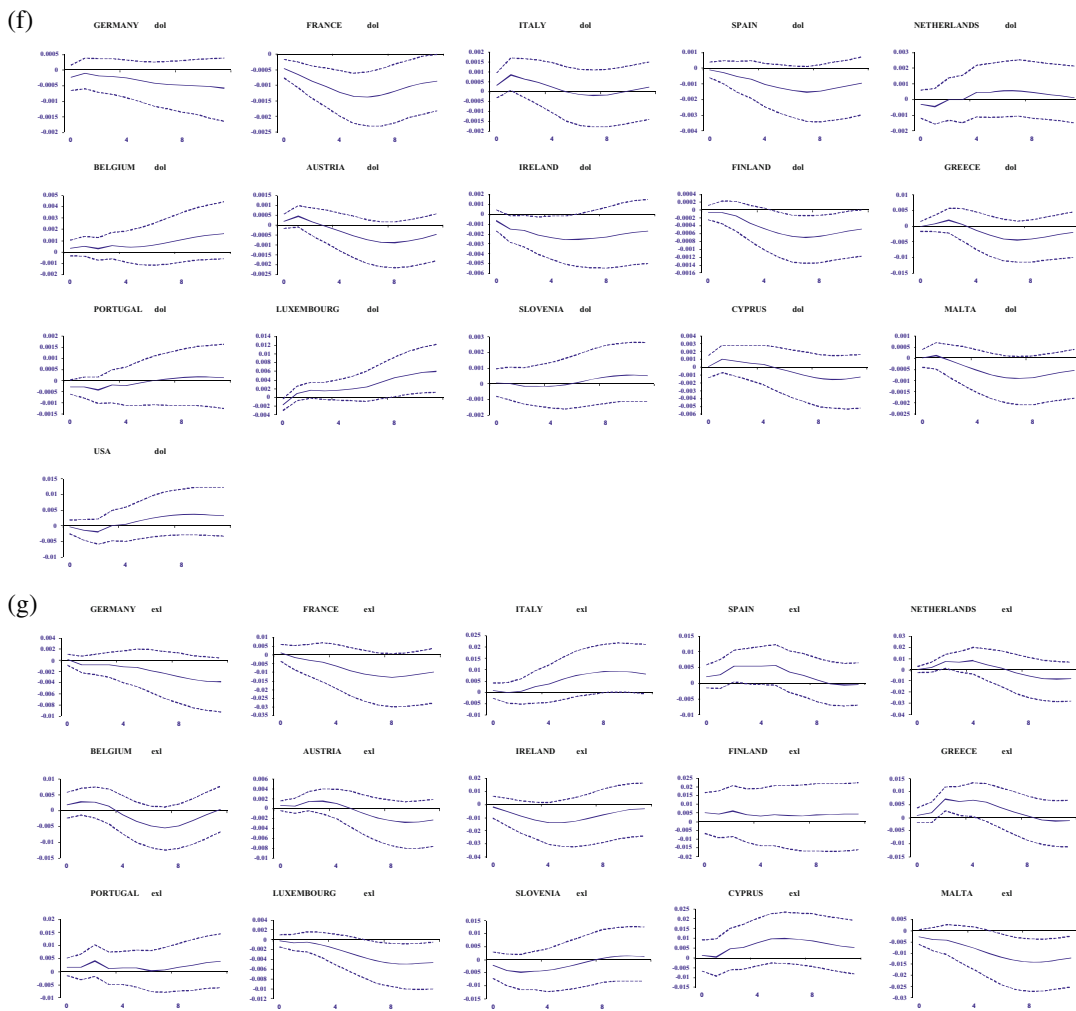


FIGURE 2 (Continued)

evidence presented in Bekaert et al. (2013) and Bruno and Shin (2015), suggesting a dampening of the *VIX* risk index when interest rates are lowered. Our result further generalizes this evidence for international spillover effects, as financial volatility also decreases in the U.S., a result highlighting that the ECB signal is positive for international investors. The impact of the interest rate shock on the long-term interest rate (*LT*) presented in panel d generates a decrease in the long-term interest rates for all countries, except in Luxembourg and Cyprus, due to the low maturity of the government debt and the financial tensions of the country during the period of analysis, respectively.

Panel e demonstrates that national banks' assets in foreign currency often decrease following a negative interest rate shock. Banks therefore reduce the amount of assets held in foreign reserves (*FCP*) due to the strength of the euro in comparison to other international currencies. In fact, the interest rate differential between the Fed Fund rate and the ECB Marginal lending facility rate was positive in 2008 and subsequently reversed in favor of the Eurozone during the sample period (see Figure A1). Therefore, the negative shock in the euro interest rate was not followed

by a reallocation of assets in foreign currency, given that the euro was not expected to depreciate with respect to the dollar.

Finally, we investigate the impact on the banking sector's balance sheet. The effect of the ECB interest rate shock on the volumes of domestic external loans (*DOL*) is negative (France, Ireland and Finland) or nonsignificant. In terms of external loans volume (*EXL*), the interest rate is largely ineffective during this period with the exception of an increase in external loans for Greece and Spain and a delayed decrease in Luxembourg and Malta. These results extend the literature that demonstrates the diminished impact of traditional monetary policy measures through the credit channel on the lending rate in particular at the zero-lower bound (Von Borstel et al., 2016). It underscores the limit of interest rate instruments to generate economic recovery through the traditional credit channel, in the zero lower bound context. The impact of a decrease in the ECB lending rate has no effect on the volume of domestic credit in United States because the cost of financing is similar in the two regions for the studied period.

In summary, our results underscore that at the zero lower bound, traditional monetary policy shocks have a mitigated effect. While we document positive effects on risk variables measured by price indicators in countries with favorable initial conditions, conventional monetary policy is ineffective at influencing volumes indicators. This result therefore allows for new European insight on the documented relationship among interest rates, risk-taking, and cross-border flows (Bruno & Shin, 2015). While interest rates succeed at modifying risk-taking, we find only a modest effect on the volume of external loans.

5.2.2 | The impact of a positive LTRO shock

Figure 3 reports the impulse response functions for European countries' variables following an increase in banks' liquidity (*LTRO*). In panel a, the effects of the positive *LTRO* shock on the spread of lending rate (*SPNFC*) are significant and negative for Germany, France, Greece, Luxembourg, Slovenia, and Malta. In line with the evidence presented in Altavilla et al. (2020), this effect is more persistent in a financially stressed country such as Greece (Tables A1 and A4). Portugal is the only country where the lending spread increases because of significant macro and borrower risks during the period of analysis (ECB, 2013). The effect on the domestic banking sectors' default risk (*CDS*) is nonsignificant except in Greece, where the banking risk increases due to solvency problems and large amounts of nonperforming loans (see the ECB financial integration report 2018 and Tables A1 and A3 as well as Figure A2). The financial volatility (*VOL*) increases for most countries. This result suggests that investors do not completely understand the credit easing policy and that the signal channel is ineffective both regionally and internationally, as the U.S. reactions are also insignificant (Gagnon & Gimet, 2020). Panel d shows a decrease in long-term interest rates (*LR*), but only in the U.S., as well as core countries with a sustainable level of debt. The purchase of government bonds by banks with the liquidities injected by the ECB can explain this result. Moreover, Fratzscher et al. (2016) show that after a *LTRO* shock, global funds are invested mainly in bonds in advanced economies at an international level and in core European countries. As a result, we observe an increase in the spread at a European level in the regional analysis.

In addition, panel e shows that the impact on assets in foreign currencies held by the domestic banking sector (*FCP*) is positive in many countries, in particular Germany, Austria, Italy, Ireland, and Spain. Therefore, banks in these countries use the new liquidity provided by central bank operations to buy foreign assets (Vari, 2020). In particular, German and Austrian banks have been

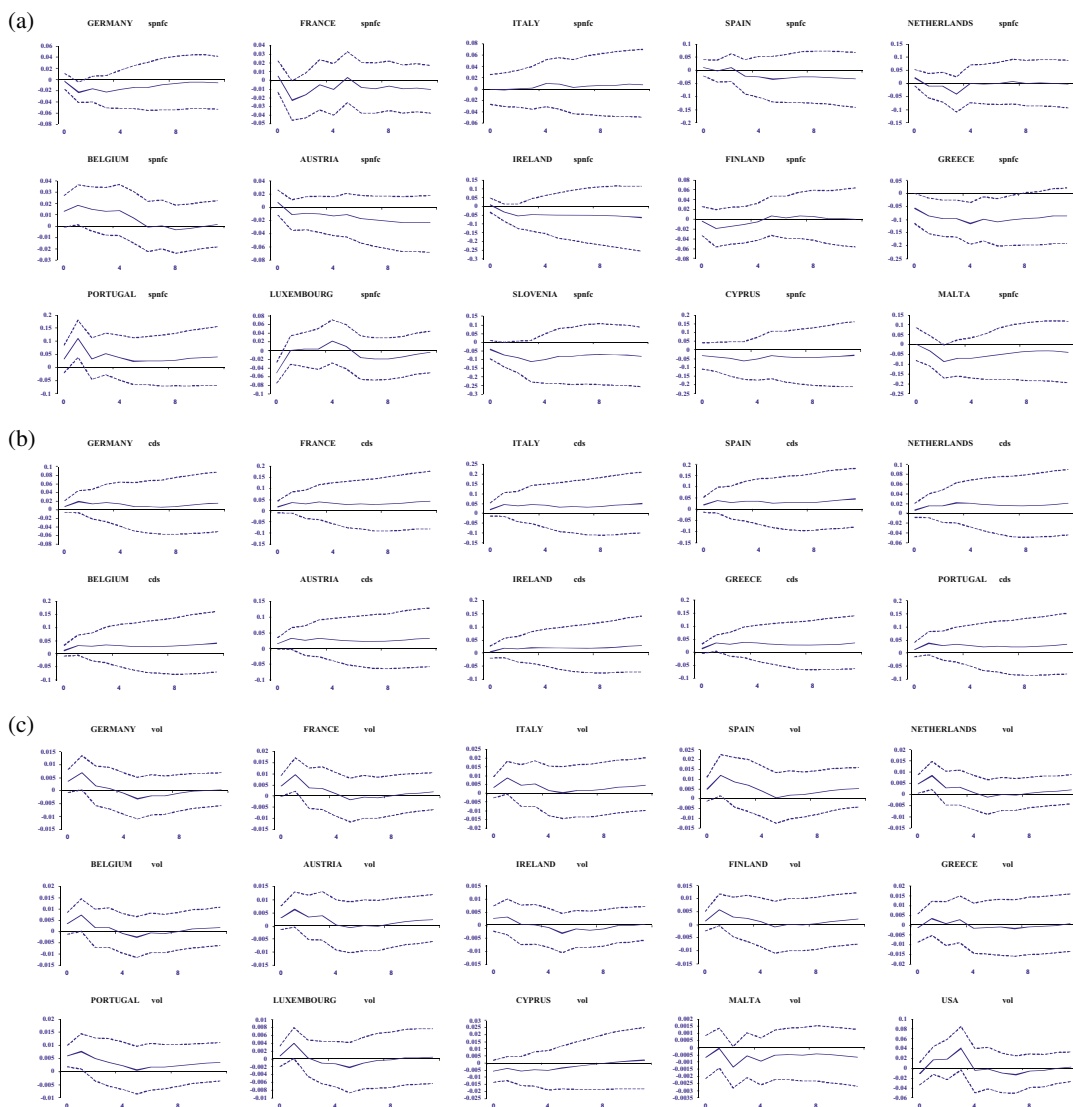


FIGURE 3 OIRFs following a positive LTRO shock. (a) Impact on national banks' lending rate spread. (b) Impact on national banks' CDS. (c) Impact on financial volatility. (d) Impact on national long-term interest rates. (e) Impact on national banks' assets in foreign currency. (f) Impact on national banks' domestic loans. (g) Impact on national banks' external loans. This figure presents the OIRFs following a positive shock in LTRO. GIRFs are obtained following the estimation of the GVAR model presented in Equation (11). Each panel presents the effect of the shock for each countries' variables, if the variable is available. The solid line represents the OIRFs' estimates, and the dotted lines are the associated confidence intervals. Variables are classified from the most exogenous to the most endogenous ones. Countries are ranked according their weight in terms of GDP. [Colour figure can be viewed at wileyonlinelibrary.com]

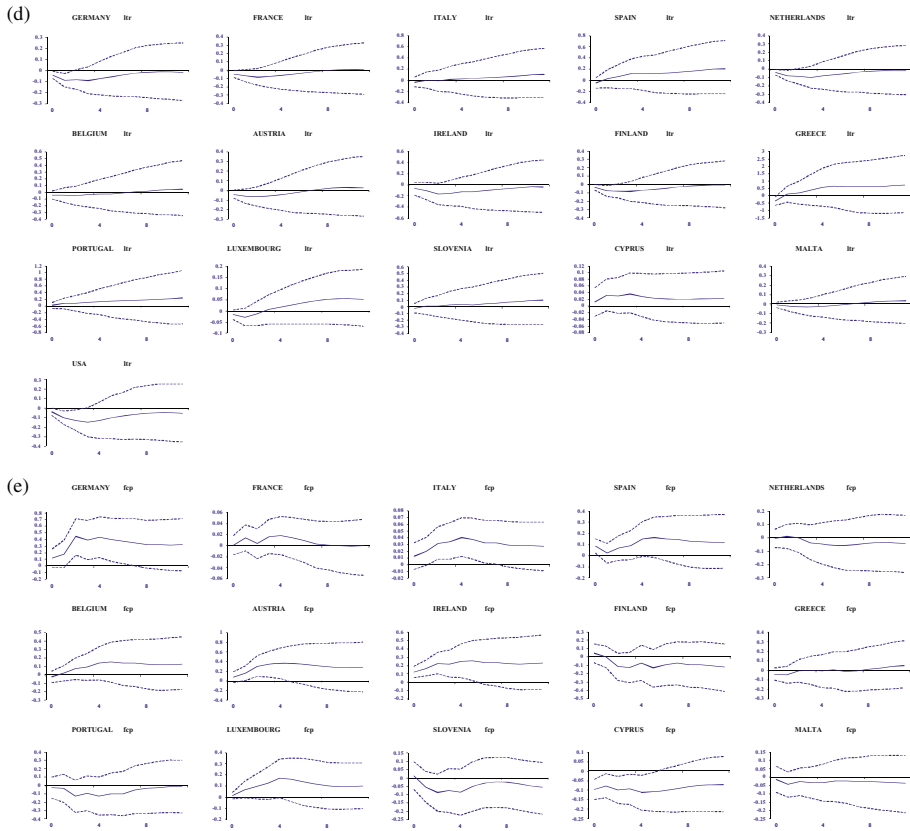


FIGURE 3 (Continued)

shown to invest more heavily in American financial assets during the sample period (García López & Stracca, 2021). The exception is in Cyprus, where external foreign assets are inferior to the external foreign liabilities (see Table A5) (Krogstrup & Tille, 2018). Finally, LTROs do not generate growth in the domestic banking sector (*DOL*, panel f). External loans (*EXL*, panel g) increase in Germany, Austria, and Malta. Again, German and Austrian banks used the liquidity provided by the ECB to invest abroad within the Eurozone rather than domestically.

In summary, LTROs were designed to stimulate credit to the private sector. These intended effects were mitigated since we do not find evidence that domestic credit increases after LTRO operations, a result supported by the observations in Ivashina et al. (2015). Rather, there were some unintended effects of LTROs abroad and within the Eurozone, not all of them negative. In fact, LTRO operations contributed to reducing fragmentation in the following way: the excess liquidity in Germany and Austria was invested elsewhere within the Eurozone (as shown by external loans), therefore increasing capital mobility within the zone. Finally, we document other consequences of LTRO operations. Rather than using their liquidity to increase their domestic loans, German and Austrian banks also invested in European core countries and USD-denominated assets, which contributed to the decrease in the long-term bond yields in those countries. They also invested in foreign assets (Colangelo et al., 2017; Krogstrup & Tille, 2018). This behavior from these banks did not meet the ECB's objective to increase credit within the Eurozone. In that case, our regional analysis suggests this can be associated with European fragmentation, a result

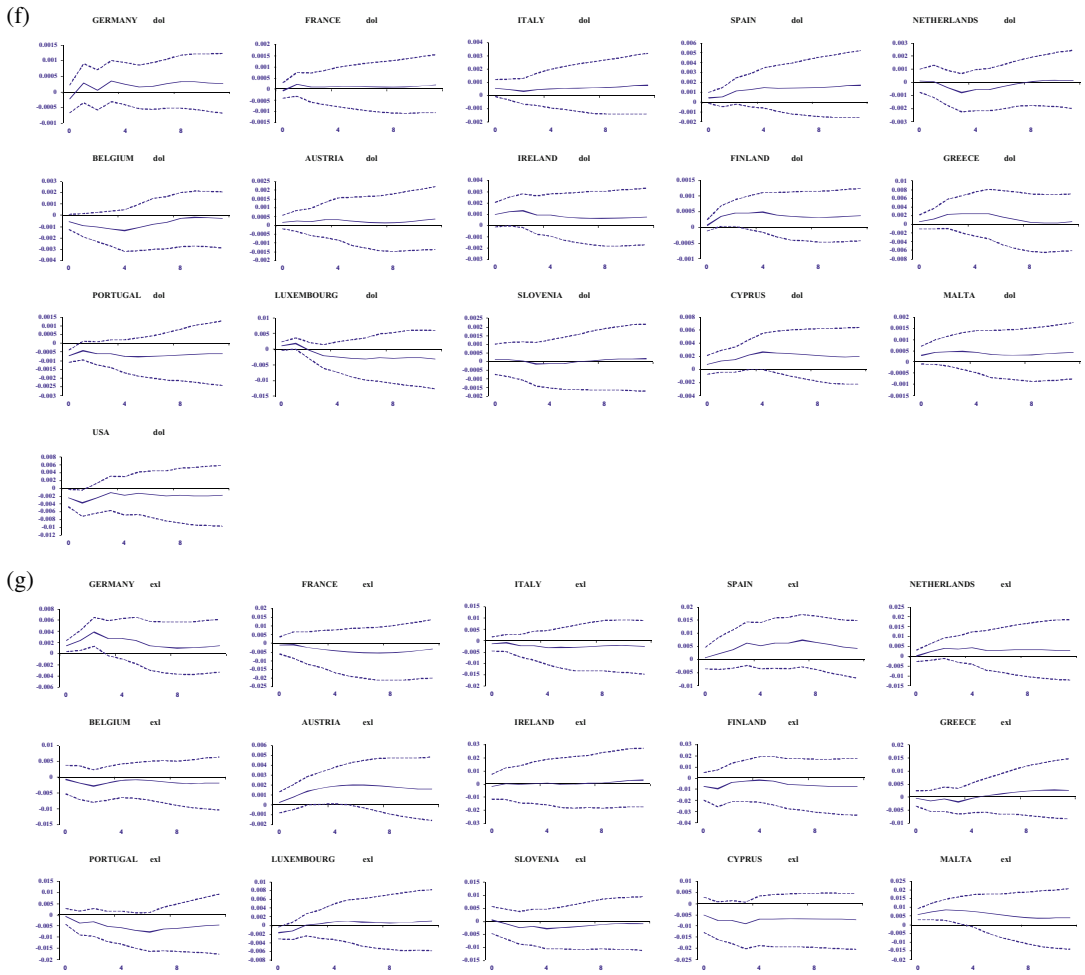


FIGURE 3 (Continued)

extending the theoretical findings presented in Vari (2020). However, the international impact of the European LTRO shock is negative on the volume of domestic credit in United States because international banks substitute their domestic lending to foreign credits in countries where the liquidity constraints are lower (Buch et al., 2019).

5.2.3 | The impact of a positive QE shock

Figure 4 presents the impulse response functions for following a positive shock in the purchases of European debt securities by the ECB (QE). We first describe the responses on several price measures. The lending spread decreases (SPNFC) in Spain, Greece, Slovenia, and Malta. These countries have more vulnerable banking sectors with the lowest level of capital and the highest share of nonperforming loans (see Table A1). This result is in line with evidence presented in Altavilla et al. (2020), Gabrieli and Labonne (2022), and Neuenkirch and Nöckel (2018). QE

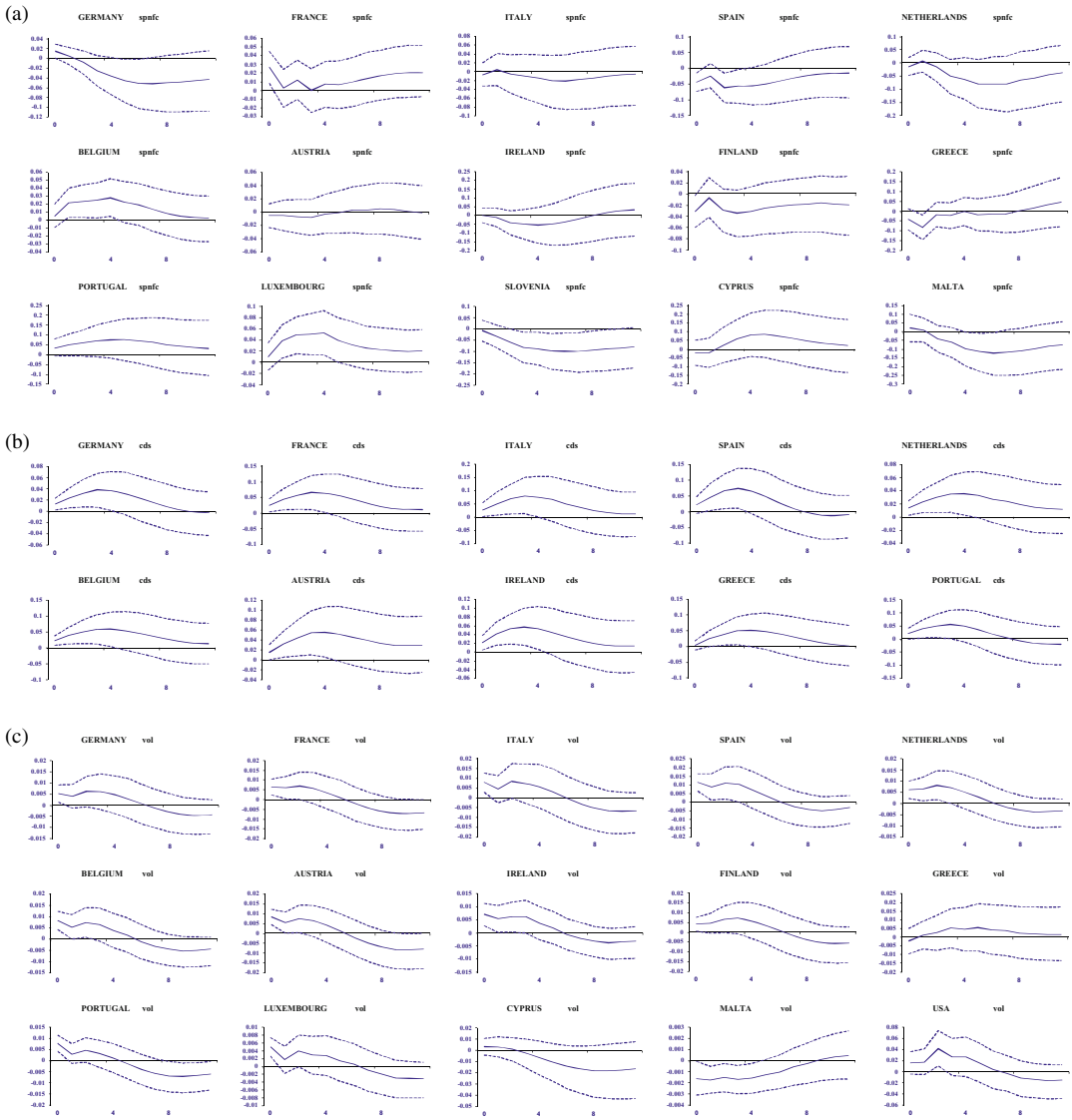


FIGURE 4 OIRFS following a positive *QE* shock. (a) Impact on national banks' lending rate spread. (b) Impact on national banks' CDS. (c) Impact on financial volatility. (d) Impact on national long-term interest rates. (e) Impact on national banks' assets in foreign currency. (f) Impact on national banks' domestic loans. (g) Impact on national banks' external loans. This figure presents the OIRFS following a positive shock in quantitative easing (*QE*). OIRFS are obtained following the estimation of the GVAR model presented in Equation (11). Each panel presents the effect of the shock for each countries' variables, if the variable is available. The solid line represents the OIRFS' estimates, and the dotted lines are the associated confidence intervals. Variables are classified from the most exogenous to the most endogenous ones. Countries are ranked according their weight in terms of GDP. [Colour figure can be viewed at wileyonlinelibrary.com]

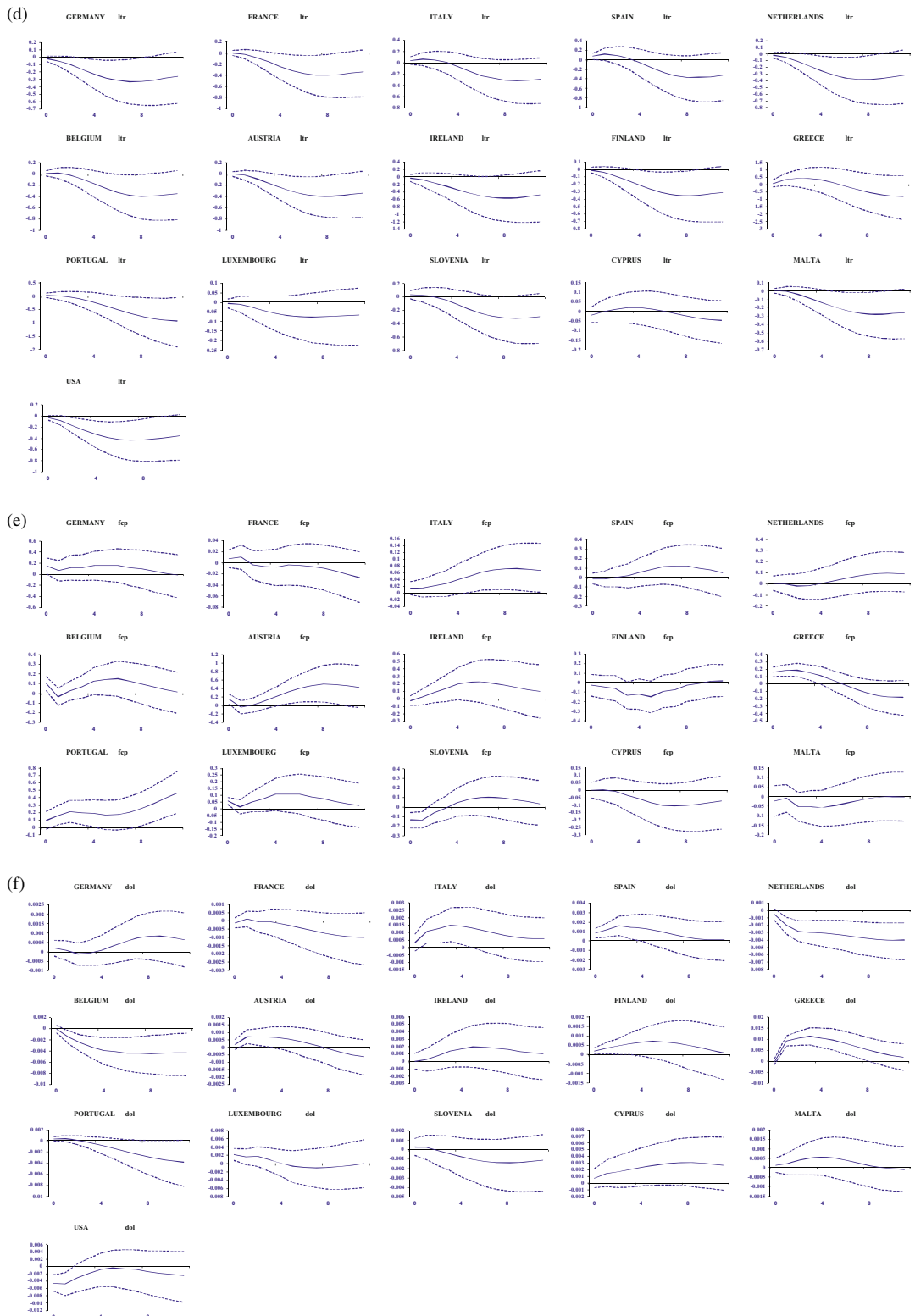


FIGURE 4 (Continued)

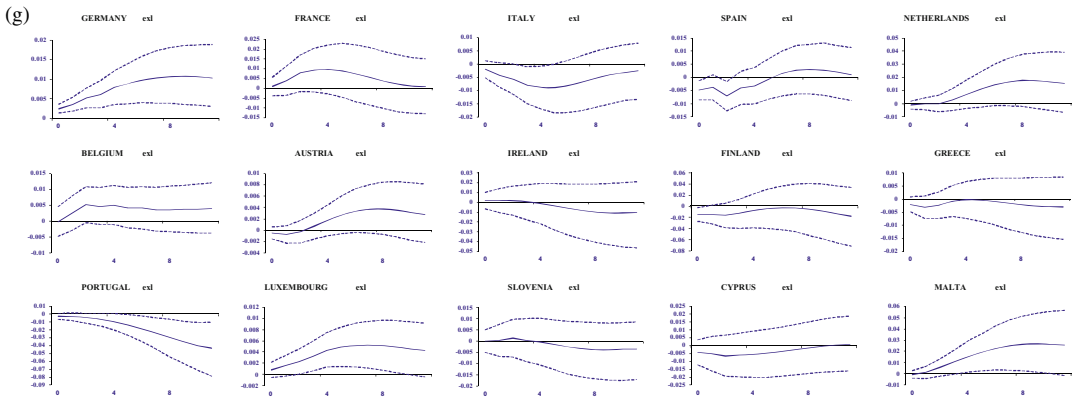


FIGURE 4 (Continued)

also has a positive impact on the lending spread in Belgium and Luxembourg, which can be explained by a substitution from indirect to direct financing (Von Borstel et al., 2016). Our results related to the CDS spreads also imply that QE can induce portfolio reallocation in riskier assets (Fratzscher et al., 2016; Pagliari, 2021), as the default risk increases temporarily in the countries in our sample following an increase in QE operation. On the financial market, realized volatility temporarily increases with QE for most countries, suggesting the shock generates some instability at a regional and an international level. Our results complement the evidence presented in Miranda-Agrippino and Rey (2020). They suggest that QE measures in the U.S. following the credit freeze crisis increase global risky asset prices, increase global cross-border flows, and sharply increase the VIX. This is an important change in financial markets given that the pre-crisis consensus was that lax monetary policies decrease VIX in the U.S. (Bekaert et al., 2013). In terms of a decrease of the long-term interest rates (LR), the QE measures first benefit the countries that have the lowest public debt and deficit (Germany, France, Netherlands, Austria, Finland, and Belgium). Since the long-term interest rates are also reduced in Ireland, Portugal, Slovenia, and Malta, contributing to low dispersion inside the Eurozone, this evidence supports a reduction in fragmentation measured as long-term interest rates after QE measures, as found in the regional model. The shock spills over into the United States, where the long-term rate decreases, highlighting the positive signal of QE shock and the role of the portfolio transmission channel (Neely, 2015). This result extends the findings of Fratzscher et al. (2016) in the case of the ECB.

Fratzscher et al. (2016) find that positive shocks in QE imply a devaluation in the euro. We find that this devaluation also causes an increase in assets in foreign currency held by banks (FCP) in several countries of the Eurozone in particular those with the lowest level of currency holdings that benefit from a decrease in the cost of holding reserves (Italy, Belgium, Austria, Ireland, Greece, Portugal, Luxembourg) (FCP) (see Table A5). These increases in foreign capital assets are also reminiscent of the decrease in the U.S. long-term rate found above.

Panel f shows the volume of domestic loans (DOL) increases in most periphery countries: Italy, Spain, Austria, Finland, Greece, and Cyprus, While external loans (EXL) decrease in Italy, Spain, Finland, Greece, and Portugal, they increase for Germany, France, Netherland, Belgium,

Austria, and Luxembourg. Thus, core countries raise their foreign credits to periphery countries benefiting from a better macroeconomic context after the QE shock, reducing fragmentation. The combined analysis of these two variables suggests that periphery countries substitute external loans with domestic loans after a QE shock. This is another indication that QE measures contribute to a reduction in fragmentation, as liquidity seems to be going where it is most needed. At an international level, the European QE shock produces an increase in foreign lending for U.S. banks in comparison to domestic credit. This phenomenon, related to the risk-taking channel in the literature, can be explained by the decrease in macroeconomic and borrower risks within the Eurozone (Buch et al., 2019; Ivashina et al., 2015).

In conclusion, we find three main consequences in the financial and banking sectors following QE shocks. (1) QE facilitates banks' risk-taking, as reflected in the increased default risk, in the increased domestic credit in peripheral countries, and in the increased external credit within the Eurozone from core countries. (2) QE measures reduce financial and banking fragmentation by reducing long term rates across the Eurozone, increasing cross-border loans within the zone by providing more domestic credits in countries that need it the most. (3) QE also has unintended external spillovers, as it increases stock market volatility and bank exposure to foreign assets.

6 | DISCUSSION AND CONCLUSION

This article studies the importance of financial and banking fragmentation through the risk-taking channel relating monetary policies, credits, and cross-border flows. The basis for our approach is to extend the analysis of the American case presented in Bruno and Shin (2015) to the post-2007 crisis in the Eurozone. Our methodology specifically allows for national heterogeneity and fragmentation while studying the joint effect of common monetary policy shocks. We show that the risk-taking channel is heterogeneous inside the Eurozone, in part because of banking and financial fragmentation, which limits the beneficial impacts of monetary policies on credit volume. However, our analysis also shows that monetary policies can contribute to alleviate financial and banking fragmentation.

Our analysis yields three important conclusions. First, conventional monetary policy alone cannot increase credit volumes. However, unconventional monetary policies can partly achieve this goal. LTROs effectively increase German banks' external credit to the rest of the Eurozone. Quantitative easing has widespread effects on credit, increasing domestic loans in peripheral countries and external loans from core countries. Second, fragmentation is still present in the Eurozone, although monetary policies can lessen its symptoms. All monetary measures succeed in reducing price dispersion indicators, but only unconventional measures have an impact on volume indicators. Third, while unconventional monetary policies are effective at improving credit conditions and reducing fragmentation, they also have additional unintended consequences. Indeed, we empirically show that the presence of fragmentation suggests that unconventional measures imply a rebalancing of European banks asset mix. In particular, after an LTRO shock, banks in core countries invest their excess liquidity in U.S. assets, limiting the European impact on credit supply. QE operations also entail financial risks in the European banking sector and an increased global financial market volatility.

Even though monetary policies can alleviate fragmentation, they cannot completely solve the problem. In the short term, the last measures implemented by the ECB, such as the pandemic emergency purchase programme (PEPP) with flexible purchases based on the national impact

of the sanitary crisis within the Eurozone, could decrease borrowing costs and increase lending, lessening the asymmetric impacts of the crisis. However, in the long term, the financial trilemma (Obstfeld, 2015; Schoenmaker, 2011) states that financial stability, national regulations, and financial integration are objectives that cannot be achieved concurrently. In order to preserve financial stability and improve banking fragmentation, which remains an important issue in the Eurozone, further steps toward regional banking regulation should be undertaken. An alternative could be to strengthen the European Banking Union and to unify the macroprudential supervision at a regional level.

ACKNOWLEDGMENTS

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available at Statistics (europa.eu) and Indicators of financial integration and structure in the euro area (europa.eu). Please see Table 1 for the complete reference numbers. These data were derived from the following resources available in the public domain: ECB Statistical Data Warehouse (europa.eu).

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ENDNOTES

- ¹ <https://www.ecb.europa.eu/press/blog/date/2020/html/ecb.blog200319~11f421e25e.en.html>
- ² The literature documents that Cyprus, Ireland, Greece, Italy, Portugal, and Spain knew large reversals in private capital inflows after the 2007 financial shock (Fagan & McNelis, 2020; Merler & Pisany-Ferri, 2012).
- ³ We differentiate core and peripheric countries (Battistini et al., 2014; Von Borstel et al., 2016). Core countries include: Austria, Belgium, Finland, France, Germany, Luxembourg, the Netherlands. Peripheric countries include countries that have experienced sudden stops at the beginning of the period of analysis (Fagan & McNelis, 2020; Merler & Pisany-Ferri, 2012) Cyprus, Greece, Ireland, Italy, Portugal, Malta, Spain.
- ⁴ We exclude the countries that were not in the Eurozone for the whole period: Slovakia, Estonia, Lithuania, and Latvia.
- ⁵ The code used is based on the code provided by Sims and Zha (1998, 1999) and is available at: https://www.estima.com/procs_perl/mainproclistwrapper.shtml. We incorporate individual dummies to control for unobservable heterogeneity in the Eurozone (Beetsma et al., 2006; Kim & Lee, 2008; Kim & Yang, 2008) and adapt the model to the case of panel data.
- ⁶ We use the code on the GVAR model available on the L. Vanessa Smith website: <https://sites.google.com/site/gvarmodelling/gvar-toolbox>.
- ⁷ Following Dees et al. (2007), the weights aggregation is based on the average 2008–2018 GDP, PPP (in thousand current international \$).
- ⁸ The lag orders of the domestic pi and foreign variables qi of the individual country VARX models are limited to 2 for parsimony.
- ⁹ To obtain the GVAR model, individual models should account for possible cointegration across variables in each country's model.
- ¹⁰ All variables are considered as foreign variables except the *EXL* one, which is by definition an external variable.
- ¹¹ We consider ECB monetary policy variables for all countries to be weakly exogenous. An additional variable, namely, the U.S. interest rate (monetary policy related interest rate, percent per annum, IMF IFS) is considered as exogenous for European countries and endogenous for the US.

¹² Following Sims and Zha (1999), error bands correspond to the 16% and 84% quartiles (68% confidence interval). Results are significant if the confidence intervals do not recover zero.

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APPENDIX A. EUROPEAN BANKS STATISTICS AND STYLIZED FACTS REGARDING THE EUROPEAN BANKING SECTOR

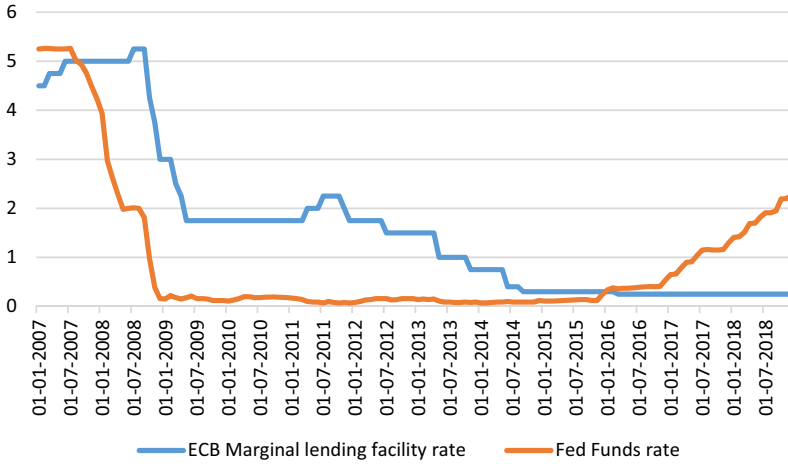


FIGURE A1 Interest rates differential [Colour figure can be viewed at wileyonlinelibrary.com]

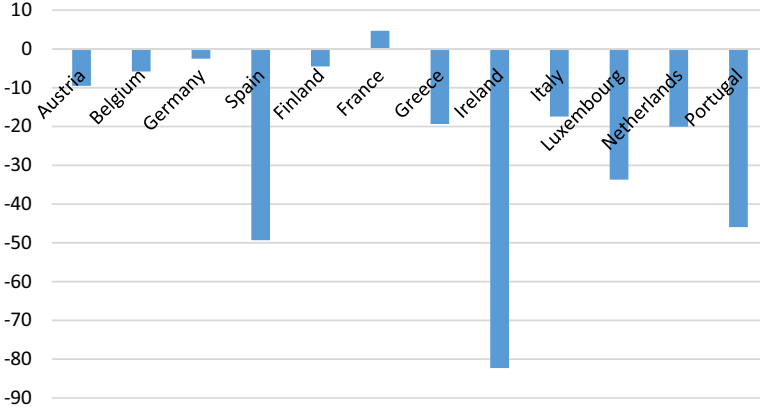


FIGURE A2 Credit to GDP gap, percentage of GDP 2017. *Source:* BIS statistics: <https://www.bis.org/statistics> [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE A1 Nonperforming loans

	2014	2015	2016	2017
Austria	7.90	6.59	5.01	3.42
Belgium	5.03	4.55	3.71	3.02
Cyprus	50.50	38.43	37.78	32.30
Germany	3.94	3.04	2.71	1.80
Estonia	12.69	9.92	6.02	2.36
Spain	8.02	6.22	5.68	4.51
Finland	1.61	1.17	1.21	1.17
France	4.26	4.04	3.70	3.14
Greece	39.78	46.79	46.27	45.04
Ireland	23.94	18.46	15.74	12.12
Italy	17.03	16.90	15.46	11.42
Lithuania	13.86	12.46	7.49	6.41
Luxembourg	3.11	2.49	2.79	2.46
Latvia	11.74	7.61	8.00	8.01
Malta	10.40	8.88	4.89	3.80
Netherlands	3.32	2.69	2.44	2.22
Portugal	17.80	19.27	19.23	16.03
Slovenia	26.22	20.18	13.21	9.34
Slovakia	9.91	8.59		8.90
Euro area	8.12	7.33	6.49	4.83

Note: Gross nonperforming loans and advances (% of total gross loans and advances).

Source: ECB (2020).

TABLE A2 Loans to deposit ratio

	2014	2015	2016	2017
Austria	103.41	99.00	96.73	96.73
Belgium	92.86	94.57	92.87	94.40
Cyprus	81.05	83.79	77.90	70.79
Germany	98.21	94.93	93.99	91.00
Estonia	72.93	72.23	75.57	60.54
Spain	90.91	92.29	92.38	89.25
Finland	141.27	135.01	132.22	141.21
France	105.45	104.70	105.80	104.45
Greece	78.93	72.85	76.76	85.15

TABLE A2 (Continued)

	2014	2015	2016	2017
Ireland	93.44	95.63	94.65	94.39
Italy	109.59	105.98	100.49	101.12
Lithuania	57.91	65.44	66.12	71.11
Luxembourg	82.10	81.08	73.27	71.21
Latvia	42.45	35.91	39.44	39.19
Malta	53.42	53.31	66.49	71.31
Netherlands	130.42	126.78	124.73	123.29
Portugal	84.79	80.92	78.18	73.40
Slovenia	72.80	70.52	73.11	72.52
Slovakia	80.53	78.55	75.75	78.50
Euro area	102.21	100.39	99.69	98.21

Source: ECB (2018).

TABLE A3 Common equity tier 1 ratio (%)

	2014	2015	2016	2017
Austria	12.18	13.09	14.46	14.60
Belgium	14.46	15.99	16.76	16.05
Cyprus	13.88	15.06	15.22	14.14
Germany	14.17	14.74	14.93	15.85
Estonia	19.30	20.36	18.78	17.64
Spain	11.73	12.63	12.74	12.62
Finland	15.91	19.56	20.09	20.28
France	11.74	12.55	13.71	14.18
Greece	13.80	16.30	16.88	16.95
Ireland	15.50	14.44	16.76	18.33
Italy	11.25	11.77	10.76	13.60
Lithuania	10.62	12.91	15.00	13.91
Luxembourg	25.49	27.19	28.00	26.89
Latvia	11.98	12.38	14.92	15.74
Malta	12.13	14.28	15.01	16.46
Netherlands	14.23	14.38	15.49	16.61
Portugal	10.91	12.12	10.82	13.83
Slovenia	18.94	19.27	19.62	18.60
Slovakia	16.59	17.42	17.79	18.48
Euro area	12.74	13.47	13.88	14.75

Source: ECB (2018).

TABLE A4 Ratio of liquid assets to short term liabilities

	Dec-00	Dec-05	Dec-08	Dec-10	Dec-12	Dec-14	Dec-16	Jun-18
Austria	54.72	43.80	50.07	51.14	50.66	47.84	45.97	42.09
Belgium	50.46	47.36	45.82	45.40	40.61	32.21	33.35	33.31
Cyprus		36.97	30.52	35.92	31.11	28.48	36.20	41.49
Germany	56.26	49.34	48.29	47.46	48.07	43.74	44.73	45.57
Estonia		21.16	23.67	16.92	18.71	27.28	24.36	30.36
Spain	39.89	35.86	29.12	28.93	35.35	41.05	34.45	35.43
Finland	34.76	21.23	19.84	20.54	35.10	23.44	34.75	46.31
Greece	58.67	28.45	24.36	30.53	17.12	10.21	8.42	14.49
Ireland	37.95	32.01	29.43	35.23	32.51	60.43	63.38	65.00
Italy	39.55	43.69	40.55	34.03	37.51	42.00	41.10	41.53
Lithuania		30.57	16.97	24.72	23.15	39.24	23.09	26.04
Luxembourg	76.29	53.32	47.81	57.60	56.80	58.37	57.38	55.86
Latvia				30.81	30.42	35.88	33.05	41.67
Malta		18.55	10.58	25.38	23.50	16.89	23.36	29.43
Netherlands	52.70	23.05	22.39	22.76	27.46	19.89	27.57	28.03
Portugal	27.41	26.13	28.29	30.70	37.51	34.90	36.76	40.71
Slovenia		46.73	24.96	32.77	35.74	61.45	51.70	43.19
Slovakia			57.72	47.81	43.04	35.55	29.16	21.69

Source: ECB (2018).

TABLE A5 External assets and liabilities in foreign currencies by European credit institutions (in millions of euros)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Austria	209,672	188,766	180,247.5	178,336.5	170,815.5	158,981.5	150,393.5	142,037	128,395	115,524.25	115,013.5
External liab	85,578	87,341.25	78,164.25	79,137.75	76,379	64,924.75	60,114.25	54,321.25	50,478	46,211.5	42,338.25
Belg	236,226	204,611	199,630.5	180,276.75	180,805.5	184,156.25	194,402	207,367	199,785.25	187,595.75	174,417.5
External liab	241,020	213,652.25	222,620	193,820.5	163,362.75	157,906.5	152,729	178,740.75	173,350.75	162,170.75	147,312.25
Cyprus	35,179	40,367.5	33,992.25	31,984.75	33,819.25	18,925.75	13,864.5	15,101.5	11,791.75	10,532	9279.75
External liab	25,035	26,383	29,241.25	31,613.75	33,634.75	24,832.75	18,318.25	21,747.25	15,815	16,120.75	12,556.5
Germ	1,276,268	1,114,194.75	1,055,107.5	991,608.5	992,803	936,716.25	1,005,829.5	1,083,694	1,028,605.25	1,043,443	1,027,308.75
External liab	749,035	692,546.25	729,583.25	651,267.5	785,027.75	622,601.5	593,827.75	683,393.25	720,530.25	774,679	738,106
Spain	197,075	201,355.5	218,031.25	221,305	244,306.5	206,980.75	191,544.25	191,043	189,079	186,001.75	196,711.75
External liab	271,124	274,644.5	275,207.5	273,904.5	201,040.5	161,961.25	126,339.25	117,241.75	111,179.5	109,482.5	113,838.5
Finland	66,997	74,192.25	86,631.75	129,507	129,786.75	131,551.5	133,893.75	134,928.75	103,884.25	51,926.5	76,509
External liab	67,499	75,792.75	94,630.25	143,762.75	178,901.75	132,777.5	130,020.75	131,670.75	130,727.5	115,341.5	122,327.5
France	879,552	800,437.25	905,262	936,813.75	900,050.25	896,578	967,505.75	1,029,741.25	1,052,125.75	1,057,529	1,254,776.25
External liab	1,046,386	962,426.25	1,021,614.75	913,315	807,039.25	807,458.5	843,868.75	898,467.25	963,718	1,002,329	1,273,461
Greece	82,993	90,329.75	86,108.5	68,301	62,294.5	56,616	51,170.25	46,955.75	38,636.25	31,393	20,596.75
External liab	74,762	66,115.5	80,381.75	72,743.25	56,466	58,249	61,423.5	31,432.5	33,067.25	32,241.5	26,534
Ireland	445,371	432,283.25	407,537.75	277,450.25	248,923.25	203,512.5	178,659.75	156,808.25	136,815.25	126,604.25	128,298.25
External liab	409,257	366,765.75	308,136.75	169,023.25	146,929	125,547	114,008	97,847.25	80,282.75	83,899.5	93,020.25
Italy	90,921	88,665.75	102,606.5	118,252.75	131,117.25	121,612	116,490	127,221.25	130,041.5	147,332.75	159,939.75
External liab	199,042	206,933.75	192,491.25	177,650	157,510.75	142,127.25	130,085.5	129,296.75	122,885.75	111,586	106,734.75
Lux	269,725	237,005.25	219,508	213,430.75	212,752.5	222,142.25	234,399.75	245,089	234,463.75	233,655	238,812.25
External liab	216,865	188,496.75	175,286.25	175,083.5	179,161.75	165,354.5	159,495.5	164,673.25	171,195.75	172,269.75	176,976.75
Port	31,779	33,241.75	42,789	39,705	45,998.5	37,866.25	32,645.75	26,092	19,314.5	17,320.75	16,693.5
External liab	80,282	81,375.25	82,378	72,693	64,383.75	53,693.25	43,716.25	39,346.5	32,041	29,124.75	27,922.5
Slov	4470	4338.25	4375.75	4175.5	3961.25	3754.25	3626.75	3377	3301.5	3588.25	3508.5
External liab	2599	2354.25	2306.75	2218.25	2165	2043	1736.25	1811.75	1722.25	1595.5	1441

Source: ECB (2020).

APPENDIX B. MAIN RESULTS FROM THE EXISTING LITERATURE

TABLE B1 ECB monetary policy and fragmentation: Main results from the existing literature

	Objectives (sample period)	Methodology	Main results
Al-Eyd and Berkmen (2013)	Analysis of the credit channel of ECB monetary policy in euro area and financial fragmented markets during the crisis using data on Germany, France, Italy, Spain, and Portugal (2003–2013)	VECM for interest rate shock	The credit channel of monetary policy does not work during the crisis, particularly in stressed markets Stressed economies are more impacted by higher lending rates
Bruno and Shin (2015)	Study of the risk-taking channel of monetary policy in the U.S. (1995–2007)	VAR for US interest rate shocks	A decrease in US interest generates a drop in cross-border banking capital flows and a decline in the leverage of international banks
Mayordomo et al. (2015)	Measures of fragmentation in the European interbank market for Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, and Spain (2005–2012)	Measure of the global dispersion on the basis of the regression coefficients	Fragmentation is: - higher in the periphery countries - increases with high financing costs, high counterparty risk, and high debt-to-GDP - decreases with a small banking sector, positive economic sentiment, announcement of the Banking Union, and ECB President's speech
Szcerbowicz (2015)	Assess the impact of the ECB monetary policy on bank and government borrowing costs in France, Italy, Greece, Portugal, Spain, and Ireland (2007–2012)	Event-based regressions to assess the effects of asset purchases and exceptional liquidity announcements on money markets, covered bond markets, and sovereign bond markets	LTROs and zero ECB deposit rate reduce money market tensions Purchases of assets lower refinancing costs of banks and governments with high sovereign risk

(Continues)

TABLE B1 (Continued)

	Objectives (sample period)	Methodology	Main results
Fratzscher et al. (2016)	Study the impacts on financial markets of ECB unconventional monetary policy in 38 economies including Austria, Finland, Germany, and the Netherlands (2007–2012)	Event study	ECB policies: -increase equity prices and lower bond market fragmentation -have a positive impact on equity markets and confidence but low effects on bond markets internationally -decrease credit risk for countries and banks
Von Borstel et al. (2016)	Study of the interest rate pass-through in the euro area during the sovereign debt crisis for Austria, Belgium, Germany, Spain, Finland, France, Greece, Ireland, Italy, the Netherlands and Portugal (2000–2013)	FAVAR (interest rate monetary policy shock)	The transmission of conventional monetary policy to bank lending rates has not changed with the sovereign debt crisis but the pass-through has changed Expansionary measures reduce sovereign and bank funding risk in periphery countries, but not the spreads between lending rates and banks' funding costs
Buch et al. (2019)	Study of the monetary policy transmission across borders and the sources of heterogeneity in this transmission using confidential micro-banking data for the U.S., euro area, Japan, and the United Kingdom (2000–2015)	Panel regressions with bank-level heterogeneity and country-time fixed effects Meta-analysis across country of international transmission analysis of the cross-border transmission of conventional and unconventional monetary policy through banks	International spillovers into lending to the private sector occur, especially for U.S. policies Bank-specific heterogeneity influences the magnitudes of transmission The impact of this heterogeneity differs greatly across countries

(Continues)

TABLE B1 (Continued)

	Objectives (sample period)	Methodology	Main results
Altavilla et al. (2020)	Analyze the monetary policy pass-through to lending rates using 325 euro area banks (2007–2017)	Two-step cross-sectional VAR model	The monetary policy pass-through is heterogeneous and depends on banks' balance-sheet characteristics Nonconventional measures reduce lending rate heterogeneity
Vari (2020)	Study of the transmission of the monetary policy in a context of interbank market fragmentation in Germany, Netherlands, Luxembourg, Finland, Portugal, Italy, Greece, and Spain (2008–2014)	Theoretical modeling and OLS regressions	Fragmentation causes interest rates and the money supply to fluctuate out of the central bank control
Pagliari (2021)	Assessment of the heterogeneous macroeconomic impact of unconventional monetary policies in the euro area (2007–2019)	Structural VAR model with stochastic volatility	Strong heterogeneity between core and peripheral euro area economies ECB's unconventional measures positively impact the economic performance of peripheral economies The macroeconomic impacts of ECB's UMPs decline over time in core economies
Gabrieli and Labonne (2022)	Study the relative role of sovereign-dependence risk and credit risk in euro area interbank market fragmentation in 115 European banks (2011–2015)	Theoretical modeling, empirical measure of interbank rates dispersion using fixed effect regressions	High nonperforming loan ratios hinder banks' access to the interbank market in the peripheral countries Large sovereign bond holdings are priced in interbank rates from mid-2011 until the announcement of the OMT The OMT has positive impacts reducing sovereign dependence and balance sheet fragmentation

APPENDIX C. VARIANCE DECOMPOSITION—REGIONAL SVAR MODELS

TABLE C1 Variance decomposition

Horizon	Eurozone					
	FINT	CDS	BOND	EONIA	FCP	EXL
(a) ECBLR						
1	0.75	0.98	0.56	0.64	13.85	0.00
2	1.04	2.14	1.26	0.86	13.20	0.02
3	1.46	3.73	2.57	1.14	12.37	0.05
4	2.02	5.57	4.37	1.39	11.53	0.10
8	4.97	12.88	13.39	1.99	8.69	0.38
12	8.21	18.21	21.17	2.28	8.06	0.84
(b) LTRO						
1	0.53	0.63	1.16	0.66	0.95	0.00
2	1.09	1.97	1.24	1.22	0.98	0.05
3	1.70	3.99	1.29	2.26	1.09	0.14
4	2.27	6.15	1.37	3.58	1.30	0.24
8	3.53	13.86	2.36	9.21	3.21	0.79
12	4.06	18.37	4.13	12.36	6.71	1.50
(c) QE						
1	1.54	0.62	1.10	1.55	0.87	0.00
2	1.85	0.65	1.25	1.63	1.01	0.01
3	2.15	0.67	1.35	1.66	1.10	0.03
4	2.44	0.70	1.42	1.66	1.14	0.06
8	3.44	0.77	1.58	1.61	1.12	0.23
12	4.17	0.83	1.69	1.56	1.08	0.48

Note: This table presents variance decompositions obtained from the estimation of model (3) for each variable following a shock (a) ECBLR, (b) LTRO, and (c) QE.