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# Bank loan supply shocks and alternative financing of non-financial corporations in the euro area

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## Abstract

We analyse the macroeconomic effects of exogenous contractions in bank lending to non-financial corporations in the euro area, Germany, France, Italy and Spain using a BVAR model with endogenous hyperparameter selection and identification via sign restrictions. We investigate the behaviour of firms' external financing sources alternative to bank loans: financing via equity, debt securities, trade credit and lending from non-banks. We analyse the comovement of these financing sources with bank lending using the *joint* posterior distribution of their impulse responses with that of bank loans. For the euro area our results show equity, debt securities and non-bank loans to be substitutes for bank loans in general equilibrium with negative responses to a positive loan supply shock while trade credit is a complement and responds positively. Quantitatively, the developments in bank loans and trade credit dominate the response of the overall sum of external financing. However, whether and which of the alternative financing sources are substitutes for or complements to bank loans in general equilibrium differs across countries.

## KEYWORDS

Bayesian VAR, external financing, euro area, joint posterior distribution, loan supply, sign restrictions

## JEL CLASSIFICATION

C32; E32; E51

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## 1 | INTRODUCTION

The analysis of developments in bank lending is an important element of the European Central Bank's (ECB) monetary policy framework. Monetary analysis, the second pillar of the ECB's monetary policy strategy, exploits policy-relevant information in changes in money and bank lending, for example, about the monetary transmission mechanism and about the importance and transmission of financial shocks (e.g., European Central Bank, ). The emphasis on bank lending derives from bank loans being the quantitatively most important component among non-financial firms' financing via debt instruments. Thus, changes in the availability of loans can have important effects on the real economy. Following the global financial crises and the contraction in bank lending various analyses have studied the effects of loan supply shocks and their importance for loan dynamics in the euro area, for example, Altavilla, Darracq-Paries, and Nicoletti (2015), Deutsche Bundesbank (2015), Gambetti and Musso (2017) and Moccero, Darracq-Paries, and Maurin (2014) as well as in individual euro area countries, for example, Bijsterbosch and Falagiarda (2015), Hristov, Hülsewig, and Wollmershäuser (2012) and Duchi and Elbourne (2016). Almost all of these analyses, however, do not account for access to alternative sources of external financing that might act as substitutes for the reduced availability of bank loans after a loan supply shock and might dampen its effects. In fact, in the euro area there has been a relative decline in the importance of bank financing, in particular bank loans to non-financial firms over time (e.g., Deutsche Bundesbank, 2018; European Central Bank, 2016). Thus, the consideration of financing sources of firms other than bank loans has become increasingly important in monetary analysis.<sup>1</sup>

In this paper, we augment standard vector autoregressive (VAR) models used in the analysis of the macroeconomic effects of loan supply shocks with alternative financing sources for firms taken from the flow-of-funds statistics. We study the effects of loan supply shocks and of other macroeconomic shocks on the different external financing sources and on overall external financing of non-financial firms and investigate whether the alternative financing sources act as complements or substitutes with respect to bank loans in general equilibrium. The analysis is carried out for the aggregate euro area and for the four large member countries (Germany, France, Italy and Spain). We show that following a positive loan supply shock bank lending in the euro area expands as does trade credit. The response of financing via equity, debt securities or loans from non-banks is negatively correlated with the reaction of bank loans. Overall external financing, that is, the sum of the financing components moves in the same direction as bank lending. The increase in bank lending and trade credit is, thus, only imperfectly compensated. The correlation patterns among financing sources and the imperfect compensation for the changes in bank loans and trade credit are broadly robust for the other macroeconomic shocks. At the individual country level results are less conclusive and differ across countries. In France and Italy, non-bank loans are positively correlated with bank loans after a loan supply shock as is trade credit in France and Spain and, to some extent, in Italy. Changes in equity financing are negatively correlated with changes in bank loans after a loan supply shock in Italy.

Based on the correlation between the impulse responses of bank loans and other external financing sources we classify the latter ones as substitutes or complements relative to bank loans. This classification concerns the general equilibrium changes in the variables after a shock. The partial equilibrium notion of substitutability and complementarity applies to firms' choice among sources of finance for given financing needs. However, for explaining the data, which are the result in general equilibrium, we cannot maintain such *ceteris paribus* assumptions. Changes in the relative supply of different sources of finance which may cause changes in firms' financing conditions are the result of economic shocks which may also affect the overall demand for financing simultaneously, for example by causing changes in output.

<sup>1</sup>Examples are European Central Bank (2020) and, for Germany, Deutsche Bundesbank (2020).

Our analysis is related to Gambetti and Musso (2017) and Bijsterbosch and Falagiarda (2015). Both use time-varying VAR models which require the VAR to be of reasonably small dimension and the availability of long data series. Since we use higher dimensional models and our data set runs from 1999 onwards only, we have to remain in a fixed-parameter VAR framework. The second important difference in our approach is that both papers do not consider alternative financing sources. For the individual country models our analysis differs from Bijsterbosch and Falagiarda (2015) furthermore, in that we include euro area aggregates for output and price level in the country models to improve the estimation of the monetary policy reaction function and the identification of the monetary policy shock.

Our paper is also related to Altavilla et al. (2015) who analyse the macroeconomic effects of loan supply shocks using a fixed-parameter Bayesian VAR model that includes debt securities issuance by non-financial corporations. They identify loan supply shocks using information from the Eurosystem's bank lending survey (BLS) and an external instrument approach. They find evidence for the substitution of bank loans with debt securities issuance in the wake of a negative loan supply shock. However, they neither include the full range of alternative financing sources nor do they consider possible differences across countries. Bonci (2014) adds flow-of-funds variables to a small structural VAR model for the euro area one-at-a-time and identifies a monetary policy shock using a Cholesky decomposition. The responses of firms' different external financing sources, however, turn out to be mostly not statistically significant and his approach does not account for possible interactions among the variables.

Aldasoro and Unger (2017) also analyse the effects of loan supply shocks on alternative financing sources but consider only the composite of equity, debt securities and non-bank loans and impose substitution between the sum of these financing sources and bank loans in their identification scheme. In contrast, we consider equity, debt securities and non-bank loans as individual components, include trade credit as another alternative financing source, and do not impose the assumption of them being substitutes for bank lending. They also do not investigate the dynamics of the overall sum of external finance.<sup>2</sup>

Becker and Ivashina (2014) identify contractions in banks' loan supply using firm-level data. Their identification method is based on the idea that conditional on a firm issuing new debt a switch from bank loans to bond finance reflects a reduced availability of loans. The results show firms' financing mix of loans versus bonds to behave pro-cyclically and that a more expansionary monetary policy leads to an increase in loans relative to bond finance. An expansion in loan supply leads to higher investment, in particular for financially constrained firms. Their identification scheme for changes in bank loan supply assumes that a negative bank loan supply shock, given the demand for overall external financing, will cause a switch from loan to bond finance and they exploit the cross-sectional variation in firms' financing choices for this identification. In our analysis, however, we use aggregate data from the flow-of-funds statistics. Furthermore, our interpretation of a loan supply shock is less restrictive and does not allow us to assume that bank loans and other financing sources move in opposite directions within a quarter. Kashyap, Stein, and Wilcox (1993) use data on bank lending to firms and their commercial paper issuance to investigate the transmission of monetary policy. They show that a restrictive monetary policy shock causes a decline in the share of bank loans in firms' short-term external finance, that is, that their financing mix shifts towards commercial paper issuance. Furthermore, changes in the financing mix have explanatory power for investment, primarily in inventories.

Concerning the general equilibrium perspective, our analyses is related to the literature on the cyclicity of different forms of finance. Covas and Den Haan (2011) analyse the cyclicity of equity and debt finance of U.S. non-financial firms. Using firm-level data they show equity issuance, which

<sup>2</sup>Their results are not directly comparable to ours because their model uses levels for real GDP and prices but growth rates for financing sources while we enter all of these variables in levels which allows for the possibility of cointegration relationships.

excludes retained earnings, to be pro-cyclical except for the largest firms. In contrast, equity issuance of the largest 1% of firms is counter-cyclical. This heterogeneity leads to an insignificant result for equity issuance on the aggregate level. Debt issuance, which includes trade credit, is pro-cyclical for all firms. Overall the positive comovement of the cyclical components of debt issuance and GDP turns out to be more pronounced than that of equity issuance.<sup>3</sup> In contrast, Jermann and Quadrini (2012) show using aggregate data for the United States that equity payouts, the negative of equity issuance, behave pro-cyclically while debt repurchases, the negative of debt issuance, behave counter-cyclically. They present a DSGE model in which shocks to firms' borrowing capacity cause these cyclical patterns.

## 2 | EMPIRICAL APPROACH AND DATA

### 2.1 | Estimation approach

We model the dynamic interactions among the variables using a Bayesian vector autoregressive (BVAR) model

$$y_t = c + B_1 y_{t-1} + \dots + B_p y_{t-p} + \epsilon_t, \quad (1)$$

where  $y_t$  is a vector of  $n$  endogenous variables in period  $t$ ,  $c$  is a vector of intercepts,  $B_i$  is a  $n \times n$  matrix of coefficients on lag  $i$  of the endogenous variables,  $p$  is the number of lags and  $\epsilon_t$  is a vector of residuals that are jointly normally distributed with mean zero and covariance  $\Sigma$ .

As the number of parameters is large relative to the sample size we impose shrinkage on the parameters using a Bayesian estimation approach. We estimate the model using the approach by Giannone, Lenza, and Primiceri (2015) who set the hyperparameters of the prior distributions of the VAR parameters in a data-driven way. Instead of fixing them ad-hoc (e.g., Sims & Zha, 1998), by estimating them using a training sample or matching the in-sample fit of the BVAR to that of a small VAR (e.g., Banbura, Giannone, & Reichlin 2010) they treat the hyperparameters as random variables to be estimated. This implies a hierarchical structure of the prior distribution in which 'hyperpriors' are imposed on the hyperparameters.

The prior for the coefficients  $B_i$ ,  $i = 1, \dots, p$  and for the covariance matrix  $\Sigma$  is of the Normal-Inverse-Wishart-type. Conditional on the vector of hyperparameters  $\gamma$  and on the covariance matrix of the reduced-form VAR residuals  $\Sigma$  we set the prior mean of the autoregressive coefficient on the first own lag of variable  $i$  equal to the estimated coefficient from a univariate AR(1) regression  $\hat{b}_i$  and the prior mean of all other coefficients equal to zero

$$E(B_{k,ij} | \Sigma, \gamma) = \begin{cases} \hat{b}_i & \text{if } i=j \text{ and } k=1 \\ 0 & \text{otherwise.} \end{cases} \quad (2)$$

The prior covariance matrix of the  $B_i$  coefficients is

$$\text{cov}(B_{k,ij}, B_{s,hm} | \Sigma, \lambda, \Psi) = \begin{cases} \lambda^2 \frac{1}{k^2} \frac{\Sigma_{ih}}{\Psi_{jj}} & \text{if } m=j \text{ and } s=k \\ 0 & \text{otherwise,} \end{cases} \quad (3)$$

<sup>3</sup>Covas and Den Haan (2012) construct a DSGE model to replicate these stylized facts.

where the hyperparameters  $\lambda$  and  $\Psi$  are elements of  $\gamma$ . The higher the lag  $k$ , the stronger the shrinkage of the dynamic coefficients towards their prior mean (2).  $\lambda$  controls the relative importance of the prior. The larger  $\lambda$ , the less important is the prior information and the smaller the shrinkage. The term  $\frac{\Sigma_{ij}}{\Psi_{ij}}$  accounts for different scales of the variables.

The prior on the covariance matrix of the reduced-form residuals  $\Sigma$  is given by an Inverse-Wishart distribution with a diagonal scale matrix  $\Psi$  and  $n+2$  degrees of freedom

$$\Sigma \sim IW(\Psi, n+2). \quad (4)$$

For the hyperparameters  $\lambda$  and the diagonal elements in  $\Psi$ ,  $\psi_i$  we follow Giannone et al. (2015) and assume relatively uninformative ‘hyperpriors’. The prior distribution for  $\lambda$  is a Gamma distribution with mode equal to 0.2, the (non-random) value of  $\lambda$  suggested in Sims and Zha (1998), and a standard deviation of 0.4. The prior mean of the  $\psi_i$  is assumed to have an inverse Gamma distribution with scale and shape parameters equal to 0.02 (see Giannone et al. 2015).

The estimation is based on a Markov Chain Monte Carlo (MCMC) algorithm and uses the Gibbs sampler to generate draws for the dynamic coefficients in the  $B$  matrices and the elements of the covariance matrix  $\Sigma$  conditional on the values of the hyperparameters. Giannone et al. (2015) derive a closed-form solution for the data density conditional on the hyperparameters which allows them to draw from the posterior distribution of the hyperparameters using a Metropolis-Hastings algorithm. Since this algorithm converges only slowly and since we estimate multiple versions of the VAR models (euro area and individual country models) we fix the hyperparameters at the mode of their joint posterior distribution which is obtained via numerical optimization. Thus, our estimates ignore the estimation uncertainty about the hyperparameters, which, however, has only very small effects on the dispersion of our objects of interest.<sup>4</sup>

## 2.2 | Data

We use quarterly data for the euro area, Germany, France, Italy and Spain from 1999Q1 to 2017Q4. Our model includes real GDP (RGDP), the GDP deflator (GDPDEF), real MFI loans to non-financial corporations (LOANS),<sup>5</sup> the euro area shadow short rate (SSR) from Wu and Xia (2016) as proxy for the monetary policy stance including unconventional monetary policy measures,<sup>6</sup> the interest rate on bank loans to non-financial corporations (LRATE), the five-year government bond yield (RATE5Y)<sup>7</sup>

<sup>4</sup>The discussion paper version contains results for the euro area using the full algorithm in Appendix C and shows that our simplifications have little effects on the results, see Mandler and Scharnagl (2019).

<sup>5</sup>MFIs are monetary financial institutions and include mainly the commercial banking sector, building societies, money market funds and central banks.

<sup>6</sup>The SSR is derived from the term structure of interest rates and in ‘normal’ times it is equal to the overnight interest rate. If short-term interest rates are constrained by the interest-rate-lower bound or if unconventional monetary policy instruments are used it can deviate from the overnight interest rate and take on lower values, see Krippner (2013), Wu and Xia (2016) or, for an overview, for example, Deutsche Bundesbank (2017). Using a SSR allows us to approximately account in our estimation for the effects of unconventional monetary policy measures on the monetary policy stance without explicitly modelling these. As a robustness check we estimated our models for the euro area and for Germany using an alternative SSR from Geiger and Schupp (2018) and found this change to have little effect on the results. In another robustness test we replaced the SSR by the EONIA.

<sup>7</sup>We choose the five-year over the ten-year bond yield as a medium-term maturity better reflects the maturities of bank lending than the ten-year yield. As a robustness test we replaced the five- by the ten-year bond yield.

and four variables from the flow-of-funds statistics: external financing of non-financial corporations via equity and shares (EQUITY),<sup>8</sup> debt securities (DEBTSEC), trade credit (TRADECR) and loans where we subtract bank loans from the latter series leaving only loans from non-bank sources (NBLOANS).<sup>9</sup> Bank loans and the flow-of-funds data are notional stocks and are deflated using the GDP deflator.<sup>10</sup> Information on the data sources is in Appendix A. Deutsche Bundesbank (2018) provides a narrative of recent developments in the financing of non-financial corporations in the euro area and in the four large EMU member countries.<sup>11</sup>

The flow-of-funds data used in this paper are not consolidated, that is, the data does not only include financing non-financial firms receive from other sector but also intra-sectoral financing. We use the non-consolidated data since data on financing by equity and shares and by trade credit are not available on a consolidated basis.<sup>12</sup> Kashyap et al. (1993) use consolidated data on loans and debt securities issuance (commercial paper) but do not consider other external financing sources (see, Kashyap et al., 1993, p. 88). We obtained results from a smaller model using only consolidated data on bank loans and debt securities as a robustness test.

Figures 1 and 2 provide an overview on the relative importance of non-financial corporations' different external financing sources. The graphs show the shares of each component in overall external financing over time. Financing through equity and shares is the most important component in the euro area and all countries. Bank loans are the second most important component in the euro area as a whole, DE and IT, and, since the late 2000s in ES, as well. Debt securities account for the smallest share in all countries. Figure 2 shows some important differences across countries: FR stands out with non-bank loans as the second most important external financing source exceeding the share of bank loans. The share of trade credit was higher in ES but has declined from over 20 to around 12 per cent since the financial crisis.

The BVAR model is estimated with five lags in log-levels for all variables except for the interest rates which are taken as decimal numbers.<sup>13</sup> After drawing the reduced-form parameters of the VAR we discard all draws which imply an explosive model.<sup>14</sup>

<sup>8</sup>This does not include retained earnings. It covers both exchange-traded and non-exchange-traded stock as well as other forms of equity shares.

<sup>9</sup>In our analysis we focus on external financing of firms. We experimented with including gross operating surplus as a proxy for firms' internal financing but found this variable to be too strongly correlated with real GDP with little independent information.

<sup>10</sup>Notional stocks are constructed from growth rates derived from the transactions-based changes in the series, that is, they do not include changes due to revaluations, reclassifications etc. For details, see European Central Bank (2012a).

<sup>11</sup>Concerning the maturity structure of the debt instruments for the euro area the outstanding volume of bank loans with maturity of up to five years to non-financial corporations is roughly twice as large as that of loans with maturity exceeding five years. The increase in firms' debt after 2008 has been mainly driven by an expansion of long-term bank loans and long-term debt securities. The maturity structure of firms' debt differs across countries. For more details, see Deutsche Bundesbank ().

<sup>12</sup>The micro-data analyses in Becker and Ivashina (2014) and Covas and Den Haan (2011) also do not control for intra-sectoral holdings of debt or equity.

<sup>13</sup>Specifically, the variables are transformed into 4xlog-levels to make them conformable with the annualized interest rates, since the prior-selection approach is not scale invariant, see Giannone et al. (2015) for details.

<sup>14</sup>We discard all draws for which the maximum eigenvalue of the VARs' companion matrix exceeds 1.01. Setting a threshold slightly above one allows us to retain draws which might imply cointegrating relationships among the variables.



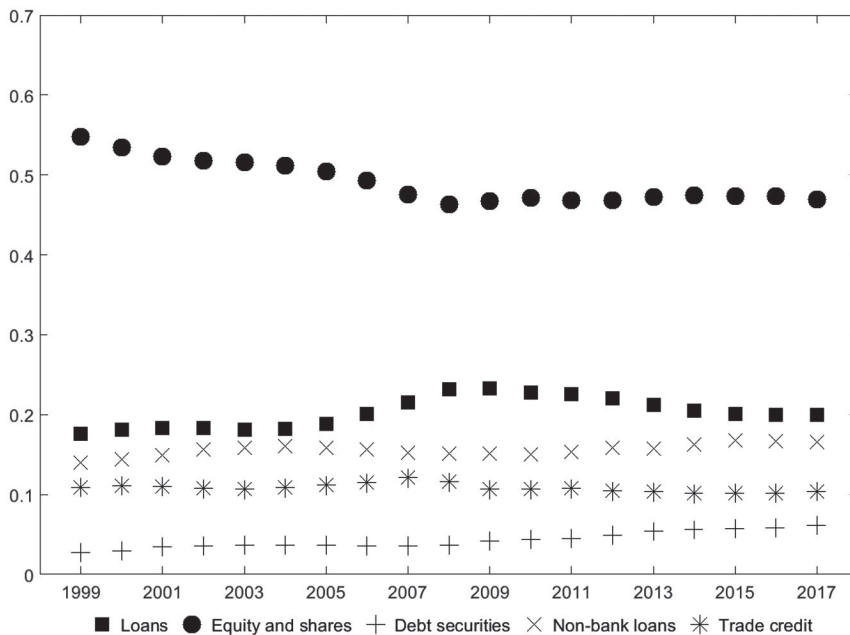


FIGURE 1 Shares of external financing sources for non-financial corporations—euro area. Annual averages

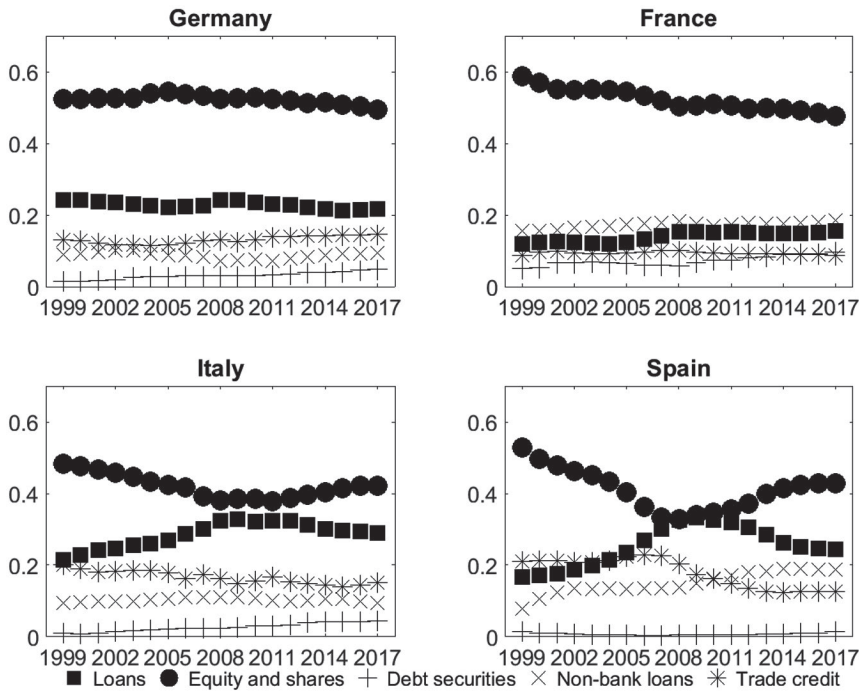
## 2.3 | Identification

We identify the structural shocks through sign restrictions using the algorithm of Arias, Caldara, and Rubio-Ramírez (2015) which is an extension of the algorithm of Arias, Rubio-Ramírez, and Waggoner (2014). It allows for both sign and zero restrictions on the impulse responses to a structural shock and sign and zero restrictions on the coefficients relating the contemporaneous values of the endogenous variables to each other.<sup>15</sup> We identify four structural shocks, an aggregate demand shock, an aggregate supply shock (inflation shock), a monetary policy shock and a loan supply shock (Table 1). While we are mainly interested in the effects of the loan supply shock the results for the other shocks will show whether the role of alternative financing sources for firms might be shock dependent. The sign restrictions for the identification of the aggregate demand and aggregate supply shocks are mostly standard (Bijsterbosch & Falagiarda, 2015; Gambetti & Musso, 2017). The restriction of an increase in the policy rate after an aggregate supply shock which raises the price level is necessary to distinguish the aggregate supply from the loan supply shock (see below) but is consistent with the central bank, for example, following a Taylor-type rule and responding more aggressively to the price level than to economic activity. For the monetary policy shock we impose the standard sign restrictions on the impulse responses, that is, a decline in output and in the price level following an exogenous increase in the policy rate. In addition, we impose positive signs on the contemporaneous reaction of the policy rate to an increase in output or the price level as in Arias et al. (2015).<sup>16</sup>

<sup>15</sup>That is, their algorithm allows to impose sign and zero restrictions on the matrix  $A_0$  in the structural representation of the VAR  $A_0 y_t = k + A_1 y_{t-1} + \dots + A_p y_{t-p} + e_t$  with  $e_t$  being the uncorrelated structural shocks.

<sup>16</sup>In terms of the notation in footnote 15 we restrict the  $A_0$  elements for output and price level in the equation for the SSR to be negative. However, we do not impose zero restrictions on the contemporaneous responses of the policy rate to the other variables as in Arias et al. (2015). The reason for this is that the Eurosystem's monetary policy strategy assigns an important role to monetary variables, such as bank credit which is at odds with such an identification assumption. See, for example, European Central Bank (2011), Section 3.5. The monetary policy shock is already identified using the sign restrictions on the impulse responses alone. Thus, not imposing the zero restrictions on the reaction coefficients does not imply that the monetary policy shock is not identified.





**FIGURE 2** Shares of external financing sources for non-financial corporations—individual countries. Annual averages

A loan supply shock causes an increase in real bank lending and real output, an initial decline in the interest rate on bank loans and an increase in the monetary policy rate. The loan supply shock represents a range of underlying structural disturbances that work through banks' loan supply, for example, exogenous changes in bank capital or net worth, changes in banks' risk-assessment of borrowers, regulatory changes (changes to capital requirements or to limits to loan-to-value ratios) etc.<sup>17</sup> We leave the impulse responses of firms' alternative financing sources unrestricted, first, because we do not wish to impose substitutability or complementarity by assumption and second, because the contemporaneous effects of the shocks on firms' demand for finance might run against a partial equilibrium substitution relationship among the sources of finance. Furthermore, since we do not impose restrictions beyond those in the standard literature the results from our extended model can be compared to the already established empirical evidence which is based on models without alternative financing sources. The identifying restrictions on the loan supply shock are similar to those in Gambetti and Musso (2017) and Bijsterbosch and Falagiarda (2015). However, as in Deutsche Bundesbank (2015) we do not impose the restriction that the loan supply shock causes a positive correlation between bank loans and the price level on impact, since this is not a robust implication across the DSGE literature on bank lending shocks (see, e.g., Gambetti and Musso 2017, Table II) and there is some evidence that restrictive financial shocks might lead to an initial increase in the price level, (e.g., Abbate, Eickmeier, & Prieto 2016; Gilchrist, Schoenle, Sim, & Zakrajsek, 2017).<sup>18</sup> In order to disentangle the loan supply from the aggregate supply shock without the restriction on the price level response we impose the assumption that an expansionary loan

<sup>17</sup>This interpretation also covers more general financial market shocks which also affect banks' lending behaviour and is consistent with the results of various DSGE models with a banking sector. For examples, see Gerali, Neri, Sessa, and Signoretti (2010); Gertler and Karadi (2011) or the summary in Gambetti and Musso (2017), Table II.

<sup>18</sup>See also Meinen and Röhe (2018) for evidence on an ambiguous response of the price level to a financial shock in the United States

**TABLE 1** Sign restrictions—Euro area model

Restrictions on impulse responses					
Variable	RGDP	GDPDEF	LOANS	SSR	LRATE
Shock					
AD shock	+	+		+	+
AS shock	−	+		+	
MP shock	−	−		+	
LS shock	+		+	+	−
Restrictions on contemporaneous coefficients					
Equation	RGDP	GDPDEF	LOANS	SSR	LRATE
Variable					
RGDP				+	
GDPDEF				+	

Abbreviations: AD, aggregate demand shock; AS, aggregate supply shock; LS, loan supply shock; MP, monetary policy shock; RGDP, real GDP; GDPDEF, GDP deflator; LOANS, real MFI loans to non-financial corporations; SSR, shadow short rate; LRATE, lending rate. Sign restrictions on impulse responses imposed on impact.

supply shock causes the central bank to increase its policy rate as it expects a future increase in the price level (see Deutsche Bundesbank, 2015).<sup>19</sup> The sign restrictions are imposed on impact.

We augment the analysis at the euro area level by analyses of the effects of loan supply shocks in the four large euro area countries (Germany, France, Italy and Spain). Since the Eurosystem's monetary policy responds to developments in the aggregate euro area economy there is the potential problem that the monetary policy reaction function and thus the dynamics of the policy rate will be incorrectly estimated if the national variables do not represent the euro area aggregates reasonably well. To account for this, we include euro area aggregates of real GDP and the GDP deflator in each individual country model and impose additional sign restrictions on the impulse responses of the euro area aggregates to the monetary policy shock. Identifying restrictions for the other three shocks are placed on the country-specific variables only, except for the monetary policy indicator. Hence, aggregate demand, supply and loan supply shocks potentially capture both country-specific and euro area common shocks.<sup>20</sup> The identification scheme for the country models is summarized in Table 2.

### 3 | RESULTS

#### 3.1 | Euro area

Figure 3 shows information on the posterior distribution of the identified loan supply shock. There are marked contractionary shocks in 2008Q3 and 2011Q4 when loan supply conditions deteriorated

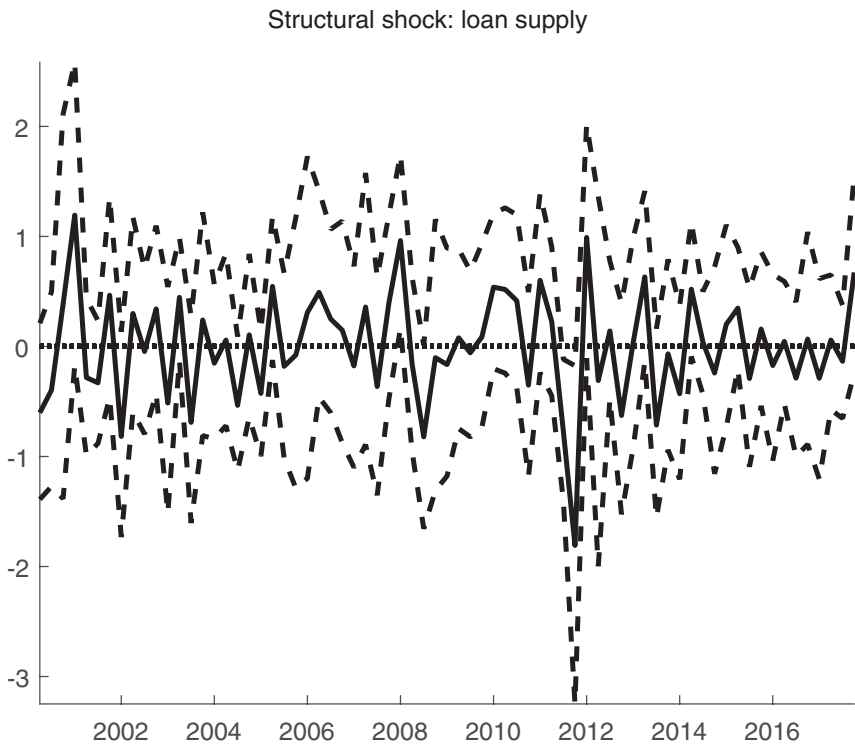
<sup>19</sup>As a robustness test we also consider a version in which we impose a zero restriction on the monetary policy response to an aggregate supply shock. This models the central bank 'looking through' temporary deviations of inflation due to supply shocks (e.g., Bean, Paustian, Penalver, & Taylor, 2011). Our results are robust with respect to this change.

<sup>20</sup>Here an issue arises with the sign restriction on the monetary policy response to these shocks. The assumption of the Eurosystem responding to potentially idiosyncratic shocks in individual countries would be difficult to maintain if we were considering small euro area countries. However, since the four countries in question carry considerable weights in the euro area aggregates even a country-specific aggregate demand, supply or loan supply shock will, all other things equal, affect the euro area averages and thus trigger a policy response.

**TABLE 2** Sign restrictions—Country model

Restrictions on impulse responses							
Variable	RGDP	GDPDEF	LOANS	SSR	LRATE	RGDP <sub>EA</sub>	GDPDEF <sub>EA</sub>
<b>Shock</b>							
AD shock	+	+		+	+		
AS shock	−	+		+			
MP shock	−	−		+		−	−
LS shock	+		+	+	−		
<b>Restrictions on contemporaneous coefficients</b>							
Equation	RGDP	GDPDEF	LOANS	SSR	LRATE	RGDP <sub>EA</sub>	GDPDEF <sub>EA</sub>
<b>Variable</b>							
RGDP <sub>EA</sub>				+			
GDPDEF <sub>EA</sub>				+			

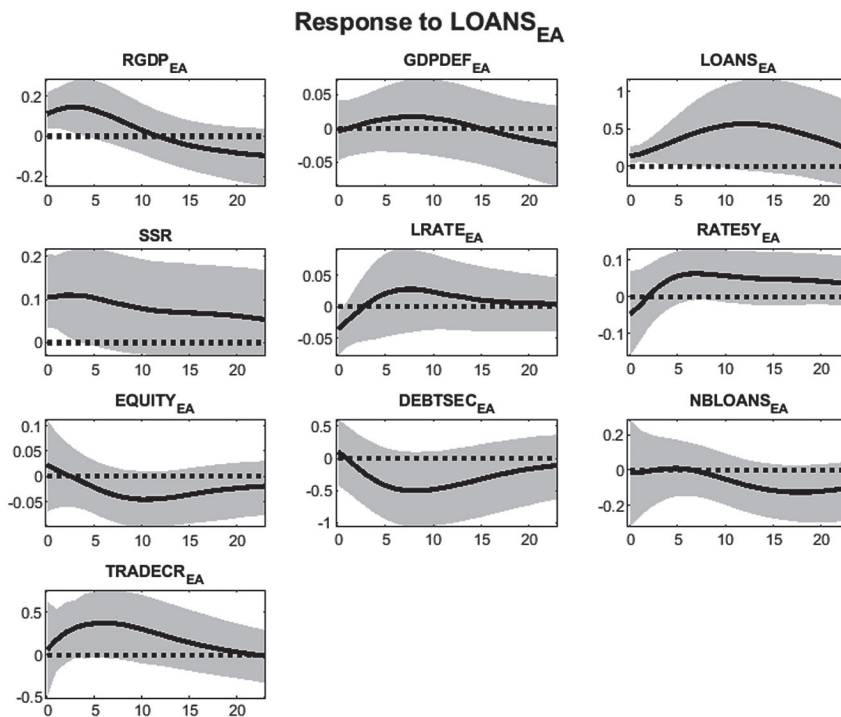
Abbreviations: AD, aggregate demand shock; AS, aggregate supply shock; GDPDEF, GDP deflator; LRATE, lending rate, subscripts ‘EA’ denote euro area variables; LOANS, real MFI loans to non-financial corporations; LS, loan supply shock; MP, monetary policy shock; RGDP, real GDP; SSR, shadow short rate. Sign restrictions on impulse responses imposed on impact.



**FIGURE 3** Identified loan supply shock—euro area. Median and 16- and 84% percentiles of marginal posterior distribution of impulse responses

(European Central Bank, 2012b). The large positive shock in 2012Q1 can be linked to the very long-term maturity refinancing operations (VLTRO) with maturity of three years.

Figure 4 displays the impulse responses of the euro area macroeconomic variables to an expansionary one-standard deviation loan supply shock in percentage deviations from baseline or, in case



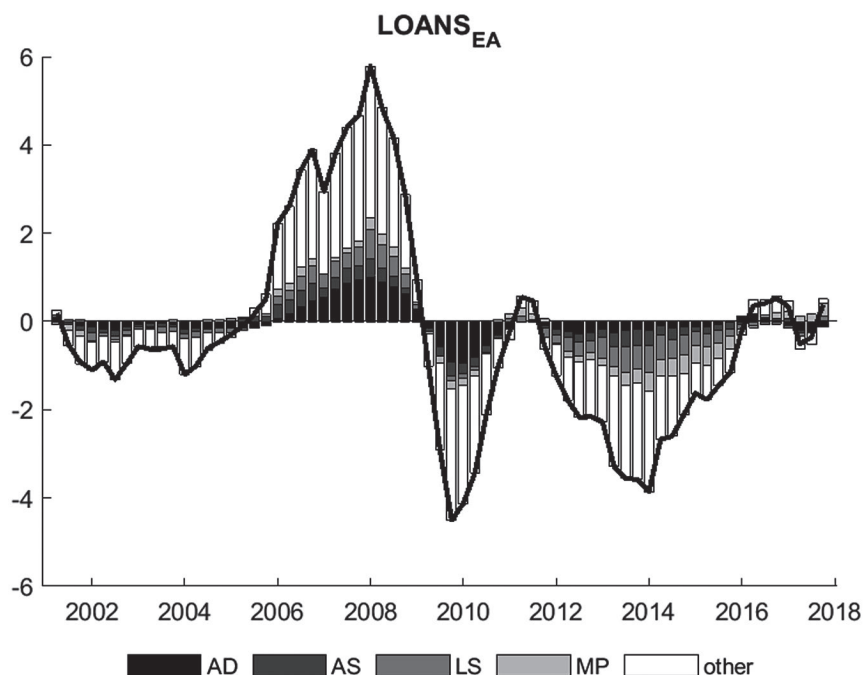
**FIGURE 4** Impulse responses to loan supply shock—euro area. Median and 16- and 84% percentiles of marginal posterior distribution of impulse responses. Percentage deviations from baseline or, in case of interest rates, difference from baseline in percentage points

of the interest rates, in percentage points. The graphs show the median (in solid black) of the marginal posterior distribution of the impulse response functions together with the interval between the 16- and 84%-percentiles. In interpreting the results we base our assessment on the location of the posterior distribution relative to the zero line. If the zero line lies outside the 16- and 84%-percentiles interval the posterior-probability ratio of the impulse response being positive (negative) is more than 4:1 and the zero line within the bands but close to the edges can still imply a posterior-probability ratio of 3:1.

The expansionary loan supply shock causes a temporary increase in output and, with delay, also a weak increase in the price level. The central bank responds with a relatively persistent increase in the policy rate. Considering the delayed increase in the price level and the hump-shaped pattern of the increase in bank lending the assumption of an increase in the policy rate in the identification scheme seems reasonable if the central bank sets monetary policy in a forward-looking way. The bank lending rate drops initially by assumption but then returns around baseline, most likely due to the monetary tightening and the increase in economic activity which both work in the direction of higher lending rates. These impulse responses are consistent with the evidence of Gambetti and Musso (2017) who also estimate a rise in the lending rate after the initial decline and an increase in the growth rate of bank lending that persists for about ten quarters.<sup>21</sup>

None of the alternative financing sources reacts to the increase in bank lending immediately but financing by equity and debt securities declines afterwards below baseline and both reach a trough after about eight to 10 quarters. In contrast, non-bank lending remains broadly unchanged for at least

<sup>21</sup>This refers to the sample averages of the estimated impulse responses from their time-varying VAR.



**FIGURE 5** Historical decomposition of financing via non-bank loans and trade credit—euro area. Annual growth rates in per cent. Median contributions of identified shocks to deviation from unconditional forecast. AD, aggregate demand shock; AS, aggregate supply shock; LS, loan supply shock; MP, monetary policy shock

two years before it declines.<sup>22</sup> Trade credit moves in the same direction as bank lending but reaches its peak at about five quarters—much earlier than bank lending and closer to the peak in real GDP.

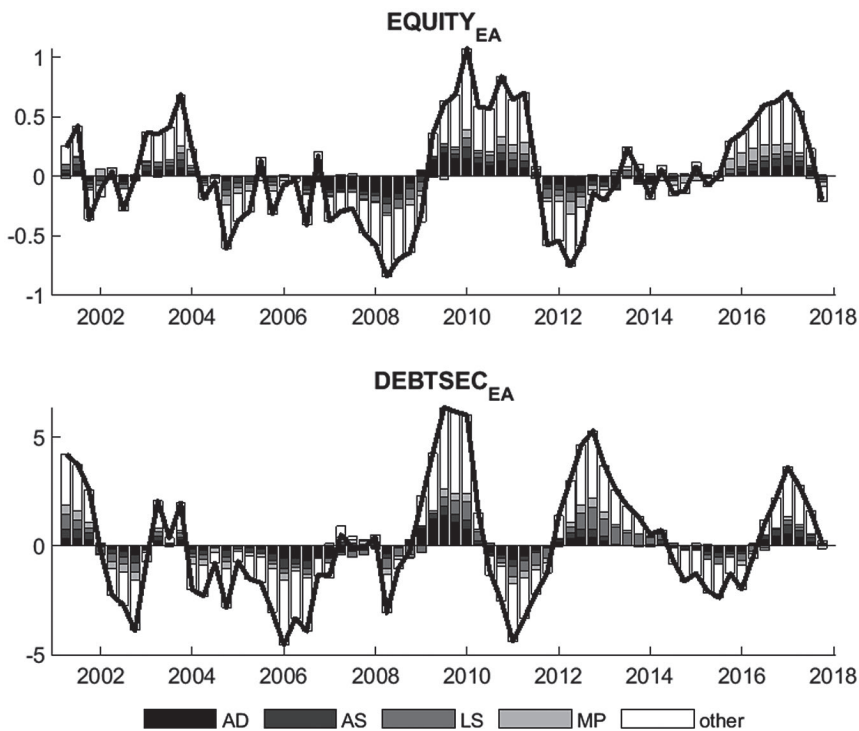
Figures 5–7 show the historical decomposition of the annual growth rates of bank loans, equity finance, debt securities, non-bank loans and trade credit.<sup>23</sup> Given that the model contains six unidentified structural shocks the identified shocks together generally account for less than half of the deviations from the unconditional forecasts.<sup>24</sup>

The effects of current and past loan supply shocks contributed positively to growth in bank lending between 2006 and 2009. From 2012 to 2015 loan supply shocks exerted a negative influence on its growth rate. The effects of loan supply shocks on equity financing turn out to be very small throughout the sample period. In contrast, loan supply shocks had sizable positive effects on financing through debt securities 2012 and 2014. We only find a notable positive impact of loan supply shocks on the

<sup>22</sup>The posterior distribution of the impact response of financing via equity and debt securities exhibits substantial mass above zero, in fact, the median responses are positive on impact. This supports the interpretation of a loan supply shock in a broad sense as discussed in Section 2 as also encompassing more general financial market shocks that impact bank lending.

<sup>23</sup>Specifically, the stacked bars show the median contribution of each of the four identified shocks to the series' deviation from its unconditional forecast from the beginning of the sample while the black line denotes the median deviation of the actual series from this unconditional forecast across all draws from the posterior distribution. The white bars represent the effects of the unidentified shocks as well as the approximation error resulting from the sum of the median contributions not being equal to the median of the sum of the contributions.

<sup>24</sup>Results on the forecast error variance decomposition of the identified loan supply shock are available upon request.



**FIGURE 6** Historical decomposition of equity and debt securities financing—euro area. Annual growth rates in per cent. Median contributions of identified shocks to deviation from unconditional forecast. AD, aggregate demand shock; AS, aggregate supply shock; LS, loan supply shock; MP, monetary policy shock

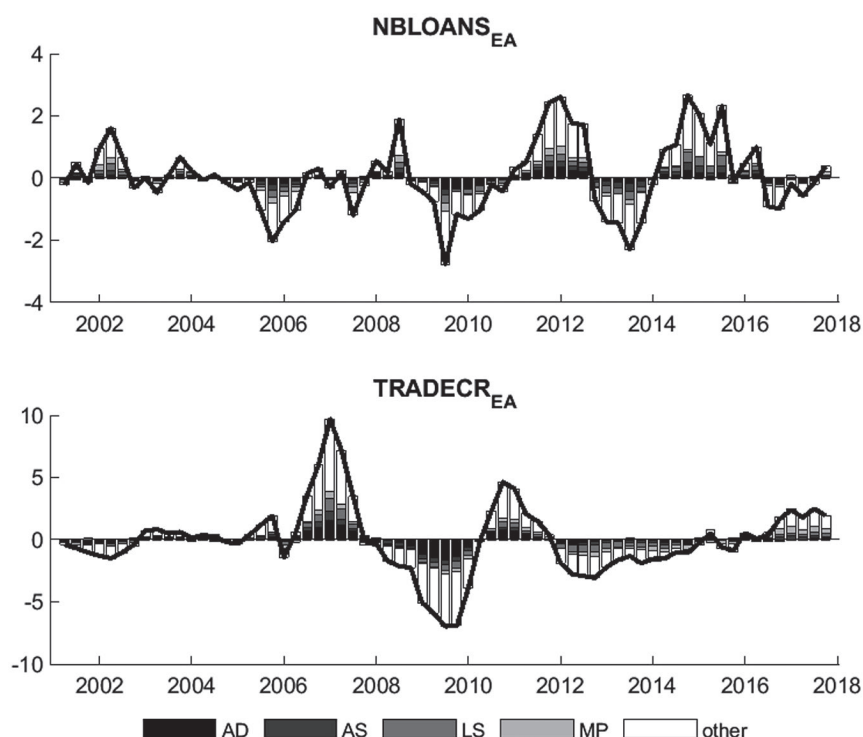
growth in non-bank lending between 2014 and 2016, later than for debt securities while the contributions of loan supply shocks to growth in trade credit broadly mirror those to bank loans themselves.<sup>25</sup> Our results for the contributions of loan supply shocks to the growth rates of bank lending and debt securities issuance are qualitatively in line with the evidence in Altavilla et al. (2015) but are considerably smaller.<sup>26</sup>

The negative medium-term developments in equity financing and debt securities after a loan supply shock that increases bank lending suggest that these two alternative financing sources might act as a substitute for bank loans while the positive response in trade credit suggests this financing source being a complement to bank lending. However, an assessment based on the marginal distributions of the impulse response functions shown in Figure 4 might be misleading since it should be based on the *joint* distribution of the impulse responses of the external financing variables.<sup>27</sup> Thus, in Figure 8 we show scatter plots of the

<sup>25</sup>Figures 5–7 show the median contributions of the shocks but do not contain information about the dispersion of the distribution. Figure 15 in Mandler and Scharnagl (2019) shows the posterior-probability ratios for a positive (negative) impact of current and past loan supply shocks on the deviation of the annual growth rate in the external financing variables from the unconditional forecast. The episodes highlighted by these statistics correspond to those discussed above.

<sup>26</sup>However, the deviation of bank loan growth from baseline in the historical decomposition is substantially smaller in our model, as well.

<sup>27</sup>It would be misleading to compare specific percentiles of the impulse responses of bank lending and an alternative financing sources to each other, even at a given point in time, as these are not generated from the same draw for the identified VAR model, see Fry and Pagan (2011) or Kilian and Lütkepohl (2018).



**FIGURE 7** Historical decomposition of bank loans—euro area. Annual growth rates in per cent. Median contributions of identified shocks to deviation from unconditional forecast. AD, aggregate demand shock; AS, aggregate supply shock; LS, loan supply shock; MP, monetary policy shock

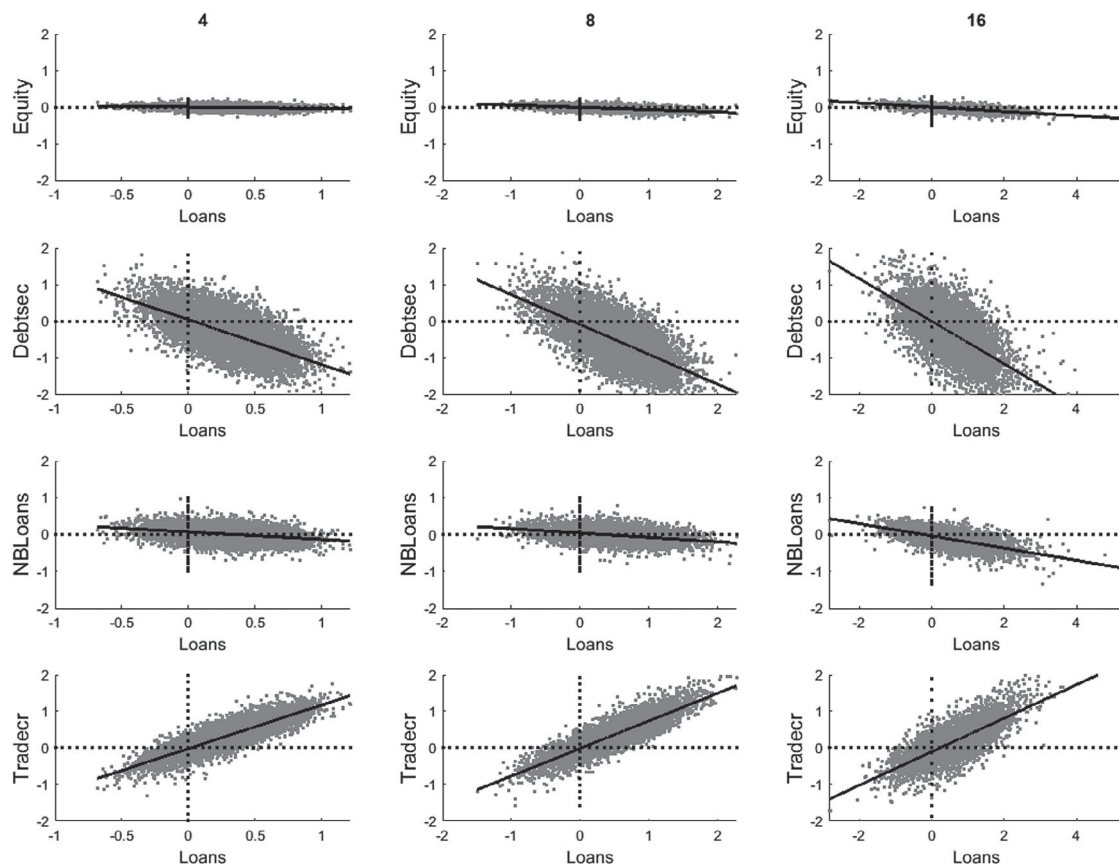
joint distribution of the impulse response in bank lending and each of the other external financing sources. Each row refers to another alternative financing source while the columns refer to different horizons for the impulse responses. The black solid lines are fitted values from a linear regression including a constant.

Figure 8 suggests a negative association between the increase in bank loans after a loan supply shock and the change in each alternative financing source relative to baseline, except for trade credit, at horizons of four quarters and longer. However, the negative comovement between bank loans and equity is relatively weak. For the impulse response of trade credit the scatter plots show strong positive comovement with that of bank loans. Our results suggest that, in general equilibrium, equity, debt securities and non-bank loans act as substitutes for bank loans while trade credit acts as a complement.

Given these relationships among financing sources we investigate to what an extent the changes in equity, debt securities and non-bank lending offset the changes in bank lending and trade credit after a loan supply shock. The lower left panel in Figure 9 shows the impulse response of the sum of the five external financing sources to the loan supply shock<sup>28</sup>: a positive loan supply shock results in an increase in overall external financing that persists for about four years. Over this horizon, the expansion

<sup>28</sup>The posterior distribution of the impulse responses is obtained by computing a weighted average of the individual variables' impulse responses for each draw of the model—which are percentage deviations from baseline—with weights equal to the average relative share of the variables in overall external financing over the estimation period (approx. 20% for bank loans, 49% for equity, 4% for debt securities, 16% for non-bank lending and 11% for trade credit). Since the weighted average is a function of the model parameters from the MCMC simulations the resulting distribution is a valid approximation to the posterior distribution of the response of overall external financing.





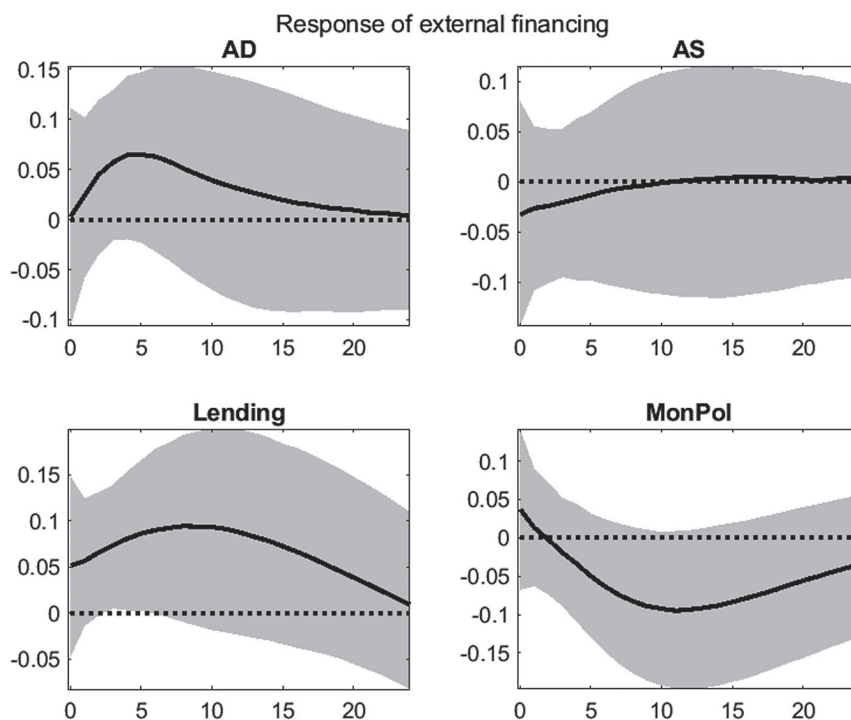
**FIGURE 8** Joint distribution of impulse responses of bank loans and alternative financing sources to loan supply shock—euro area. Scatter plots of impulse response of real MFI loans to non-financial corporations (horizontal axes) and impulse response of variable indicated (vertical axes). Columns indicate impulse response horizon. Black lines are obtained from linear regression of impulse responses on vertical axes on impulse responses on horizontal axes

in bank lending and the accompanying rise in trade credit dominate the contraction in equity and debt securities issuance. Consequently, a contractionary (negative) shock to bank lending would result in an overall reduction of external financing since the expansion in the substitutes would be not sufficient to compensate for the decline in bank lending and trade credit.<sup>29</sup>

Figure 9 shows the effects of these shocks on the sum of the external financing sources. A positive aggregate demand shock has no contemporaneous but a delayed positive effect on external financing of non-financial firms which peaks at about five quarters (see top left panel). This results mainly from the expansion in bank lending and trade credit to firms while, in particular, equity financing for up to about two years, but to some extent, also debt securities contract.<sup>30</sup> For the aggregate supply shock there is no clear response of the sum of external financing. Finally, a contractionary monetary policy shock causes a delayed reduction in external financing which bottoms out at about two and a half

<sup>29</sup>Impulse responses and the corresponding scatter plots for the other three identified shocks are shown Mandler and Scharnagl (2019).

<sup>30</sup>For the impulse responses of the individual variables, see Mandler and Scharnagl (2019).



**FIGURE 9** Impulse responses of external financing to identified shocks—euro area. Median and 16- and 84% percentiles of marginal posterior distribution of impulse responses. Percentage deviations from baseline or. AD, aggregate demand shock; AS, aggregate supply shock; Lending, loan supply shock; MonPol, monetary policy shock. AD and Lending shocks increase output, AS and MonPol shocks reduce output

years. Among the debt instruments the monetary policy shock primarily causes a decline in bank loans and trade credit. This is consistent with the evidence in Kashyap et al. (1993) for the United States that a restrictive monetary policy shock shifts the mix in firms' short-term debt finance away from bank loans. A similar transmission mechanism, that is, a change in debt composition towards loans (and trade credit) is also at work for the aggregate demand and the loan supply shock (Figure 4) as bank loans and trade credit expand after a positive shock while debt securities either contract or do not move in a clear direction.

From Figure 9 we conclude that, except for the aggregate supply shock, for which we do not find much evidence for a directional reaction in financing, the response of the sum of the external financing is always in the direction of the response of bank lending, although bank loans and its complement trade credit only account for about 20% and 11% of the sum of all five financing sources in the sample average, respectively (see footnote 28). Thus, substitution with other financing sources is only partial and the changes in the other external financing components are not sufficient to compensate for the change in bank lending and trade credit in general equilibrium. For a negative loan supply shock this implies that, although some of the other financing sources will expand while bank lending contracts, the substitution will be incomplete, the decline in bank lending will dominate and firms' overall external financing will decrease.

Covas and Den Haan (2011) show equity issuance and debt issuance, which includes loans, debt securities and trade credit, to be both pro-cyclical with respect to real GDP. According to Figure 9 overall external financing is pro-cyclical as well for the aggregate demand, loan supply and monetary policy shocks as it moves in the same direction as real output. The impulse response functions for the

individual shocks suggest that both equity and debt finance respond pro-cyclically to the monetary policy shock with the debt response mostly driven by bank loans and trade credit. Bank loans and trade credit also respond pro-cyclically to the aggregate demand and loan supply shock but debt securities issuance tends to move in the opposite direction. However, quantitatively the effect of the pro-cyclical debt components dominates (see footnote 28). The cyclical pattern of debt in our results is also consistent with the evidence in Jermann and Quadrini (2012).

The scatter plots of the joint posterior distribution of the impulse responses are broadly similar across shocks.<sup>31</sup> Thus the general equilibrium substitution relationship between equity, debt securities and non-bank lending on the one and bank lending on the other side as well as the complementary relationship between bank loans and trade credit turn out to be largely independent of the structural shock.<sup>32</sup>

Table 3 summarizes the results from the scatter plots. It presents mean estimates of the elasticities of the alternative financing sources with respect to a change in bank lending after a shock. To derive this table, we run OLS regressions on the scatter plots of the impulse responses (e.g., Figure 8) and tabulate the estimated slope coefficients. These correspond to the slopes of the black lines shown in Figure 8. Since the impulse responses are measured in percentage deviations from baseline, the slope coefficients can be interpreted as elasticities of the alternative financing sources with respect to bank lending after a shock. We use these elasticities as summary statistics for the information in the scatter plots. Negative values indicate substitution, positive ones complementarity between financing sources in general equilibrium. In order to assess how much confidence we are to place in the estimates in Table 3 we compute for the same impulse response horizons the share of draws from the BVAR model for which the response of bank loans and the alternative external financing source in question have an identical sign, that is, the responses go in the same direction. Shares above 0.5 indicate complementarity (more matching signs in the impulse responses than opposing signs), while shares below 0.5 indicate substitution (more opposing signs than matching signs). The relevant table is in Appendix B. Those mean elasticity estimates which coincide with posterior-probability ratios of at least 2:1 for or against identical signs in the impulse responses are set in bold in Table 3.<sup>33</sup> In the following discussion we focus on these estimates.

For the euro area we find marked negative elasticities on debt securities for all shocks and all horizons, supporting our conclusion of a substitution relationship with bank lending. The elasticities on non-bank loans and, in particular, equity are small in absolute value. However, although elasticities remain weak, equity can be considered a substitute for bank loans from eight quarters on based on the posterior-probability ratio for negative comovement. For non-bank loans elasticities become markedly negative at the 16 quarters horizon at which these loans can be classified as substitutes for bank loans. Trade credit is a complement to bank loans at all horizons but its elasticity with respect to bank loans declines as the impulse response horizon lengthens. The classification into substitutes and complements is robust with respect to the structural shocks as the bold coefficients do not change their sign.

<sup>31</sup>The details are shown in Mandler and Scharnagl (2019).

<sup>32</sup>However, different structural shocks potentially have the strongest effects on the correlation structure of the variables on impact. As the impulse response horizon becomes longer the effect of the dynamic coefficients becomes more and more important. Since our results do not indicate strong differences in the impact effect of the shocks on the alternative financing sources our results are likely to be mostly driven by the dynamic coefficients which lead to similar results across shocks when the impulse response horizon grows longer.

<sup>33</sup>This corresponds to shares above 0.66 or below 0.33 in Table B1.

**TABLE 3** Estimated impulse response elasticities of alternative financing sources with respect to bank loans

Shock	Horizon				8 quarters				16 quarters			
	EQ	Debt	NBL	TC	EQ	Debt	NBL	TC	EQ	Debt	NBL	TC
Euro Area												
LS	-0.04	-1.23	-0.20	1.20	-0.06	-0.82	-0.12	0.76	-0.06	-0.58	-0.17	0.46
AD	-0.04	-1.09	-0.16	1.11	-0.07	-0.84	-0.11	0.75	-0.06	-0.58	-0.17	0.44
AS	-0.04	-1.06	-0.15	1.07	-0.06	-0.86	-0.12	0.77	-0.06	-0.61	-0.17	0.47
MP	-0.04	-1.09	-0.16	1.09	-0.07	-0.82	-0.11	0.73	-0.06	-0.61	-0.17	0.47
Germany												
LS	0.02	-0.23	-0.96	0.36	0.05	-0.53	-0.89	0.20	0.06	-0.68	-0.88	-0.07
AD	0.05	-0.04	-0.62	0.17	0.05	-0.38	-0.83	0.12	0.07	-0.52	-0.94	-0.13
AS	0.05	-0.25	-0.68	0.27	0.05	-0.53	-0.70	0.20	0.06	-0.60	-0.70	0.10
MP	0.04	-0.09	-0.55	0.19	0.06	-0.50	-0.75	0.22	0.04	-0.58	-0.69	0.15
France												
LS	-0.02	-0.48	0.15	0.39	-0.05	-0.39	0.27	0.37	-0.05	0.20	0.25	0.28
AD	-0.01	-0.03	0.19	0.32	-0.04	-0.14	0.28	0.33	-0.06	-0.22	0.25	0.30
AS	0.01	0.02	0.13	0.29	-0.03	-0.18	0.25	0.34	-0.05	-0.28	0.24	0.31
MP	0.02	0.10	0.10	0.31	-0.02	-0.03	0.23	0.33	-0.05	-0.20	0.23	0.31
Italy												
LS	-0.17	-0.12	0.35	0.55	-0.34	-0.52	0.49	0.55	-0.42	-1.32	0.59	0.36
AD	-0.08	0.31	0.44	0.30	-0.30	-0.79	0.54	0.52	-0.40	-1.48	0.62	0.42
AS	-0.04	-0.26	0.45	0.36	-0.31	-0.77	0.59	0.47	-0.40	-1.48	0.58	0.38
MP	-0.07	-0.57	0.55	0.33	-0.30	-0.85	0.69	0.46	-0.39	-1.57	0.68	0.37
Spain												
LS	0.01	0.28	-0.14	1.29	-0.04	-0.01	-0.08	1.17	-0.06	-0.09	0.03	0.92
AD	0.01	0.11	-0.04	1.10	-0.04	-0.09	-0.03	1.10	-0.07	-0.09	0.02	0.92
AS	0.02	0.11	-0.02	1.03	-0.03	-0.08	0.03	1.12	-0.07	-0.09	0.02	0.94
MP	0.01	0.02	-0.03	1.03	-0.05	-0.09	-0.03	1.04	-0.07	-0.08	-0.01	0.96

*Notes:* Elasticity of deviation of volume of financing from baseline with respect to the deviation in bank loans from baseline. Estimated slope coefficients of OLS-regression of impulse responses of alternative financing source on impulse response of bank loans. Regression includes constant.

Abbreviations: shocks: AD, aggregate demand shock; AS, aggregate supply shock; LS, loan supply shock; MP, monetary policy shock. variables: Debt: debt securities; EQ: equity; NBL, non-bank loans; TC, trade credit. Elasticities with posterior-probability ratios for positive or negative comovement above 2:1 in bold.

### 3.2 | Country results

The second to fifth panels of Table 3 show estimated elasticities of alternative financing sources with respect to bank lending for the four largest euro area countries. As for the aggregate euro area these serve as summary statistics for the joint posterior of the impulse response functions of bank lending and each of the alternative financing sources.<sup>34</sup> Again bold figures denote positive or negative elasticities at posterior-probability ratios of at least 2:1.<sup>35</sup>

For the individual countries the results are less conclusive than at the euro area aggregate level. For Germany the results are all inconclusive. For France Table 3 shows trade credit and non-bank loans to be complements to bank loans in general equilibrium but the evidence for equity and debt securities is inconclusive. In Italy, non-bank loans can be categorized as complements to bank loans, in particular following a loan supply shock for which we find posterior-probability ratios for positive comovement of 2:1 or more from four quarters onwards. Equity financing moves inversely to bank loans after eight quarters. Again, trade credit acts as a general equilibrium complement for bank lending for the loan supply and the monetary policy shock but the signs on the elasticities are also positive for the other shocks. The only clear result for Spain is that trade credit is a complement to bank loans at all horizons with elasticities around one. As for the euro area the categorization of the alternative financing sources as substitute for or complement to bank loans in general equilibrium is largely independent of the shock. The bold entries never change sign and for each country and at a given horizon the elasticity estimates do not differ much by shock.

### 3.3 | Robustness tests

Except for the interest rate on bank loans the models do not include indicators of the cost of firms' external financing. As a robustness check we added corporate bond yields from Gilchrist and Mojon (2018) as the cost of financing via debt securities issuance and the annual stock return as a proxy for the cost of equity financing. In the first variant of this model, we imposed no sign restrictions on the added variables. In the second variant we assumed that the impulse response of the corporate bond yield moves in the same direction as the bank lending rate. This assumption is in line with the interpretation of the loan supply shock as a broader financial market disturbance (see Section 2.3). For both of these model variants we obtained very similar results to the classification in Table 3. In another robustness check we added firms' gross savings from the flow-of-funds statistics to the model, thus, augmenting the model by a variable that proxies for firms' internal financing. The classification of the external financing sources as substitutes for or complements to bank loans remained close to the one in Table 3. An analysis as in the table for the relationship between bank loans and gross savings showed savings to be a substitute for bank loans in the euro area and in IT.

We also carried out the analysis using consolidated debt securities outstanding as in Kashyap et al. (1993), that is, only debt securities issued by non-financial corporations which are held by other sectors. Except for this data series and bank loans we drop all other flow-of-funds series from the model as equity and shares and trade credit are only available as non-consolidated data. The results

<sup>34</sup>The scatter plots, the impulse responses and the historical decompositions for each country and structural shock can be found in Mandler and Scharnagl (2019).

<sup>35</sup>See Table B1 in Appendix B.

are available upon request and again indicate that debt securities act as substitutes to bank loans in the euro area. At the individual country level the results are again mostly inconclusive.

Replacing the five-year government bond yield by the ten-year yield in the euro area model did not change our results. We also checked the role of the SSR as monetary policy indicator: (a) we replaced the SSR by Wu and Xia (2016) by the one from Geiger and Schupp (2018) and obtained very similar results to our baseline model(s). (b) we used the EONIA instead of the SSR. This change implies that the identified monetary policy shocks no longer account for unconventional monetary policy measures. Our results on the substitutability or complementarity of the financing sources are robust with respect to this change.

## 4 | DISCUSSION AND CONCLUSIONS

We analyse the effects of shocks to bank lending on non-financial corporations' external financing both in the euro area and in Germany, France, Italy and Spain and account explicitly for possible interactions of bank lending with alternative sources of financing for firms. We investigate whether and which of the financing sources are complements to or substitutes for bank loans in general equilibrium. We study the responses of the different financing variables to identified structural shocks and check for positive or negative comovement in the variables. Thus, our classification of a financing variable as a substitute or complement relative to bank loans is (a) dynamic, that is, relates to the horizon of the impulse responses and (b) cyclical, since it concerns deviations from steady state. Our analysis does not investigate secular developments, for example, related to structural changes in the financial system. It is also important to reiterate that our results concerning non-bank loans and trade credit being complements to bank loans in some countries is a general equilibrium result. In partial equilibrium perspective in which firms choose their financing structure given their financing needs alternative financing sources and bank loans are likely to be substitutes from the firm's point of view: a reduction in the availability of bank lending or an increase in the lending rate provides an incentive to substitute bank loans by the other financing means as in Becker and Ivashina (2014). Our results concern the relationship between the external financing sources when all the other endogenous variables adjust to the structural shocks, as well and the *ceteris paribus* assumptions cannot be maintained.

We show that it is important to focus on the joint distribution of the responses of the alternative financing sources and bank loans in order to assess whether they act as substitutes or complements. On the euro area level we find equity, debt securities and non-bank loans to be substitutes for bank loans in general equilibrium while trade credit is a complement. Substitution is imperfect and the overall sum of the external financing components including bank loans moves into the direction of the latter. Moving below the euro area aggregates, which, if any, financing sources are substitutes for or complements to bank loans in general equilibrium differs across the individual countries. In France and Italy, non-bank loans are complements to bank loans as is trade credit in France and Spain and, to some extent in Italy. Equity financing is a substitute for bank loans to non-financial corporations in Italy. Results for Germany are inconclusive. We show our classification to be robust with respect to changes in bank lending being due to different structural shocks.

In the euro area external financing moves in the direction of bank lending. Thus, the changes in bank lending, reinforced by complementarity with other financing sources, dominate the dynamics of external financing. Compensation by substitutes, if any, is imperfect. In the case of a negative, that is, contractionary loan supply shock this implies that alternative financing sources, even if some substitution takes place cannot, on a macroeconomic level, fully compensate for the effects of a reduction in bank lending.



While we find strong evidence for a systematic relation of the dynamics in bank loans and the four alternative external financing sources for firms following structural shocks in the euro area aggregates, results at the individual country level are not as pronounced. This is a puzzling result as the four countries account for the bulk of the euro area aggregate variables.<sup>36</sup> One possibility might be higher estimation uncertainty at the country level. For example, the percentile bands on the impulse response functions of the four flow-of-funds variables to the loan supply shock in the individual countries generally tend to be wider than those for the euro area. One reason for this might be that the individual country models include two additional variables compared to the euro area aggregate model: euro area real GDP and GDP deflator, which introduces additional parameters and might result in an unfavourable trade-off if they contain little additional information. We reestimated the country models for France and Germany without the two euro area variables, which might result in a misspecified monetary policy reaction function as discussed in Subsection 2.3, but we found only a small improvement in our results.<sup>37</sup> Another possibility is that the sign restrictions for the aggregate demand, aggregate supply and loan supply shocks at the country level on the common monetary policy interest rate might be a problem but these restrictions are required for disentangling the different structural shocks. A more favourable explanation is that country-specific noise in the flow-of-funds data might to some extent cancel out in the euro area aggregates which would reduce the estimation uncertainty at the euro area level. A fact in support of this hypothesis is that the elasticity estimates Table 3 which are large in absolute values but do not pass the test in Table B1, such as, for example, those for non-bank loans in Germany or for debt securities in France and Spain broadly show the same signs as those estimated for the euro area aggregates.

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<sup>36</sup>In terms of the sample averages of the time series the four countries account for 75% of euro area MFI loans to non-financial corporations, 73% of equity, 72% of debt securities, 91% of non-bank loans and 89% of trade credit.

<sup>37</sup>For Germany we obtain for the loan supply shock some evidence for non-bank loans being a substitute for bank loans at a posterior-probability ratios of 2:1. For both countries the estimation algorithm selected more shrinkage, that is, smaller values for  $\lambda$  in the larger model but the modest decline does not suggest that the additional data are uninformative. We also experimented with including additional variables, such as the bank bond or corporate bond vs. government bond spreads from Gilchrist and Mojon (2018) but this also did not lead to more clear-cut results.



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## APPENDIX A

### DATA

- *Real GDP* Gross domestic product at market prices, chain linked volume, calendar and seasonally adjusted data. Source: Eurostat. Downloaded from the ECB's Statistical Data Warehouse (SDW).
- *GDP Deflator* Gross domestic product at market prices, deflator (index), calendar and seasonally adjusted data. Source: Eurostat. Downloaded from the SDW.
- *MFI loans to non-financial corporations* We construct an index of notional stocks, using the outstanding amounts at the end of the period, financial transactions (flows) and, after they become available, financial transactions (flows) which are adjusted for sales and securitizations; data are neither seasonally nor working day adjusted. For details on the construction of notional stocks, see European Central Bank (2012a). Source: ECB (Balance sheet indicators—BSI). Downloaded from the SDW.
- *Shadow short rate* Shadow short rate from Wu and Xia (2016); we use observation for final month in quarter; backward extension of data with EONIA. Download from <https://sites.google.com/view/jingcynthiawu/>
- *Lending rate* Interest rate loans other than revolving loans and overdrafts, convenience and extended credit card debt; loans of credit and other institutions to non-financial corporations, new business; we use observation for final month in quarter; backward extended using the Area Wide Model Database. Source: ECB (MFI interest rate statistics—MIR). Downloaded from the SDW.

- *Five-year government bond yield* Five-year benchmark bond yield; average of observations through period. Source: ECB. Downloaded from the SDW.
- *Equity* Non-financial corporations—liabilities, equity—non-consolidated. We construct an index of notional stocks using the closing balance sheet information and the transaction amounts (see above); data are neither seasonally nor working day adjusted. Source: ECB and Eurostat. Downloaded from the SDW.
- *Debt securities* Non-financial corporations—liabilities, debt securities—non-consolidated. We construct an index of notional stocks using the closing balance sheet information and the transaction amounts (see above); data are neither seasonally nor working day adjusted. Source: ECB and Eurostat. Downloaded from the SDW.
- *Non-bank loans* Non-financial corporations—liabilities, loans—non-consolidated. We construct an index of notional stocks using the closing balance sheet information and the transaction amounts (see above); data are neither seasonally nor working day adjusted. We subtract from this series, which includes MFI loans, the series for MFI loans (see above). Source: ECB and Eurostat. Downloaded from the SDW.
- *Trade credit* Non-financial corporations—liabilities, trade credit and advances—non-consolidated. We construct an index of notional stocks using the closing balance sheet information and the transaction amounts (see above); data are neither seasonally nor working day adjusted. We subtract from this series, which includes MFI loans, the series for MFI loans (see above). Source: ECB and Eurostat. Downloaded from the SDW.

## APPENDIX B

**TABLE B1** Proportion of draws with impulse responses of bank loans and alternative financing source of identical sign

Horizon	4 quarters				8 quarters				16 quarters			
Shock	EQ	Debt	NBL	TC	EQ	Debt	NBL	TC	EQ	Debt	NBL	TC
Euro area												
LS	0.38	0.21	0.46	0.89	0.20	0.16	0.38	0.90	0.20	0.24	0.18	0.76
AD	0.26	0.30	0.50	0.86	0.24	0.32	0.40	0.77	0.29	0.31	0.26	0.74
AS	0.44	0.30	0.41	0.82	0.31	0.25	0.37	0.83	0.24	0.26	0.25	0.78
MP	0.48	0.31	0.39	0.82	0.42	0.28	0.39	0.85	0.29	0.32	0.30	0.79
Germany												
LS	0.57	0.54	0.43	0.55	0.54	0.47	0.41	0.51	0.56	0.42	0.39	0.52
AD	0.46	0.47	0.40	0.58	0.47	0.44	0.40	0.52	0.54	0.43	0.42	0.48
AS	0.58	0.51	0.47	0.60	0.53	0.45	0.43	0.54	0.58	0.42	0.37	0.54
MP	0.49	0.50	0.46	0.53	0.46	0.50	0.42	0.54	0.49	0.48	0.43	0.53
France												
LS	0.38	0.41	0.67	0.76	0.36	0.46	0.71	0.72	0.42	0.47	0.65	0.69
AD	0.36	0.41	0.68	0.71	0.39	0.45	0.66	0.72	0.38	0.44	0.68	0.72
AS	0.57	0.56	0.68	0.70	0.47	0.54	0.75	0.70	0.42	0.48	0.67	0.68
MP	0.42	0.39	0.60	0.72	0.33	0.32	0.80	0.81	0.42	0.48	0.68	0.74
Italy												
LS	0.34	0.46	0.69	0.69	0.23	0.45	0.69	0.70	0.21	0.37	0.68	0.64
AD	0.40	0.54	0.60	0.61	0.33	0.51	0.67	0.54	0.28	0.40	0.71	0.61
AS	0.45	0.49	0.61	0.62	0.28	0.43	0.66	0.63	0.20	0.37	0.69	0.66
MP	0.41	0.46	0.61	0.60	0.18	0.44	0.68	0.72	0.12	0.37	0.71	0.69
Spain												
LS	0.55	0.48	0.57	0.80	0.42	0.44	0.55	0.78	0.34	0.48	0.53	0.81
AD	0.46	0.47	0.53	0.78	0.41	0.47	0.50	0.79	0.34	0.46	0.52	0.81
AS	0.52	0.52	0.51	0.74	0.44	0.48	0.50	0.79	0.32	0.45	0.52	0.84
MP	0.55	0.58	0.51	0.80	0.44	0.55	0.57	0.81	0.30	0.51	0.57	0.76

Notes: Share of draws from posterior distribution of impulse responses to identified shocks for which bank loans and alternative financing source respond with identical sign.

Abbreviations: shocks: AD, aggregate demand shock; AS, aggregate supply shock; LS, loan supply shock; MP, monetary policy shock; variables: Debt, debt securities; EQ, equity; NBL, non-bank loans; TC, trade credit.