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Heterogeneous Loans and the Effect of Monetary Interventions

Abstract

The amount of credit in the economy is a heterogeneous aggregate that can be analyzed across different dimensions. Considering such dimensions provides insights into the effect of monetary policy interventions because the credit components are observed to respond differently. Several possible motivations are behind such a differential response and those relate to either demand and supply factors intrinsic to the transmission mechanism of monetary policy. Our objective is to unveil such a differential response across a couple of relevant dimensions and discuss the possible causes behind what observed. The analysis refers to the US and is based on a vector auto-regression estimated using Bayesian techniques and identified with a combination of sign and zero-restrictions.

JEL-Codes: E440, E510, G200, G210, C110.

Keywords: bank loans, non-bank loans, monetary interventions, households, corporate business, non-corporate business, Bayesian VAR.

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1 Introduction

In normal times the price of credit is indirectly driven by monetary policy. When the transmission mechanism works, a monetary policy change causes all the rates to change in the same direction. As a first consequence, even though quite slowly, the amount of loans adjusts. However, the effect on loans does not depend uniquely on the interest rate increase, many concurrent factors get in motion and contribute to the observed response (Albertazzi et al. 2020). For instance, empirical research (Bernanke & Gertler 1995) shows that loans to different groups respond in a different manner to the same monetary innovation, at least in the short to medium term: credit to corporations is observed to increase, while loans to households are observed to decrease (Den Haan et al. 2007).[1] Interest rates, however, increase for all groups, such a difference is therefore likely to depend on other concurrent factors triggered by the monetary innovation, factors that find room in the multiple channels of the transmission mechanism (Drechsler et al. 2018*a*). Studying loans along different dimensions is therefore important to assess the role that those factors play, and this can be achieved through the response of loan categories on which those factors are more likely to impact. In addition to the borrower dimension, also loans for different scopes are observed to respond differently (Cloyne et al. 2016) and we can expect the same when different kinds of lenders are involved.

The objective of our research is to study how different loan categories respond to a monetary policy shock identified with a combination of sign and zero restrictions, similarly to Arias et al. (2019). Our prime focus is to distinguish across loans to different groups, and across loans granted by banks and non-bank institutions; but we disentangle the effect of monetary interventions also over loans for different scopes. This enriches the analysis and serves to evaluate more in details those concurrent factors. Our study is based on the estimation of a large Vector Auto-Regression (VAR), which we deem suited to account for the interactions across the variables, and employs an identification approach different from what found in previous VAR estimations in which the focus is on different loan categories (Den Haan

[1] At our knowledge, the first to find and provide an explanation for this puzzle are Gertler & Gilchrist (1993*a*,*b*, 1994). The same emerges also in a number of subsequent contributions; among the others, Den Haan et al. (2007) for the US, Busch et al. (2010) for Germany, Giannone et al. (2012) for the Euro Area aggregate. It emerges also when the larger debt aggregate, instead of just loan liabilities, is used for the analysis as in Cafiso (2019).

et al. 2007). This serves to check that some relevant stylized facts found in previous contributions are not bounded to the structural identification approach used and to move the analysis to a more state-of-the-art level.

The paper is structured as follows. Section 2 discusses some relevant research contributing on the effect of monetary innovations on loans. Section 3 details the estimation of the VAR using the Bayesian approach. We report and discuss the results of our analysis in Section 4. Section 5 draws the conclusions.

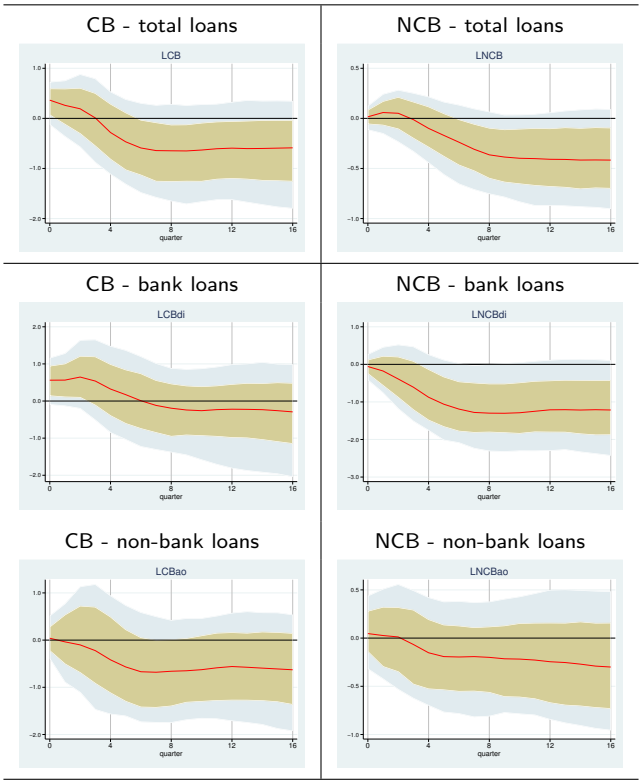
2 About monetary innovations and heterogeneous loans

The literature on the effect of Monetary Policy (MP) innovations is vast and on continuous development. Recent contributions, such as Kaplan et al. (2018), Guerrieri & Lorenzoni (2017), highlight the importance of heterogeneous agents in order to grasp different features of the MP effect on the economy. In addition to the borrower dimension, we believe that other dimensions of heterogeneity are worth to investigate when credit is involved: the lender typology as well as the scope of the loan granted. In support of this and to contextualize the discussion, Figure 1 reports the impulse-responses of some loans that we have used in our analysis, namely of corporate loans and of non-corporate loans (borrower dimension), and of loans from banks and non-bank institutions (lender dimension).[2] The impulse-responses show significant heterogeneity at the impact for different borrowers (first row of graphs), while non-bank loans suggest that monetary policy might not be as effective in reducing the amount of loans granted (third versus the second row of graphs).

Regarding the set of possible lenders, credit markets have evolved much and a larger role of non-depository institutions in financing corporations has been observed; the middle-left graph in Figure 3 shows this trend in our data. Particularly advanced dynamic economies, in which credit markets have been subject to deregulation in the nineties, exhibit this evolution. For instance, related to this, Drechsler et al. (2018*a*) comment on the birth of money-market mutual funds as an alternative to bank deposits. Apart from considerations about the risk that these institutions load to the financial system (Adrian & Shin 2009), it is important to verify whether the larger role they play implies that monetary

[2] Full information on the data and on how such IRFs are obtained is provided further on in section 3

Figure 1: Response to a MP intervention: loan aggregates



CB stands for corporate-business, NCB for non-corporate business. Total Loans is the summation of mortgages and loans from banks and non-bank institutions. The brownish area on the front is for the 16-84 interquantile confidence band, the light-blue area on the background is for the 5-95 interquantile confidence band.

policy is less effective to drive the money supply (Nelson et al. 2018, Chen et al. 2018), given the different regulation they are subject to (FSB 2013).

At the same time, credit materializes into different kinds of loans, which serve for different scopes and have specific characteristics in terms of conditions, collateral, etc. Some of those bring higher risks than others, as the recent financial crisis has shown regarding mortgages (Justiniano et al. 2019, Kaplan et al. 2020), but could also respond in a significantly different way to policy innovations because of those characteristics (Brady 2011). Symmetrically, the transmission of policy innovations depends on credit heterogeneity, the characteristics of the largest stocks of credit in the economy therefore matter for the effectiveness of monetary policy.

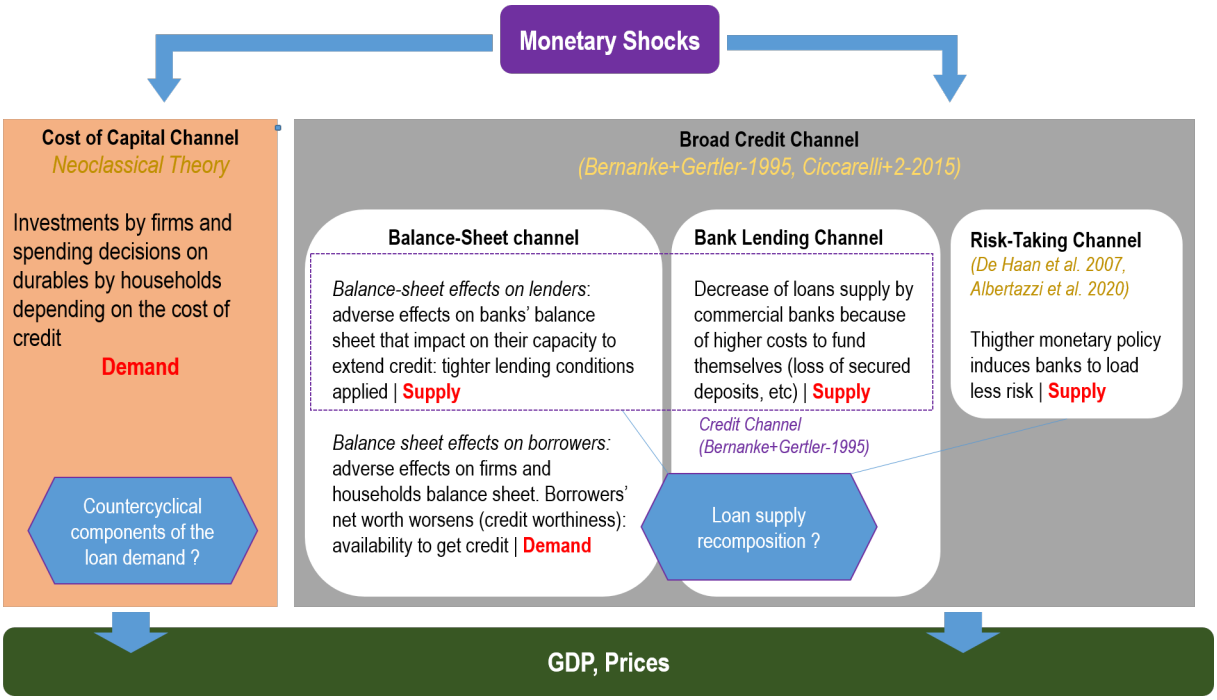
As for the part of the transmission mechanism that involves credit, research distinguishes two channels (Albertazzi et al. 2020): the Cost of Capital Channel [A] (or, more easily, cost of credit) and the so-known Broad Credit Channel [B] (an expression used in Ciccarelli et al. 2015). Jointly, they describe how credit aggregates respond to a monetary policy change as the result of both demand and supply factors (Kashyap & Stein 2000, Bernanke 2007, Ciccarelli et al. 2015). The broad credit channel is made of the balance-sheet channel, the bank-lending channel and the risk-taking channel (Bernanke & Gertler 1995, Den Haan et al. 2007, Albertazzi et al. 2020). The cost of capital channel [A] pertains to the demand side, the balance sheet channel regards both demand [B1i] and supply [B1ii], the bank-lending channel [B2] concerns the supply side as the risk-taking channel [B3]. Figure 2 provides a summary of these terms and a sketch. At least in very general terms, we need to clarify these effects.[3]

2.1 Demand-side drivers of the loan response

Since the cost of credit increases in case of a monetary tightening, the demand from borrowers (both firms and households) should decrease; this is the cost of capital channel (Bernanke & Gertler 1995). Secondly, the monetary tightening has adverse effects on borrowers' balance sheet impairing their

[3]The analysis of credit aggregates involves an identification issue typical of demand-supply equilibrium quantities. To wit, when we observe a credit increase/decrease, it is not straightforward to understand whether that variation is due to the demand or supply. Credit aggregates conceal the push behind their variation, which can be hypothesized only through other variables that impact on those aggregates and are imagined to mirror demand or supply factors.

Figure 2: Transmission of monetary shocks through credit



capacity to get credit (creditworthiness): their net worth or capacity to provide collateral diminishes. This is the balance-sheet effect on borrowers and it implies less lenders' ability to get funds (Albertazzi et al. 2020). Both these effects are negative. This might not be the end though. Indeed, there is need to extend our considerations to the real economy's evolution in case of a monetary innovation.

A monetary tightening is believed to have a negative effect on economic activity and therefore on borrowers' revenues/cash-flow; we will confirm this through our results in section 4. Even though the evolution of loans is pro-cyclical in general, on this ground, the loan demand could also have significant counter-cyclical components (Bernanke & Gertler 1995 page 44). To wit, firms could demand more loans at first to counterbalance their cash-flow decrease. At the same time, some households may demand more credit to smooth their consumption. These are demand components whose weight could be concealed in the net final effect observed, but might have a majority weight at some point along the process. As for this, Gertler & Gilchrist (1993*a*, 1994) argue that large firms manage to increase their borrowing in case of monetary tightening while small firms do not. Recent contributions (Barraza et al. 2019, Greenwald et al. 2020) suggest that this result strictly depends on the availability of credit lines to large firms. Then, what is observed to increase are loans under commitments, alias withdraws from those credit lines at conditions not altered by the monetary innovation; while new term-loans decrease

and conditions on those tighten. Corporations are more likely to have credit lines while small firms are not, this is why corporation loans can increase as long as those lines are available at the previously-agreed conditions, subsequently they decrease either because firms stop demanding or because those lines extinguish. Another possible reason why corporations might demand more loans, to distinguish from their intention to contrast a decreasing cash-flow, is to take advantage of those credit lines. Indeed, they might prefer now those to other financing sources (e.g., bond issuance), which should be relatively more expensive after the monetary hike (Bernanke & Kuttner 2005). Furthermore, to the extent that monetary hikes are associated with higher uncertainty, firms might wish more liquidity to cope with that uncertainty as a precautionary motivation (Brianti 2021).

2.2 Supply-side drivers of the loan response

A monetary tightening is likely to increase banks' funding costs (external finance premium), they consequently reduce their loan supply; this is the bank-lending channel. Drechsler et al. (2017) argue that one of the reasons for a higher external finance premium is the deposit loss caused by the larger spread banks ask, a spread proportional to their market power. They call this mechanism "the deposit channel".

Secondly, banks too bear adverse balance-sheet effects and these reduce their capacity to extend credit, all that should take them to apply tighter lending conditions. This is the balance-sheet effect on lenders. The same includes what Albertazzi et al. (2020) refer to as banks' capitalization channel, which consists of the banks' change of credit supply necessary to meet the capital-adequacy regulation.

Last, a monetary innovation triggers risk-related changes in banks' assets and liabilities. To wit, a monetary tightening pushes interest rates up and diminishes assets and collateral value (Bernanke & Kuttner 2005). This modifies a bank' assessment of its potential borrowers and makes it rule out some who previously were eligible. Furthermore, Drechsler et al. (2018*b*) show that risk premia enlarge as a consequence of an interest rate increase (this point is also in Gertler & Karadi 2015) because it changes the opportunity cost of holding liquidity buffers. This is the risk-taking channel and it implies a decreasing supply of credit.[4]

For credit supply too, however, some components might evolve in a different direction with respect to

[4]Related to this, Gilchrist & Zakrajšek (2012) show that variations in risk premia have direct consequences on economic activity.

the aggregate evolution observed, at least shortly after a monetary tightening. As we discuss further on in this section, recomposition effects could emerge and lenders might therefore reshuffle their portfolio. For instance, banks could move towards comparatively less-risky borrowers such as large corporations (Ciccarelli et al. 2015), and/or away from more risky assets, such as mortgages in favour of short-term business loans (Bidder et al. 2021). As for this, Den Haan et al. (2007) affirm that following a monetary tightening, banks increase their short-term commercial and industrial loans because those earn higher returns (short-term interest rates are higher and those loans relatively safer). The substitution out of long-term and risky assets and into C&I loans makes it possible that the supply of C&I loans increases even if deposits decrease (page 906).[5]

In a nutshell, Den Haan et al. (2007) suggest that the first reason why banks reshuffle towards short-term business loans relates to differences in risk between households and other borrowers. The second to changes in the relative profitability of consumer and firm loans. The third reason refers to hedging by adjusting the portfolio in order to align the maturities of assets and liabilities (Drechsler et al. 2018*a*, Peek & Rosengren 2010). The fourth is related to bank capital regulations and to the effect on current-period profit margins. Important to notice that these motivations regard directly banks, while other non-bank intermediaries, being subject to by-far looser regulation on risk management (FSB 2013), are likely not to be responsive to such changing conditions.

Funding of US financial intermediaries The bank-lending channel suggests that banks' loan supply decreases after a monetary tightening given that banks find more expensive to fund themselves, largely because of a deposit loss (their loan supply curve shifts inwards); Drechsler et al. (2017) have recently reaffirmed the importance of this mechanism. Differently, Bernanke (2007) and Ciccarelli et al. (2015) sustain that such a channel does not seem to play a significant role in the US market. They argue that the monetary tightening is likely to cause only a very limited increase of the cost of funds to US intermediaries. This is because US banks get funds predominantly through the market by issuing their

[5] Den Haan et al. (2007) link this effect to the evidence that interest rates on commercial and industrial loans respond quickly at the deepest to the monetary policy hike, while the others do at a slower pace and at a smaller extent; mortgage rates lag behind all. Such a differential response of interest rates changes the relative value of the different loans to banks. At the same time, a monetary tightening pushes the return of assets up (such as government bonds). Then, banks could reshuffle their portfolio away from more risky engagements (i.e. loans to sub-prime borrowers) and prefer those assets with a now-increased expected return. Jiménez et al. (2014) provide further evidence on the fact that a monetary expansion induces banks to reshuffle their portfolio towards more risky loans.

own liabilities or certificates of deposit. The monetary tightening causes a higher cost to the extent that those liabilities became more onerous to issue, but that extent is limited. In other words, banks' external finance premium is only marginally impacted by the monetary tightening. The same applies to corporations: large firms finance themselves on the market either through their own liabilities or by issuing equities. Differently, small firms are more dependent on intermediaries and this is why a difference between the two might emerge since these cannot avoid intermediaries for their financing needs.

In this regard, Ciccarelli et al. (2015) observe a by-far stronger and predominant role of the bank-lending channel in the euro area (compared to the US). Their conclusions on the credit channel reflect such peculiarities of the US market: a monetary policy shock is transmitted to real activity mainly through the balance sheet channel. Differently, this is transmitted mainly through the bank-lending and cost of capital channel in the euro area.

3 VAR analysis

In the previous section, we have listed and discussed the different forces that contribute to the effect of a monetary innovation on credit. Such forces do not impact symmetrically on different credit aggregates. The scope of the analysis, whose details we explain in this section and whose results are discussed in the next one, is to unveil how differently loan categories are impacted by a monetary innovation and to explain that difference with reference to the demand and supply factors previously discussed.

The empirical analysis is based on a VAR model estimated on US data for the period 1973q1-2007q4. We decided to employ Bayesian estimation techniques to overcome some drawbacks typical of the frequentist approach.[6] Details on the estimation of the reduced form as well as on the structural identification of the monetary interventions are in the following subsection 3.2. Central to the contribution of our work to the current literature is the use of different loan categories on which to check the transmission of the monetary interventions. To this end, we include loans to different borrowers, from different lenders and for different scopes; a detailed discussion of the data follows.

[6] First and foremost, Bayesian techniques allow the estimation of large VARs with a standard number of observations, they deal with the over-parametriziation issue (Bańbura et al. 2010) by shrinking the parameter space. Second, the likely non-stationarity of the series under considerations is embedded in the prior distribution by appropriate values of its hyperparameters.

3.1 Data

The analysis is based on US quarterly data and is developed around the loan series extracted from the Financial Accounts of the United States (Board of Governors of the Federal Reserve System). The loan series are for the borrower groups:

- Households and non-profit organizations (HH),
- non-financial Corporate Businesses (CB),
- non-financial Non-Corporate Business (NCB).

Loans are from all sources, depository and non-depository institutions.[7] For each borrower group we have the following categories:

- Total Mortgages (TM), it includes home, multifamily residential, commercial and farm mortgages granted by government and private institutions (banks and non-banks);
- Depository Institution loans (DI), to which we refer to as bank loans, include all loans by banks except for open market papers, mortgages and consumer credit, which are shown in other aggregates;
- Advances and Other loans (AO), to which we refer to as non-bank loans, are mainly from entities other than depository institutions, the US government and the rest of the world;
- Consumer Credit (CC), which is available only for households, it includes loans granted by depository and non-depository institutions, both public and private.[8]

A graph reporting the loan levels for the three borrower groups is in Figure 3. The other variables in the VAR can be conceptually clustered in the following groups. Real variables: the gross domestic

[7] The loan series data are made available non-seasonally adjusted, we have seasonally adjusted them by using the X-13ARIMA-SEATS program developed at the U.S. Census Bureau; loan series exhibit a strong seasonality on the 4th quarter.

[8] Some student loans are an example of consumer credit granted by government agencies, also automobile loans are part of this aggregate.

product, sales, inventories; these are to account for economic activity and for firms' cash flow (sales).[9] Prices: a world index of commodity prices, the consumer price index, the Standard & Poors 500 index; these are to reflect price developments of goods and financial securities. Interest rates: the federal funds rate, an average interest rate on short-term business loans (Bank Prime Loan rate), an average interest rate on personal loans with 24 months maturity, an average interest rate on mortgages with 30 years maturity, the excess bond premium of Gilchrist & Zakrajšek (2012); these are to account for the cost of loans as well as of the level of risk in the economy.[10]

The list of all variables with the respective source is in Table 1. Data are available starting from different dates and up to the end of 2018, but the analysis is for the period 1973q1-2007q4; we exclude the most recent period to avoid the Global Financial crisis (2008) and the Great Recession (2009).

Some statistics on loans The evolution of loans for each borrowing group is plotted in Figure 3. To gain information on the amount of each category over the total, we report weights in Table 2 and plot them in the second column of Figure 3. As for each borrower group contribution to the total amount of loans in the economy, at the end of the period used for the analysis (2007q4), loans to households represent 67% of the total, loans to corporations amount to 14%, loans to small firms amount to 18%.

In terms of structural composition (within each group), loans to households and non-corporate business are very much stable over time. Differently, loans to corporate business exhibit a structural change well before the global financial crisis and recession, as shown by the decreasing weight of bank loans; this is linked to the growing importance of finance companies in the US financial system.

[9] We constructed the inventory series in levels from variations (national accounts records) and made them directly comparable to the sales index series in levels released by the OECD. Inventory variations are indirectly compiled based on the identity: production is equal to sales plus the inventory change ($P_t = S_t + \triangle I_t$) (Ramey & West 1999).

[10] The excess bond premium is a measure of investor sentiment or risk-aversion in the corporate bond market with a high information content for economic activity. Gilchrist and Zakrajsek (2012) find that an increase in the excess bond premium reflects a reduction in the effective risk-bearing capacity of the financial sector and a contraction in the supply of credit that has recessionary effects on the economy.

Table 1: List of variables

#	borrower	variable	source	short
1		Gross Domestic Product	OECD	GDP
2		Sales	OECD	SAL
3		Inventories	OECD	INV
4		World index of commodity prices	Datastream	WCP
5		Consumer Price Index	OECD	DEF
6		Standard & Poors 500 index	Datastream	S&P500
7		Fed Funds Rate	FRED	FFR
8		Interest rate on short-term business loans	FRED	IR03M
9		Interest rate on 24 months personal loans	FRED	IR24M
10		Interest rate on 30 years mortgages	FRED	IR30Y
11		Excess Bond Premium	GZ2012	EBP
12	Households and Non-Profit	Total Mortgages	BGFRS	HH-TM
13		Depository Institutions Loans nec	BGFRS	HH-DI
14		Advances and Other Loans	BGFRS	HN-AO
15		Consumer Credit	BGFRS	HH-CC
16	Corporate Businesses	Total Mortgages	BGFRS	CB-TM
17		Depository Institutions Loans nec	BGFRS	CB-DI
18		Advances and Other Loans	BGFRS	CB-AO
19	Non-corporate Businesses	Total Mortgages	BGFRS	NCB-TM
20		Depository Institutions Loans nec	BGFRS	NCB-DI
21		Advances and Other Loans	BGFRS	NCB-AO

As for the sources, OECD stands for Organization for Economic Cooperation and Development, BGFRS for Board of Governors of the Federal Reserve System, FRED is the Saint Louis Fed's online application to extract data, GZ2012 stands for Gilchrist-Zakrajšek (2012). The column 'short' reports the acronyms of the loan items used throughout the paper.

Figure 3: Loans by component, levels and weights

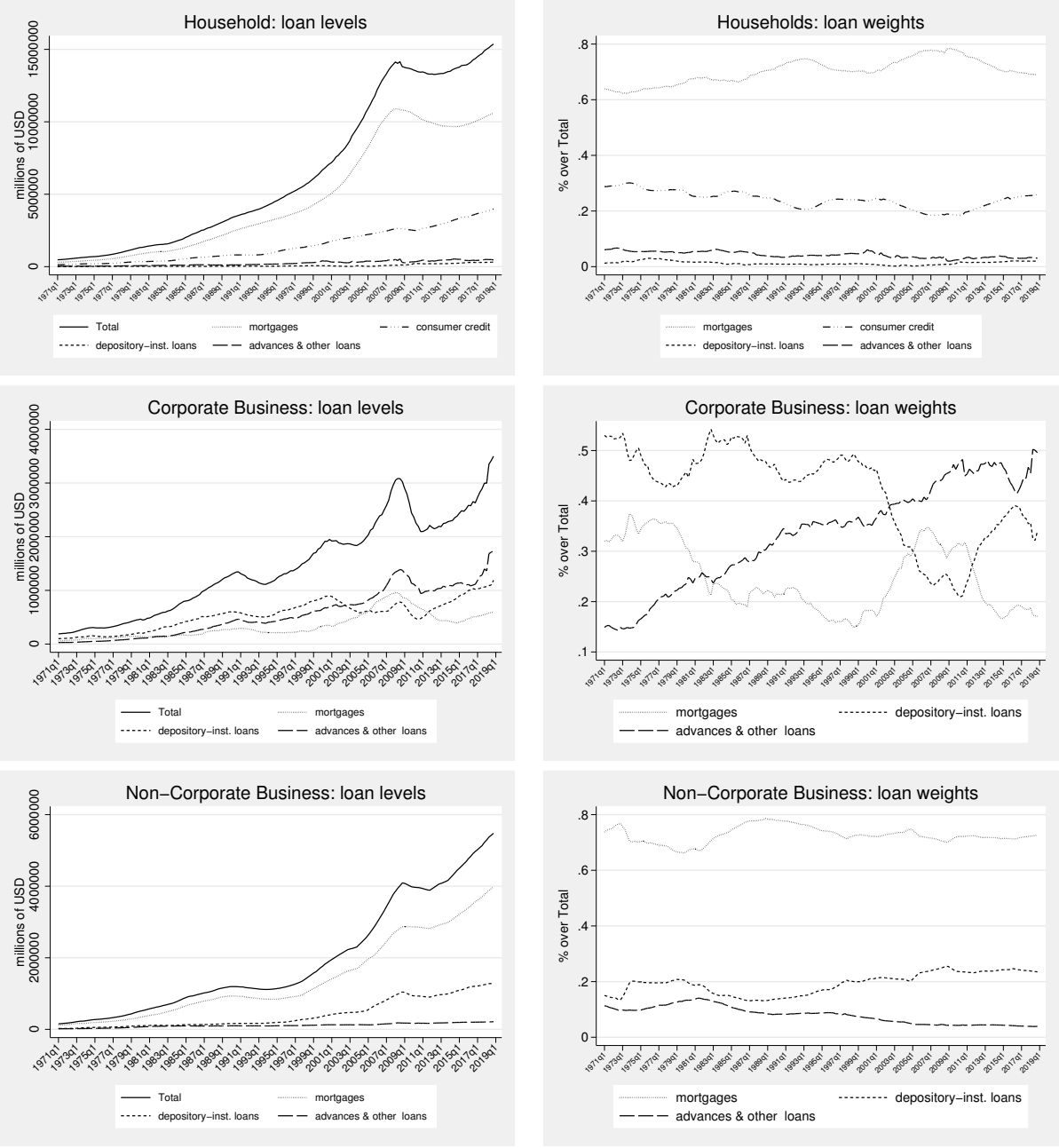


Table 2: Loan weights

Panel A	HH				CB			NCB		
1970q1-1979q4	56.7%				22.6%			20.7%		
1980q1-1989q4	55.8%				21.3%			22.9%		
1990q1-1999q4	63.9%				18.7%			17.5%		
2000q1-2009q4	67.7%				14.5%			17.8%		
2010q1-2018q4	66.7%				11.9%			21.4%		
1970q1-2018q4	62.0%				17.9%			20.0%		
Panel B	-TM	-CC	-DI	-AO	-TM	-DI	-AO	-TM	-DI	-AO
1970q1-1979q4	63.9%	28.4%	2.0%	5.7%	34.2%	48.1%	17.8%	71.0%	18.1%	10.9%
1980q1-1989q4	68.0%	25.7%	1.2%	5.1%	23.1%	49.9%	27.0%	73.6%	15.3%	11.1%
1990q1-1999q4	72.1%	22.8%	0.9%	4.1%	18.6%	46.4%	35.0%	74.8%	16.9%	8.3%
2000q1-2009q4	74.9%	21.0%	0.6%	3.5%	27.4%	32.0%	40.6%	72.3%	22.4%	5.2%
2010q1-2018q4	72.1%	23.0%	1.8%	3.2%	21.3%	32.6%	46.1%	71.9%	23.8%	4.2%
1970q1-2018q4	70.2%	24.2%	1.3%	4.3%	25.0%	42.0%	33.0%	72.7%	19.2%	8.0%

HH is for households, CB is for corporate-business, NCB is for non-corporate business. TM is for total morgages, CC for consumer credit, DI for depository-institution loans, AO for advances and other loans.

3.2 Estimation

The empirical analysis is based on the following reduced-form VAR:

$$Y_t = \alpha + \sum_{i=1}^{p} \beta_i Y_{t-i} + u_t$$

in which Y_t is a 21-variable vector. The variables enter the model in annual growth rates, except for interest rates that are in levels. The VAR includes 4 lags for each variable to cover one year of data as it is common in the literature. This results in a very high number of parameters to estimate so that the VAR model suffers from an over-fitting problem. In order to deal with such over-parametrization, we apply Bayesian methods and estimate a large-BVAR model (Bańbura et al. 2010).

The informativeness of the prior distributions is crucial to shrink the over-parameterized model. Here, we follow Giannone et al. (2015), i.e., we select the appropriate degree of shrinkage by treating priors' hyperparameters as additional unknown parameters, formulating a prior over them and maximizing the marginal likelihood to derive their posterior values. The prior of the coefficients and of the variance-covariance matrix is a Normal-Inverse-Wishart: $\Sigma \sim IW(\Psi, d)$, $\beta \mid \Sigma \sim N(b, \Sigma \otimes \Omega)$. Here, Ψ, d, b and Ω are functions of a set of hyperparameters γ. The prior for the VAR coefficients combines

three prior densities: the Minnesota, the sum-of-coefficients and dummy-initial-observation priors.[11] The tightness of these priors is determined by the three hyperparameters λ, μ, and δ, respectively. The innovation in Giannone et al. (2015)'s approach is that they treat these hyperparameters as unknown so that the model has a hierarchical structure.[12]

Structural Identification

Identification of the MP shocks is based on Arias et al. (2019): we combine sign and zero restrictions on contemporaneous structural coefficients to specify a plausible policy-rate rule that captures the systematic component of monetary policy. In order to explain this, let us rewrite our VAR model in structural form as follows:

$$A_0 Y_t = c + \sum_{l=1}^{p} A_l Y_{t-l} + \varepsilon_t \ ,$$

Y_t is the $n \times 1$ vector of endogenous variables, c is a vector of intercepts, A_l is an $n \times n$ matrix of structural parameters for $0 \leq l \leq p$ with A_0 invertible and p the lag length. The vector of structural shocks ε_t is Gaussian with mean zero and covariance matrix I_n.

The identification strategy of Arias et al. (2019) restricts the elements of the first column of the matrix A_l for $0 \leq l \leq p$ as it represents the monetary policy equation:

$$r_t = \phi_y y_t + \phi_p p_t + \sum_{i=3}^{n} \phi_i z_{i,t} + \sigma \varepsilon_{1,t} \ , \tag{1}$$

in which $\phi_1 = \phi_y$ and $\phi_2 = \phi_p$. This equation abstracts from lag variables and shows that the Fed Funds Rate (r_t) depends on real GDP (y_t), the GDP deflator (p_t), and all the remaining variables in the model ($z_{i,t}$), including commodity prices. The coefficients are restricted to obtain a Taylor-type monetary policy rule: the monetary authority is assumed to react contemporaneously only to output and prices (i.e. $\phi_i = 0$), and its reaction is positive (i.e. $\phi_y > 0$ and $\phi_p > 0$). These restrictions are consistent with Christiano et al. (1996) and discussed in details in Arias et al. (2019).

[11] The Minnesota prior assumes that the limiting form of each VAR equation is a random walk with drift so that it allows to effectively shrink the model. The sum-of-coefficients prior and the dummy-initial-observation prior are necessary to account for unit root and cointegration.

[12] The algorithm draws the hyperparameters with a Metropolis step and then, conditional on the value of γ, the VAR parameters are drawn from their posterior. This algorithm generates 20.000 draws, of which we discard the first 10.000 as burn-in and use the last 10.000 for inference.

Obviously, the central bank does not directly observe the contemporaneous level of output and prices, but other real-time indicators are available that allow to learn about the current state of the economy. If this is plausible when using monthly data as in Arias et al. (2019), then it is even more likely to happen in a quarterly framework. As regards commodity prices, we assume that the central bank does not react to them as this allows us to reduce the probability of models implying a rise in prices, as documented in Arias et al. (2019). Furthermore, we assume that stock prices decline on impact after a contractionary monetary policy shock. This assumption is consistent with the findings of Bernanke & Kuttner (2005) and it has also been used by several authors to identify monetary policy shocks, e.g. Jarocinski & Karadi (2020).

We implement the restrictions considering that the coefficients of the monetary policy rule can be decomposed as $\phi_y = -a_{0,11}^{-1}a_{0,12}$, $\phi_p = -a_{0,11}^{-1}a_{0,13}$, $\phi_i = -a_{0,11}^{-1}a_{0,1i}$ and $\sigma = -a_{0,11}^{-1}$. Therefore, the identifying restrictions imply that $a_{0,11} > 0$, $a_{0,12} < 0$, $a_{0,13} < 0$ and $a_{0,1i} = 0$, which represent the sign and zero restrictions that we impose on the matrix A_0. Arias et al. (2019) show that this set of restrictions are sufficient to obtain that output, prices and non-borrowed reserves decline after a contractionary monetary policy and the impulse responses are consistent with those obtained by Smets & Wouters (2007) who estimate a large-scale DSGE model.[13]

3.3 Robustness of the estimation

The robustness of the conclusions drawn on impulse-response analysis has been tested through the following robustness checks. With respect to our baseline VAR, we have estimated also a smaller VAR, which includes only the by-borrower aggregations (this VAR counts 15 variables instead of 21), and a larger VAR including further variables, which are sub-components of the advances and other loans category (this one includes 25 variables). For the scope of the analysis, we will discuss partially their output in the following sub-sections in comparison with the baseline estimation to draw insights on further aspects. On the whole, their output is consistent with the baseline estimation. We have also tested a further specification that adds total and non-borrowed reserves to our baseline model, the

[13] Our algorithm evaluates 10000 draws from the posterior distribution of the model's parameters. In the baseline estimation, 628 draws satisfy the sign and zero restrictions. As recommended by Arias et al. (2018) we computed the effective sample size, i.e. the actual number of independent draws produced by the importance sampler, which is 566. Therefore, the effective sample size represents 0.9 of the draws satisfying the sign and zero restriction; this share is high enough to ensure that our sample is not dominated by only few draws.

results remain very much the same in this case too.

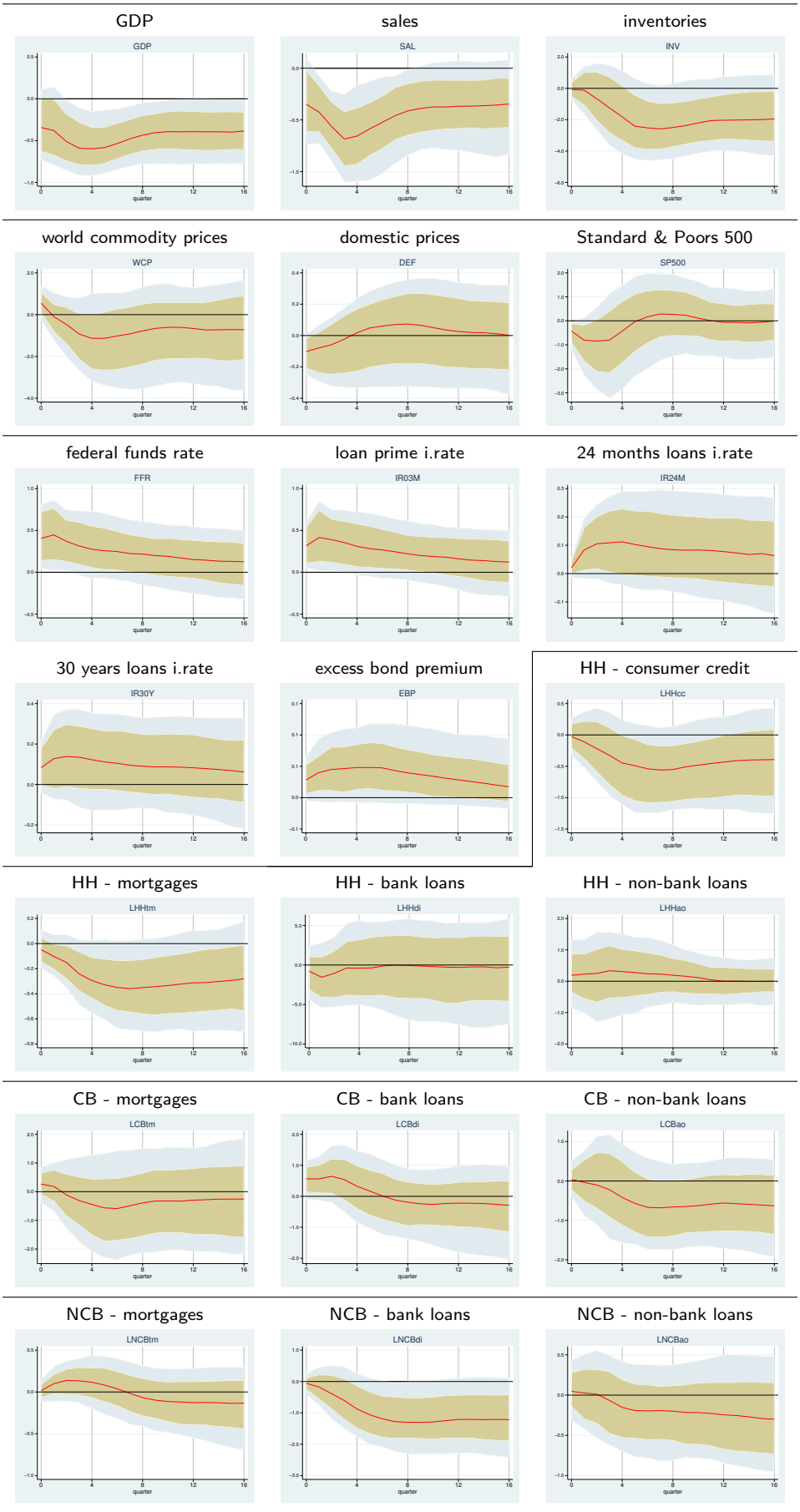
As further robustness checks, we have changed some restrictions imposed on the baseline estimation. First, we excluded restrictions on stock prices, in this case few impulse responses have slightly wider credible sets, but our main results remain valid. Secondly, we included restrictions on the excess bond premium, also in this case the impulse-response functions remain highly comparable.

4 The effect of monetary policy shocks

The impulse-response functions (IRFs) of all variables to a MP shock are plotted in Figure 4; IRFs are ordered for the blocks of variables in Table 1. A detailed discussion for the different blocks follows in the next subsections. Moreover, we present next IRFs from an alternative estimation that includes the loan categories in the baseline model aggregated by borrower (15 variables instead of 21), this serves to present results that summarize the responses at a more aggregate level.

Table 3 reports the Forecast Error Variance Decomposition (FEVD) at different horizons. The values are the portion of the forecast error variance of each variable explained by MP shocks, such values indicate that those portions are quite low for all loan categories included. This is not surprising and simply suggests that there are other main drivers of loans. The portions increase significantly for the GDP, prices and short-term interest rates. The FEVD values found are in line with those in Benati (2016) and suggest that the bulk of the fluctuations of the variables is driven by other shocks than monetary ones.

Figure 4: Response to a MP shock: all variables



HH stands for households, CB for corporate-business, NCB for non-corporate business. The brownish area on the front is for the 16-84 interquantile confidence band, the light-blue area on the background is for the 5-95 interquantile confidence band.

Table 3: FEVD

horizon	q16	**q50**	q84	q16	**q50**	q84	q16	**q50**	q84
	GDP			sales			inventories		
1	0.012	0.19	0.608	0.003	0.049	0.148	0.001	0.008	0.04
4	0.045	0.259	0.557	0.049	0.119	0.209	0.011	0.048	0.144
8	0.08	0.278	0.52	0.053	0.124	0.218	0.026	0.101	0.253
12	0.07	0.255	0.493	0.045	0.11	0.194	0.026	0.115	0.27
16	0.063	0.243	0.473	0.039	0.097	0.178	0.023	0.109	0.255
	domestic prices			world commodity prices			Standard & Poors 500		
1	0.007	0.129	0.551	0.001	0.01	0.034	0	0.003	0.014
4	0.015	0.054	0.284	0.005	0.015	0.044	0.003	0.011	0.048
8	0.018	0.054	0.172	0.004	0.023	0.087	0.006	0.017	0.052
12	0.013	0.051	0.146	0.004	0.021	0.087	0.007	0.02	0.054
16	0.01	0.046	0.139	0.004	0.021	0.081	0.007	0.02	0.056
	federal funds rate			loan prime rate			24 months loans i.rate		
1	0.028	0.27	0.738	0.02	0.206	0.552	0.001	0.007	0.028
4	0.027	0.208	0.575	0.019	0.199	0.54	0.005	0.065	0.227
8	0.016	0.133	0.406	0.015	0.142	0.388	0.006	0.058	0.211
12	0.016	0.086	0.305	0.012	0.099	0.284	0.007	0.046	0.182
16	0.014	0.062	0.233	0.012	0.068	0.228	0.007	0.041	0.156
	30 years loans rate			excess bond premium			HH - consumer credit		
1	0.002	0.031	0.143	0.001	0.012	0.039	0.001	0.018	0.052
4	0.006	0.045	0.211	0.005	0.025	0.07	0.006	0.033	0.112
8	0.006	0.04	0.161	0.007	0.037	0.098	0.01	0.044	0.17
12	0.006	0.035	0.134	0.008	0.04	0.099	0.009	0.042	0.168
16	0.005	0.03	0.121	0.009	0.04	0.099	0.009	0.04	0.163
	HH - mortgages			HH - bank loans			HH - non-bank loans		
1	0.001	0.01	0.04	0	0.004	0.016	0	0.003	0.015
4	0.007	0.031	0.086	0.002	0.008	0.022	0.003	0.008	0.026
8	0.014	0.063	0.132	0.003	0.011	0.026	0.005	0.013	0.034
12	0.013	0.065	0.147	0.003	0.011	0.029	0.006	0.016	0.038
16	0.012	0.06	0.146	0.003	0.013	0.033	0.007	0.018	0.038
	CB - mortgages			CB - bank loans			CB - non-bank loans		
1	0.001	0.006	0.023	0.005	0.042	0.11	0	0.005	0.017
4	0.003	0.011	0.033	0.005	0.037	0.106	0.004	0.02	0.064
8	0.004	0.016	0.058	0.01	0.028	0.076	0.01	0.032	0.089
12	0.004	0.017	0.056	0.01	0.027	0.061	0.01	0.033	0.095
16	0.004	0.019	0.057	0.008	0.024	0.057	0.009	0.033	0.102
	NCB - mortgages			NCB - bank loans			NCB - non-bank loans		
1	0	0.003	0.015	0	0.005	0.027	0	0.004	0.021
4	0.002	0.012	0.037	0.004	0.027	0.088	0.003	0.011	0.033
8	0.003	0.013	0.034	0.015	0.065	0.153	0.004	0.013	0.04
12	0.005	0.013	0.037	0.018	0.082	0.166	0.004	0.013	0.041
16	0.005	0.015	0.042	0.02	0.091	0.171	0.004	0.015	0.046

Check Table 1 "List of variables" for all the variable full names.

4.1 The coefficients of the monetary policy rule

Table 4 reports the estimated structural coefficients of the monetary policy equation. In our baseline model, the posterior medians of ϕ_y (MP response to GDP) and ϕ_p (MP response to Prices) are 0.89 and 1.66, respectively. This means that the federal funds rate responds nearly one-to-one to output and more than one-to-one to prices. All the remaining coefficients are equal to zero by constructions. Therefore, our identification retrieves coefficients that are consistent with those obtained by Arias et al. (2019) and also with the conventional estimates found in the related literature.

Table 4: Structural coefficients of the MP equation

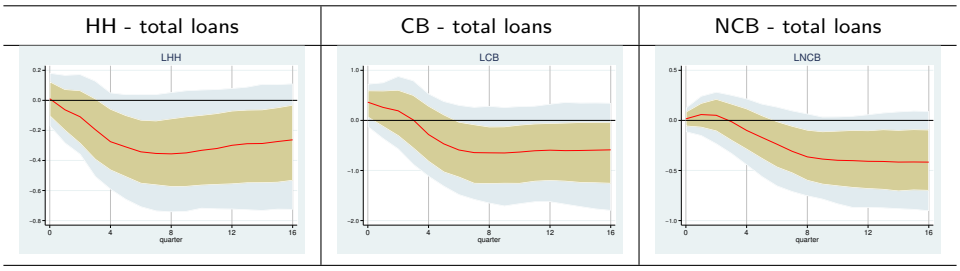
		q16	**q50**	q84
MP response to GDP	ϕ_y	0.26	0.89	2.13
MP response to Prices	ϕ_p	0.43	1.66	4.79

4.2 The response of loans and of the other variables

Total Loans by borrower Figure 5 shows the response to a monetary intervention of total loans to household, to corporate and non-corporate business. The response of corporate loans confirms the puzzling empirical finding discussed in previous contributions (Bernanke & Gertler 1995): corporation loans increase at the time of the shock, while household and non-corporate loans decrease as expected.

Recent contributions (Barraza et al. 2019, Greenwald et al. 2020) report convincing evidence about the role of the demand as the main driver of the corporation-loans increase. Then, this finding confutes previous contributions, namely Den Haan et al. (2007), which had tipped the balance towards supply-side forces. Those recent contributions show that the loan increase is made possible by the availability of credit lines to corporations, which withdraw from those lines after the shock. As discussed in section 2, there could be different concurrent reasons why corporations withdraw from those lines. Regardless of those reasons, following Barraza et al. (2019), Greenwald et al. (2020) we can imagine that loans to non-corporate business decrease because credit lines are less likely available to small firms.

Figure 5: Response to a MP shock: loans by borrower group



HH stands for households, CB for corporate-business, NCB for total non-corporate business. The brownish area on the front is for the 16-84 interquantile confidence band, the light-blue area on the background is for the 5-95 interquantile confidence band.

Dis-aggregated loans: mortgages, consumer credit, bank and non-bank loans Figure 4 shows the response of each loan category to a MP intervention. As for mortgages, we detect a significant response only in the case of household: they decrease as expected with a trough at around two years. Even though not significant, the response of corporate mortgages at the impact mimics what observed for corporations at the aggregate level.

Bank loans do not exhibit a significant response for households. This is likely to depend on the fact that it is just a residual category for households since the largest components of total loans to households (mortgages and consumer credit) are not included. Indeed, on the contrary, consumer credit exhibits a clear decrease after a MP shock. As for bank loans to corporate business, they increase at the impact, while bank loans to non-corporate business decrease with a trough at two years after the shock. Such a difference is at the basis of the loan puzzle observed at the aggregate level and, speaking of bank loans, it might therefore really depend on the availability of credit lines to corporations as previously discussed. Under the assumption that those lines are less likely to small firms, we coherently observe bank loans to non-corporate business to decrease. Indeed, Barraza et al. (2019), Greenwald et al. (2020) report that just loans within credit lines increase after a monetary shock, while new term-loans decrease.

In general, the response of non-bank loans differs from bank loans' in the case of firms, namely non-bank loans seem not to respond significantly. There may be several reasons for this. The most obvious one being the different regulation in which non-bank institutions operate (FSB 2013), that might allow them to be less concerned than banks about capital requirements and risk. We will discuss this point in the next subsection 4.3.

Interest rates To conclude on the loan responses, it is useful to reconsider them jointly with the response of the interest rates that more likely impact them. It is to notice that the rates we included in the model are linked to different loan categories so that a unique interpretation of their movement is not possible. Nevertheless, it is plausible that the interest rate on 3-month business loans influences a substantial portion of bank and non-bank loans to corporate and non-corporate business, while the interest rate on 24-month personal loans is likely to influence bank and non-bank loans to households, as the FFR to which seems strictly correlated. The response of interest rates is in the third/fourth row of graphs in Figure 4.

A neat difference in terms of evolution emerges between the FFR and the 3-month business rate on one side, and the 24-month personal rate and the 30-year mortgage rate on the other. Namely, short term rates react soon to the policy intervention, while longer-term ones adjust more slowly. This generates a difference implying short-term loans to be relatively more remunerative than long-term ones shortly after the shock; the peak is at the 1st quarter after the shock for the short term rates, while it is at the 3/4th quarter for the longer ones. From a supply perspective, assuming there is demand for such more expensive loans, this discrepancy increases the lender incentives to extend credit to the business sector and to decrease it to households.[14] We also observe an increase of the excess bond premium that signals a rise in risk aversion and it might be at the basis of a larger corporations' appetite for loans instead of market-based funding (such as bond issuance or certificate of deposits), particularly if they benefit of credit lines at a predetermined interest rate.

GDP, sales and inventories The graphs in the first row of Figure 4 show the response of the GDP, sales and inventories. The GDP evolution is as expected: it exhibits a significant decrease with a trough at the 4th quarter. The response of sales is very similar to the GDP's, both in terms of evolution and magnitude. Sales is a proxy for consumption, the largest GDP component, this is likely the reason why their dynamics is alike. Furthermore, sales should reflect also firms' cash-flow. Then, their decrease provides support to the hypothesis that firms might demand more loans in case of a monetary tightening to compensate for the concurrent cash-flow decrease.

By construction, the evolution of inventories is strictly correlated to sales and production. At

[14] The same divergence across rates was at the basis of Den Haan et al. (2007)'s supply-side explanation of the loan puzzle; explanation that the above-mentioned recent contributions seem to confute.

constant production, a sales decrease implies an increase in inventories. Our results are somehow consistent with such a dynamics. Indeed, the response of inventories is lagged with respect to sales, this might signal that firms adjust their production level after the sales decrease and this causes inventories to decrease.

Domestic prices, commodity prices and stock prices The response of the GDP deflator suggests that a monetary tightening is effective in reducing domestic prices; we assume that domestic prices are part of the central bank's reaction function in our identification approach. Differently, world commodity prices do not enter the central bank's reaction function and are observed to increase at the time of the MP shock but their median response quickly becomes negative and the probability is substantial after 1 year.[15] As for the evolution of the stock-price index, it is observed to decrease in response to a MP shock, as requested by the identification assumption, but it remains negative for the subsequent quarters as well.

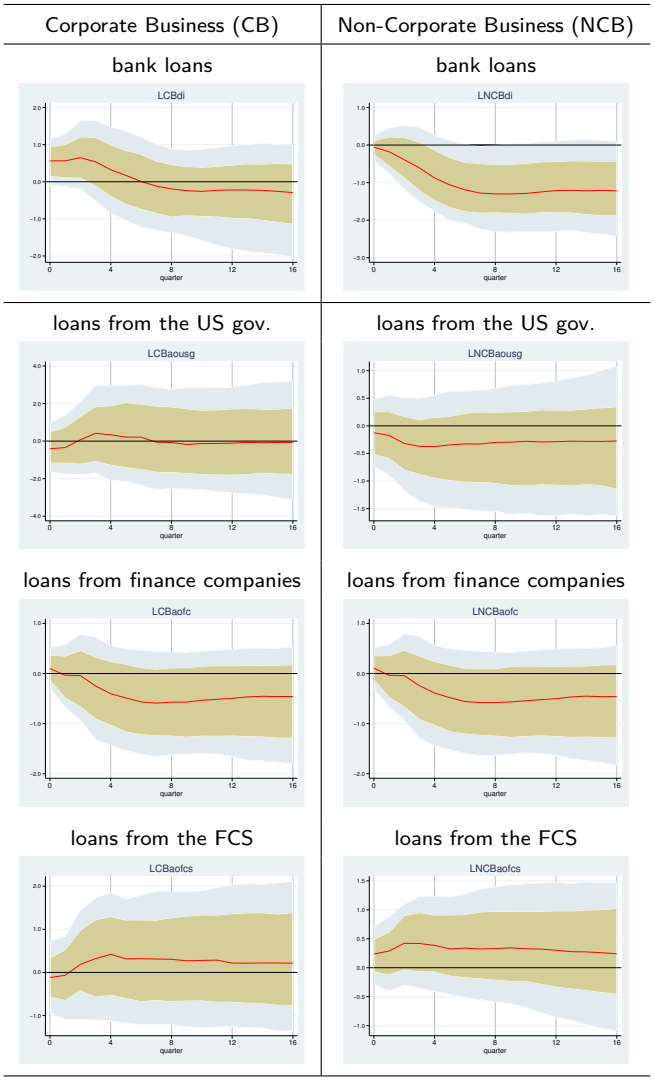
4.3 Inside non-bank loans

The analysis includes "advances and other loans", alias non-bank loans. These loans are granted by non-depository institutions and include concessional loans (such as credit extended by the government). Table 7 in the appendix reports the list of all the components by borrower and the relative weights.[16] It is known that non-depository institutions are subject to a much softer regulation than banks (FSB 2013), consequently they are interesting to compare against banks. To this end, we split non-bank loans for different lenders whose characteristics are easier to distinguish and, by knowing those characteristics, run a comparison against banks. In details, we check the response of loans from the US government, finance companies and the Farm Credit System; the latter being a system of borrower-owned lending institutions and specialized service organizations. Particularly the first two operate under a different regime than banks in terms of regulation and financing, this may help to understand the reason behind a specific response given their characteristics. To wit, if risk is the main reason why banks reshuffle their portfolio following a monetary tightening (Den Haan et al. 2007), we should observe a milder response

[15] The introduction of commodity prices in the VAR is to deal with the well-known price puzzle encountered in similar estimations (Estrella 2015).

[16] Just the residual part "Rest of the World" might include loans from foreign depository institutions.

Figure 6: Responses to a MP shock: AO components



FCS stands for the Farm Credit System. The brownish area on the front is for the 16-84 interquantile confidence band, the light-blue area on the background is for the 5-95 interquantile confidence band.

by finance companies since they are under looser requirements. In Figure 6 we plot the IRFs from a VAR in which we have replaced the AO aggregate for corporate and non-corporate business with the above-mentioned components. The VAR is a 25-variable system in this case. In the first row we report also the response of bank loans for ease of comparison.

By comparing the graphs in the second to forth row against the ones in the first row emerges that only bank loans exhibit a statistically significant response. Not surprisingly, loans from government agencies are not responsive to a monetary intervention but, more interestingly, finance companies are unresponsive too. We will discuss this more in details in the next section.

As for loans from the Farm Credit System, those to corporate business do not respond significantly (but amount just to 1% of non-bank loans to corporate business, Table 7 in the appendix), those to non-corporate business exhibit a weekly significant response that might suggest that small firms increase their loan demand (in this case they amount to 31% of non-bank loans to non-corporate business). According to Monke (2016), such loans (thanks to tax benefits) are cheaper than those granted by commercial banks, a portion of their (supposedly) observed increase could therefore be demand-driven and caused by substitution away from the relatively more expensive bank loans.

4.4 Discussion of the results

The evolution of the interest rates found is very much comparable to what is in Den Haan et al. (2007). The prime loan rate (interest rate on 3-month business loans) responds quickly at the deepest to a monetary tightening, while all the other rates first start at a lower level, achieve a maximum and then revert towards zero; the response of the prime loan rate is four times higher at the peak. From a demand perspective, this should discourage more firms than households. On the contrary, from a supply perspective, short-term loans become more remunerative relatively to the others; particularly if lenders can finance themselves at a cost that increases comparatively less. On the grounds of the interest rate divergence observed, a recomposition of loans in favor of corporations seems a possible outcome. Nevertheless, we do not know how much of the observed increase stems from banks' discretionary decision or derives from the fulfilling of an obligation as in the case of an increase of loans under commitment. If the increase is due to this last option, then the higher interest rate does not apply, while it applies to new term-loans that seem to decline after a monetary tightening, as shown by our analysis through indirect indicators (to wit, the response of bank loans to non-corporate business).

Of course, lenders (banks in particular) cannot just look at the return of loans but need to care about the risk that those loans bring. In this regard, Ciccarelli et al. (2015) affirm that negative balance-sheet effects are more adverse on households, who therefore worsen their creditworthiness compared to firms; along this line, the same balance-sheet effects should be stronger on small firms than large firms (Gertler & Gilchrist 1993*a*, 1994). Our results confirm this possible hierarchy of adverse balance-sheet effects since we observe loans to households (consumer credit) and to small firms to decrease.

Loans from non-bank institutions are in general less responsive to a monetary intervention than

banks. This might depend on different causes, but we believe that a different regulatory regime has a prime role (FSB 2013). In any case, non-bank loans have been increasing in the last decades and this suggests that monetary authorities might be losing grip on an expanding part of credit (Nelson et al. 2018, Chen et al. 2018).

5 Conclusions

In this research work we have studied how different loan categories respond to monetary-policy shocks identified by considering the systematic response of the central bank to output and inflation à la Arias et al. (2019). Our objective was to unveil the different response of well-distinguished loan categories and to link that response to specific parts of the monetary-policy transmission mechanism.

Even though with differences in terms of timing and size, we have shown that MP interventions cause an increase of all market interest rates, then the differential net effect observed across loan categories needs to depend on other factors too, such as risk management, switch across different financing sources, availability of credit lines, etc. Following Ciccarelli et al. (2015), as well as Bernanke (2007), if the response observed in the US market depends truly on balance-sheet effects, then our analysis confirms that those are more adverse on households and small firms. On the other hand, results might more simply depend on the availability of credit lines to corporations as suggested by Barraza et al. (2019), Greenwald et al. (2020), then we can deduce that those lines are available just to corporations. More likely, both motivations subsist as well as further ones, which relate to necessary risk adjustment subsequent to the monetary innovation, in accordance to the response of the excess bond premium and the price of securities shown through our results.

Considering non-bank loans suggests that non-depository institutions are much less responsive to policy interventions, this might pose relevant challenges to monetary policy to the extent that those institutions enlarge their role in advanced economies, as some recent research has been pointing out (Nelson et al. 2018, Chen et al. 2018).

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Appendix.

Table 5: Total Mortgages: components by borrower

FRB code	component
	Households and nonprofit organizations (HH)
+ FL153165105	HH; home mortgages; liability
+ FL163165505	Nonprofit organizations; commercial mortgages; liability
	non-financial Corporate Business (CB)
+ FL103165105	CB; home mortgages; liability
+ FL103165405	CB; multifamily residential mortgages; liability
+ FL103165505	CB; commercial mortgages; liability
+ FL183165605	Corporate farm business; farm mortgages; liability
	non-financial Non-Corporate Business (NCB)
+ FL233165605	Non-corporate farm business; farm mortgages; liability
+ FL113165003	NCB; total mortgages, excluding non-corporate farms; liability

Table 6: Depository-Institution loans: components by borrower

FRB code	component
	Households and nonprofit organizations (HH)
+ FL763068213	U.S.-chartered DIs; other bank loans to HH; asset
+ FL753068213	Foreign banking offices in the U.S.; other bank loans to HH; asset
+ FL713068303	Monetary authority; DI loans n.e.c. to households (Term Asset-Backed Securities Loan Facility); asset
	non-financial Corporate Business (CB)
+ FL763068105	U.S.-chartered DIs; DI loans n.e.c. to NF business; asset
+ FL753068110	Foreign banking offices in the U.S.; commercial and industrial loans and leases to U.S. addressees; asset
- FL753069603	Foreign banking offices in the U.S.; bankers' acceptances; asset
+ FL743068005	Banks in U.S.-affiliated areas; DI loans n.e.c.; asset
+ FL473068005	Credit unions; DI loans n.e.c.; asset
- FL113168005	NCB; DI loans n.e.c.; liability
	non-financial Non-Corporate Business (NCB)
+ FL233168005	Non-corporate farm business; DI loans n.e.c.; liability
+ FL113168003	NCB; DI loans n.e.c., excluding non-corporate farms; liability

Note: DI stands for depository institution.

Table 7: Advances and Other loans: components by borrower

FRB code	component	weight
	households and nonprofit organization (HH)	
+ FL 15 31692 03	HH; U.S. government loans; liability	11%
+ FL 15 31694 05	HH; policy loans; liability	47%
+ FL 15 31693 05	HH; Sallie Mae loans; liability	0%
+ FL 66 30670 03	Security brokers and dealers; margin accounts at brokers and dealers; asset	42%
	non-financial Corporate Business (CB)	
+ FL 10 31692 05	CB; U.S. government loans, including loans to automakers; liability	4%
+ FL 10 31695 35	CB; finance companies loans; liability	60%
+ FL 10 31697 05	CB.; customers' liability on acceptances outstanding to commercial banking; liability	8%
+ FL 26 30695 00	Rest of the world; U.S. NF business loans; asset	17%
+ FL 10 31698 03	CB; syndicated loans; liability	4%
+ FL 18 31693 05	Corporate farm business; Farm Credit System loans; liability	1%
+ FL 73 30690 13	Holding companies; other loans and advances due from U.S. addressees; asset	3%
	non-financial Non-Corporate Business (NCB)	
+ FL 11 31692 05	NCB; U.S. government loans; liability	46%
+ FL 11 31695 35	NCB; finance companies loans; liability	23%
+ FL 11 31693 05	NCB; Farm Credit System loans; liability	31%

Notes: Weights are over the total for the period 1971q1-2007q4.