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Bank loan components, uncertainty and monetary transmission mechanism

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We study the dynamic characteristics of bank loan components and seek to resolve the puzzle raised by den Haan et al. (2007) that commercial and industrial loans increase following monetary contraction. By estimating a set of structural vector autoregression models on US data for 1954-2015, we demonstrate that when risk and balance sheet factors are controlled for, business loans decrease after monetary tightening, what is consistent with bank-lending channel of monetary policy transmission mechanism. This result is robust to VAR specification and to the measure of uncertainty employed. We distinguish between volatility measures of uncertainty and measures of uncertainty as vagueness/"unknownness" of economic outlook and show that business loans go down following uncertainty shock only after the latter uncertainty measure is used. We demonstrate that controlling for risk factors is critical for explaining the dynamic properties of business loans, as variance of business loans is driven by innovations to uncertainty and credit risk to the greater extent than by innovations to macroeconomic variables.

Keywords: Uncertainty, Bank loans, Vector autoregression.

JEL Classification Numbers: E40.

1 Introduction

In the course of the recent financial crisis monetary authorities in many countries have been trying to promote credit growth by adopting a range of policies, including lowering nominal interest rates. According to the bank-lending channel of monetary transmission mechanism, banks are expected to increase loans issuance when the policy stance is easy. This, however, did not happen. Despite the measures undertaken, credit growth in many advanced economies has been predominantly negative for a prolonged period[2]. In this context a finding by den Haan et al. (2007), that commercial and industrial (C&I) loans respond to monetary easing by significant decline, has a special relevance, as it allows to explain (at least, partially) weak or negative credit growth in the conditions of highly accommodative stance of monetary policy. This finding, however, is not in line with the bank-lending channel of monetary transmission that has been established as relevant by many works in macro-finance empirical literature (see, among others, Bernanke and Blinder (1992), Kashyap and Stein (1995), Kishan and Opiela (2000)).

In our empirical analysis we aim at resolving the puzzle of den Haan et al. (2007) by taking into account various risk and balance sheet factors that are found to be influential in credit market[3]. We conjecture that controlling for macroeconomic uncertainty, credit risk, indebtedness of

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[2] For details see IMF Global Financial Stability Report, October 2013.

[3] See, among others, Stock and Watson (2012), Banerjee et al. (2015).

corporates and banks' capital ratio allows to explain the responses of disaggregated loans to monetary policy shocks by avoiding omitted variables bias and to provide a valuable insight to the portfolio behavior of bank loans following various types of shocks.

First, we introduce a benchmark vector autoregressive (VAR) model that builds upon den Haan et al. (2007). A VAR process for commercial and industrial loans in this specification includes three major monetary policy VAR variables: real GDP, inflation and a monetary policy instrument and a bank loan measure. In addition to commercial and industrial loans, we analyze dynamic patterns of real estate loans and consumer loans within this benchmark setup. Our specification, however, is different from the one in den Haan et al. (ibid.) in several aspects. First, by using the Chow tests we formally test the VARs for structural changes in the relationships between business loans and key macro variables. We identify two structural breaks in the model's parameters: first, related to the shift of the US monetary policy to an anti-inflation stance in 1980-1982, and second, to the financial crisis of 2008-2009. We therefore analyze the dynamic properties of loans over three periods separated by the breakpoint dates[4]. Second, we perform robustness checks of monetary policy shock effects by using alternative policy indicators, in particular, nonborrowed reserves of depository institutions and 3 month Treasury bill rate. Third, we analyze the responses of banks' Treasury and agency securities' holdings and total loans to monetary and real activity shocks. Forth, we analyze the dynamic patterns of loans and securities' holdings after the financial crisis of 2008-2009 by making use of monthly data on macroeconomic and financial variables. We find that in the benchmark model specification business loans feature positive response to monetary tightening (the result also obtained by den Haan et al. (ibid.)) only over the period of 1983-2007; over 1954-1979 and over 2010-2015 all types of loans respond to monetary contraction negatively.

We then augment the model with a set of risk and balance sheet variables that are found to make substantial impact on banks' decisions about loans' issuance. We find that controlling for macroeconomic uncertainty, credit risk, indebtedness of corporates and capital ratio of banks allows to resolve the puzzle raised by den Haan et al. (2007). In particular, commercial and industrial loans show significant decline following monetary contraction when risk and balance sheet factors are included, what is consistent with the predictions of the bank-lending channel of monetary transmission mechanism. Robustness checks confirm that this result holds for various proxies of uncertainty – volatility measures (the stock market option-based implied volatility, conditional and unconditional heteroskedasticities of GDP growth) and those that capture uncertainty as vagueness (news-based uncertainty index and composite index of economic policy uncertainty). Hence, we conclude that banks play a role in monetary transmission mechanism in line with the bank-lending channel; banks reduce the supply of business loans, not only the supply of consumer loans and mortgages after monetary tightening.

Next, we demonstrate that analyzing the dynamic properties of disaggregated loans gains valuable insights into the portfolio behaviour of banks. This is due to the fact that, as we show, micro components of total loans have different laws of motion. Hence, examination of disaggregated loans is beneficial comparing to analysis of only total loans' dynamics, first, for better understanding of the workings of monetary transmission mechanism, and second, for understanding the regularities of various classes of loans' issuance. We show that responses of different types of loans to macroeconomic, risk and balance sheet shocks are heterogeneous. First, uncertainty shock has a significant negative impact on issuance of mortgages and business

[4] The periods we look at are 1954Q4-1979Q4 (before the turn of the US monetary policy to an anti-inflation stance in 1980-1982), 1983Q1-2007Q4 (before the financial crisis of 2008-2009) and over 2010Q2-2015Q4 (after the financial crisis).

loans[5], while the effect on consumer loans is of the opposite sign – they go up on impact of uncertainty shock. Second, a positive innovation to corporates' indebtedness reduces issuance of business and real estate loans, while consumer loans increase. Third, issuance of business loans and consumer loans goes down following an innovation to credit risk, while issuance of mortgages does not change significantly. Forth, a balance sheet shock, i.e. a positive innovation to banks' capital ratio, has a positive impact on business loans and consumer loans, whereas real estate loans decrease.

Forecast error variance decomposition suggests that different factors contribute to explaining the variance of different classes of loans: while changes in variance of commercial and industrial loans' are largely explained by changes in credit risk, variance of mortgages' volumes is mainly defined by uncertainty and balance sheet shocks; finally, consumer loans variance is explained by innovations to real activity and inflation. We demonstrate that positive innovations to uncertainty have negative impact on business loans only when uncertainty is measured as vagueness/unknownness of economic outlook; a spike of volatility (of GDP growth and the stock market option-based implied volatility) does not have a significant impact on issuance of C&I loans.

Finally, we obtain evidence on substitution between different types of assets in banks' portfolios. In particular, banks reduce loans issuance and increase cash and securities holdings responding to uncertainty and credit risk shocks. This evidence is in line with predictions of portfolio theory, which argues that higher riskiness of loans results in decreasing proportion of loans in portfolios. Thus, banks' expectations about future returns of various assets on their balance and their riskiness matter, when a decision about portfolio allocation is made. Additionally, we obtain that a positive shock to real activity induces banks to reallocate assets from cash and securities into credit. An innovation to the indebtedness of the corporate sector entails decreasing issuance of business loans and mortgages and increasing lending of individuals.

Related literature

Our work is related to several strands of literature. First, this is the literature that investigates the empirical relevance of the bank-lending channel of monetary policy, particularly, the effect of policy shocks on bank lending volumes. Bernanke and Blinder (1992) demonstrate that fall in banks' assets following monetary contraction is first concentrated almost entirely in securities; total loans feature a brief positive response in the beginning and then go down persistently. Gertler and Gilchrist (1993) and den Haan et al. (2007) look at disaggregated loans in the VAR setup and find that while real estate and consumer loans decline substantially after monetary tightening, business loans respond to an innovation to the federal funds rate positively. To support the relevance of bank lending channel, Kashyap and Stein (1995) show the contrast in dynamics of loans issued by small and large banks; they demonstrate that large banks increase total and C&I loans after monetary contraction in two out of four of their model specifications, however, this result is statistically insignificant. Ben Mohamed (2015) uses the data from the Senior Loan Officer Opinion Survey to separate out the impact of monetary easing on credit demand and credit supply (the volume of loans issued is not taken into account) and finds that in case of business loans this impact is positive. Our work differs from these studies, first, by establishing the dates of structural changes in relationships between loans and their potential determinants and controlling for them; second, we include risk and balance sheet factors in the models, whereas other works mentioned here only take into account standard monetary model

[5] For business loans this holds only when the "vagueness" measures of uncertainty are used; see the details in section 4.

variables: a real activity measure, inflation and a monetary policy measure. Thereby emerges the critical difference in our results.

Second, our paper relates to empirical literature that aims at detecting the factors fundamental for bank loans issuance. Kishan and Opiela (2000) and Van den Heuvel (2002) show that low capital levels restrain lending after monetary policy tightening. Contrary to this, Berrospide and Edge (2010) find only small effects of bank capital on lending. That banks reduce volumes of lending primarily when they face liquidity constraints is shown by Kashyap and Stein (1995) – for the US, - and by Angeloni, Kashyap and Mojon (2003) for the European economies. Lown and Morgan (2006) emphasize that credit standards are crucial in explaining the dynamics of business loans. Gambacorta and Marques-Ibanez (2011) demonstrate that banks' stability, in particular, banks' capital, their dependence on market funding and on non-interest sources of income play an important role as a factor of bank lending both in Europe and in the US. A growing stream of literature analyzes the effects of uncertainty on credit market developments. Stock and Watson (2012) show that shocks associated with uncertainty and financial disruptions are critical, in particular, because they produced the 2008-2009 recession. Balke and Zeng (2013) and Caldara et al. (2013) argue in favour of output and uncertainty shocks as main drivers of financial intermediation activity. Baum et al. (2009) and Quagliariello (2008) demonstrate that macroeconomic uncertainty is a significant determinant of banks' investment decisions by presenting evidence of negative association between macroeconomic uncertainty and cross-sectional variability of banks' total loan-to-asset ratios. To the best of our knowledge, the effect of macroeconomic uncertainty on different loan components has not been studied before; this is how our work adds to existing literature.

Third, our work is related to the literature on bank risk management and portfolio allocation. Salas and Saurina (2002) demonstrate that during economic booms banks expand their lending activity and relax their selection criteria, such that in the following downturns bad loans increase, producing losses. Froot et al. (1993) and Froot and Stein (1998) use theoretical analysis to demonstrate that active risk management allows banks to hold less capital and to invest more aggressively in risky and illiquid loans. Cebenoyan and Strahan (2004) confirm this empirically with respect to credit risk management, while Brewer at al. (2000) suggest evidence that active management of market risk influences bank performance and risk. We demonstrate that there is portfolio reallocation not only between risky loans and safe assets, but also between different classes of loans in response to macroeconomic, risk and balance sheet shocks.

This paper is organized as follows. Section 2 presents the empirical approach used: the data, the uncertainty measures, the VAR model and identification. Structural break tests performed are specified in section 3. Section 4 discusses the empirical results obtained in the benchmark and the extended models, while section 5 suggests interpretation of these results.

2 Empirical approach

Aiming at establishing the most important determinants of loan components' dynamics and at resolving the puzzle raised by den Haan et al. (2007), we start our analysis with the structural vector autoregression model as specified by den Haan et al. (ibid.), who examine the portfolio behaviour of bank loans following monetary and non-monetary shocks. The benchmark VAR models include one of loans components or safe assets in addition to the federal funds rate, a price index and a real activity measure. On the next step, we extend a set of model's variables to verify, whether there is an additional information content in the other factors' variation for explaining loans' dynamics. In particular, we control for corporate leverage, charge-off rate, capital ratio and uncertainty in the extended model.

2.1 Data

The dataset includes US quarterly data from 1954Q4 to 2015Q4. To estimate the models after the financial crisis break point, we use monthly data from 2010M4-2015M12. The details of definitions, treatment and sources of the data are reported in Appendix A. Most of the data series are taken from the St Louis Federal Reserve Economic Data and the Board of the Governors of the Federal Reserve System, Data Download Program. All the monetary values are real and deflated with a GDP implicit price deflator. All the series are seasonally adjusted: they either come as seasonally adjusted by the source agency or are adjusted with the X-13ARIMA-SEATS algorithm. Additionally, the variables' values are taken in logs (with the exception of interest rates). Figure 1 in Appendix A shows the levels data for the variables.

We use bank loan series from the H.8 releases (Asset and Liabilities of Commercial Banks in the United States) by the Federal Reserve. We analyze data on banks' commercial and industrial loans[6], real estate loans, consumer loans[7] and safe assets. Safe assets include cash and Treasury and agency securities, i.e. assets with low/minimal level of risk. These four types of assets comprise 66-79% of commercial banks' total assets depending on the period[8]. The percentages of each class of asset in total portfolio are reported in Table 1, Appendix A. Figure 2 displays their dynamics.

Federal funds rate is taken as a benchmark measure of monetary policy, given that it records shocks to supply of bank reserves and is a good indicator of monetary policy actions[9]. We employ three-month rate on Treasury bills and nonborrowed reserves of depository institutions as alternative monetary policy measures robustness check of monetary policy effects[10].

Leverage of non-financial corporates is a measure of the corporate sector indebtedness, which could potentially be an important determinant of business loans' issuance. Recent evidence shows that leverage is a key factor shaping financial vulnerability[11], that's why we look at it as at a measure of ex-ante riskiness of non-financial corporates. Credit risk of a particular class of bank loans, i.e. ex-post riskiness of loans, is measured by a charge-off rate on them.

Two groups of proxies are employed to measure macroeconomic uncertainty: volatility measures and measures that capture uncertainty as "vagueness". Among the former, the first measure is a

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[6] We use "commercial and industrial loans" and "business loans" interchangeably.

[7] There is an upward spike in the volume of all types of loans (especially, in consumer loans) in the beginning of 2010 due to a new reporting requirement issued by the Financial Accounting Standards Board. To avoid including this spike into the model, we estimate the model after the financial crisis period on the sample that starts in 2010Q2 (or 2010M4).

[8] The types of bank assets, which are not analyzed here, are interbank loans, loans to commercial banks, trading assets, other securities, other loans and leases and other assets.

[9] We go along McCallum (1983), Bernanke and Blinder (1992), Bernanke and Mihov (1998) and Sims (1992) in that.

[10] Eichenbaum (1992) and Christiano and Eichenbaum (1992) argue that innovations to nonborrowed reserves primarily reflect exogenous shocks to monetary policy, while innovations to broader monetary aggregates primarily reflect shocks to money demand.

[11] See, for example, Shularick and Taylor (2012) and Gourinchas and Obstfeld (2012).

realised unconditional volatility of GDP growth based on rolling sample standard deviations over a 5 years window[12]:

$$\sigma_t = (\sum_{j=1}^{20} g_{t+j}^2 - \frac{1}{20}\sum_{j=1}^{20} g_{t+j})^{1/2} ,$$

where g_i is an annualized quarter-to-quarter growth rate of real GDP.

Second, we use conditional volatility of GDP growth to measure uncertainty. We estimate heteroscedasticity of real GDP growth with a GARCH (1,1)[13]. In particular, the volatility is estimated as conditional variance from GARCH model. The mean equation of GARCH specification is:

$$g_t = c + \theta g_{t-1} + \epsilon_t,$$

where g_t is the annualized quarter to quarter growth rate of real GDP, c and θ are parameters, and ϵ_t is a heteroscedastic error term. The conditional variance equation is:

$$\sigma_t^2 = \omega + \alpha\epsilon_{t-1}^2 + \beta\sigma_{t-1}^2,$$

where the conditional variance σ_t^2 is specified using parameters ω, α and β, news about volatility from the pervious period ϵ_{t-1}^2 and last period's forecast variance σ_{t-1}^2. The results of GARCH (1,1) model estimation are given in Table 4, Appendix A.

Another measure of uncertainty employed here is VXO index, a stock market option-based implied volatility proxy, which measures anticipated volatility of the Standard & Poor's 100 index[14].

A second group of uncertainty measures we use are those that aim to capture vagueness/'unknownness' of future economic outlook. We employ the news-based economic uncertainty index, constructed by Baker et al. (2015)[15] and the composite index of economic policy uncertainty index.

The benchmark VAR model is a small-size monetary vector autoregression model, which includes GDP, GDP implicit price deflator, federal funds rate and either of loan components or safe assets. For robustness checks of the effects of monetary policy we use nonborrowed reserves of depository institutions and short-term interest rate. For the second model, we extend the set of variables and include simple capital ratio of banks, charge-off rate, leverage of non-financial corporates and macroeconomic uncertainty. Given limited data availability on charge-off rates and economic policy uncertainty index, we estimate the extended model for the period from 1985Q1 to 2015Q3.

[12] Unconditional volatility of GDP growth is used a macroeconomic uncertainty measure, for example, in Fogli and Perri (2015) and in Basu and Bundick (2015).
[13] A similar measure of macroeconomic uncertainty was constructed in Cesa-Bianchi and Fernandez-Corugedo (2014) on TFP data.
[14] We use VXO and not VIX index, because data for VXO index is available for the longer period (from 1986) comparing to data available for VIX (from 1990). See http://www.cboe.com/micro/vix-options-and-futures.aspx for details.
[15] See http://www.policyuncertainty.com for details.

2.2 Empirical methodology

We are following a standard procedure and estimate a structural VAR to study the impact of monetary policy and other non-monetary factors on bank loan variables. A VAR model considered is:

$$Z_t = B_1 Z_{t-1} + \cdots + B_q Z_{t-q} + u_t, \tag{2.1}$$

where Z_t is a k-dimensional vector of observable variables, u_t is a k-dimensional vector of reduced-form error terms, and consistent estimates of the coefficients B_i's are obtained by running ordinary least squares equation by equation on (2.1). Z_t is partitioned into the blocks:

$$Z_t = \begin{pmatrix} X_{1t} \\ S_t \\ X_{2t} \end{pmatrix},$$

where S_t is a monetary policy instrument, the time t federal funds rate, or alternatively, the volume of nonborrowed reserves of depository institutions, or a three-month rate on Treasury bills. X_{1t} is a $(k_1 \times 1)$ vector with elements whose contemporaneous values are in the information set of the central bank, such that S_t is affected by variables is X_{1t} contemporaneously; X_{1t} is not influenced by S_t in period t. X_{2t} is a $(k_2 \times 1)$ vector with elements whose contemporaneous values are not in the information set of the central bank, so S_t is not affected by their influence, but it does exert an impact on them in period t. $k = k_1 + 1 + k_2$. Drawing from Christiano et al. (1999), we assume that the relationship between the VAR disturbances and the fundamental economic shocks, ε_t, is given by

$$u_t = \tilde{A}\varepsilon_t.$$

$\tilde{A}$ is a $(k \times k)$ matrix of coefficients, and ε_t is a $(k \times 1)$ vector of uncorrelated fundamental shocks with a unit standard deviation each, so $E[u_t u_t'] = \tilde{A}\widetilde{A}'$. To determine the effects of a monetary policy shock, a restriction, imposed on $\tilde{A}$, is that it is a block lower-triangular matrix:

$$\tilde{A} = \begin{bmatrix} \tilde{A}_{11} & 0_{k_1 \times 1} & 0_{k_1 \times k_2} \\ \tilde{A}_{21} & \tilde{A}_{22} & 0_{1 \times k_2} \\ \tilde{A}_{31} & \tilde{A}_{32} & \tilde{A}_{33} \end{bmatrix},$$

where $\tilde{A}_{11}$ is a $(k_1 \times k_1)$ matrix, $\tilde{A}_{21}$ is a $(1 \times k_1)$ matrix, $\tilde{A}_{31}$ is a $(k_2 \times k_2)$ matrix, $\tilde{A}_{22}$ is a (1×1) matrix, $\tilde{A}_{32}$ is a $(k_2 \times 1)$ matrix, $\tilde{A}_{33}$ is a $(k_2 \times k_2)$ matrix, and $0_{i \times j}$ is a $(i \times j)$ matrix with zero elements.

For the benchmark specification we assume that X_{2t} is empty. In particular, the assumption is that monetary authority observes and responds to contemporaneous information on all other variables. We consider this is a plausible assumption given that data on price level, industrial output, aggregate employment and other indicators of aggregate real economic activity are available to the FED on monthly basis[16]. We find empirical support for this assumption: a pairwise Granger causality test suggests that the direction of Granger-causation runs from loans to funds rate and not the other way around (Table 3, Appendix A). In the New Keynesian approach this assumption corresponds to the notion of a feedback interest rate rule of monetary

[16] This assumption is made, among others, by Christiano and Eichenbaum (1992), Christiano et al. (1999), Eichenbaum and Evans (1995), Strongin (1995), Bernanke and Blinder (1992), Bernanke and Mihov (1995), and Gertler and Gilchrist (1994).

authority, which closes general equilibrium models. For robustness check we also consider an alternative order: X_{1t} is assumed to be empty. This alternative identification scheme is adopted by den Haan et al. (2007), who assume that monetary authority does not respond to contemporaneous information. We obtain evidence supporting alternative specification as well: estimated cross-correlation coefficients between loans (business loans and real estate loans) and funds rate indicate that loans lead funds rate by one quarter, such that correlation of the federal funds rate is the strongest with the past values of loans (see Table 2, Appendix A).

We place loan volumes on the last place in X_{1t} block. The assumption is that banks observe contemporaneous information on real activity and inflation when deciding on loans' issuance. Cross-correlation coefficients between growth of loans and GDP growth, on one side, and between growth of loan and inflation, on the other side, indicate that GDP and inflation lead loan volumes. Granger causality tests show that past values of GDP help to predict loans and not the other way around. This evidence justifies making the assumption of bank loans being ordered after a real activity and inflation measures. We also try an alternative order when loan volumes are placed last, based on the assumption that banks see the policy rate set by the central bank contemporaneously, in this case all the variables are placed in block X_{2t}, while X_{1t} is empty.

Thus, the variables' order in the benchmark model is: a real activity, an inflation measure, loan volumes or safe assets (added one at a time) and a monetary policy instrument. An alternative order for robustness check of monetary policy effects is: a monetary policy instrument, a real activity measure, inflation proxy and, finally, loan volumes or safe assets.

Table 1. Models analyzed.

	Benchmark model	Extended model
Variables (in the VAR order)	- Real GDP - GDP deflator - Loans/safe assets - Federal funds rate (or an alternative policy measure) *For robustness check of monetary policy effects* - Federal funds rate (or an alternative policy measure) - GDP - Inflation - Loans/safe assets	- Uncertainty - Real GDP - GDP deflator - Leverage of corporates - Capital ratio - Loans/safe assets - Charge-off rate - Federal funds rate
Estimation periods	1) 1954Q4-1979Q4 (quarterly data) 2) 1983Q1-2007Q4 (quarterly data) 3) 2010M4-2015M12[17] (monthly data)	1985Q1-2007Q4 (quarterly data)

A wider set of variables is included in the extended model. In particular, measures of uncertainty, capital ratio, charge-off rates and leverage of non-financial corporates are used to assess whether there is an additional information content in fluctuations of these factors for

[17] We start the third sample in 2010M4 and not earlier, because the data on loans has a break in March and April of 2010, when the new reporting requirements issued by the Financial Accounting Standards Board were introduced. Financial Accounting Statements (FAS) 166 and 167 have implications for how banks treat off-balance-sheet special purpose vehicles.

explaining variations of bank loans. This ordering is based on several assumptions. First, it is assumed that uncertainty shocks influence all other variables contemporaneously, such that uncertainty is an underlying characteristic of the state of economy being unaffected by other variables contemporaneously[18]. This consideration is corroborated by estimates of cross-correlation between uncertainty proxies and business loans – the former leading the latter (Table 3, Appendix A), - and by Granger causality tests, which show that when Granger causality effect is significant, the direction of this effect goes from uncertainty to loans (Table 2, Appendix A)[19]. It is worth noticing that the strongest negative correlation between uncertainty and business loans is found for the following uncertainty proxies: VXO index, news-based uncertainty index and composite policy uncertainty index. Granger causality tests confirm close relationships of loans with VXO index and news-based index, for which the Granger causation effects are significant. We use news-based uncertainty as a benchmark measure of economic uncertainty in our extended model. The results for employing the other uncertainty measures are also available in Appendix D.

Leverage of non-financial corporates is placed after real activity and inflation measures based on the assumption that companies observe contemporaneous values of uncertainty, real activity and inflation, when making decision about how much debt to incur, whereas all credit variables are not observed by them. Capital ratio of banks is placed before loans. Capital adequacy requirements affect the amount of risky assets banks can have on their balance sheets, and that is the reason why we assume that banks see and take into account the level of their capital ratio when making decisions about risky loans' issuance. Finally, charge-off rate on loans is placed after loan volumes. It is assumed that the value of loans removed from the books and charged by corporates against loss reserves depends on the volume of loans issued by banks to firms. Thus, the variables' order in the extended model is: an uncertainty proxy, a real activity measure, an inflation measure, leverage of the corporates, banks' capital ratio, loan volumes or safe assets (added one at a time), charge-off rate on a certain class of loans (or a charge-off rate on total loans in case of a VAR with total loans or safe assets) and a monetary policy instrument.

Based on Akaike information criterion (AIC) (and in line with Schwarz and Hannan-Quinn information criteria), the benchmark specification of the model includes two lags. The lag orders of the extended model specifications are also based on Akaike information criterion and are given in Appendix C notes to figures.

3. Stability analysis

Empirical business cycles literature argues that there have been important changes in the characteristics of dynamics of the series analyzed[20]: a shift of the US monetary policy to an anti-inflation stance in 1980-1982 and the financial crisis of 2008-2009. We employ formal structural stability tests to check our VAR models for the parameters' stability at these two possible break dates.

We use Chow tests to test the hypothesis of VAR models parameters' constancy following Canova (2007) and Lutkepohl (2005). The null hypothesis of time invariance of the parameters

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[18] This identification scheme draws from Bloom (2009), Baker et al. (2015) and Bachmann et al. (2012), where uncertainty measure is ordered first in the VAR.

[19] This holds for all uncertainty proxies except for conditional volatility of GDP growth, for which correlation with loans is found to be nonsignificant and Granger causality effect doesn't go in the direction from uncertainty to loans.

[20] See, for example, Bernanke and Mihov (1998), Cogley and Sargent (2002), Primiceri (2006), Stock and Watson "Has the Business Cycle Changed and Why?" and Koop et al. (2009), among others.

throughout the sample period is checked against the possibility of a change in the parameter values at period T_B. We consider three versions of Chow tests: break-point test, sample-split test and Chow forecast test[21]. P-values are computed in two ways: first, treating the break date as unknown (this serves the purpose of detecting the date of structural break), and second, treating the break date as determined exogenously (to confirm the break existence, or as a robustness check of the result obtained at the first step). See Appendix B for details of the approach used.

The Chow tests are designed to detect one potential structural break from the sample (Canova (2007), Lutkepohl (2001)). Our sample period 1954-2015 includes two possible shifts, therefore, we apply the tests for only two adjacent time intervals separated by one potential break date and exclude the interval left. Hence, testing for parameters stability during the US monetary policy shift, we exclude the period from the onset of financial crisis from the test. The test sample in this case is 1954Q4 to 2007Q4. Testing the hypothesis of model's parameters stability during the financial crisis we exclude the period before 1980. The test sample in this case is 1983Q1 to 2015Q3. Results of testing for structural breaks are given in Table 1.

Table 1. Structural change tests.

	Test sample period	Unknown break date test		Exogenously determined break date					
		Suspected breakpoint interval	The identified break date	Chow breakpoint test		Chow split-sample test		Chow forecast test	
				λ_{BP}	p-value	λ_{SS}	p-value	CF	p-value
The US monetary policy shift	[1954Q4, 2007Q4]	[1979Q1, 1983Q4]	1980Q4	240.541	0.000	165.928	0.000	8.581	0.000
The financial crisis 2008-2009	[1983Q1, 2014Q4]	[2008Q1, 2009Q4]	2008Q3	147.675	0.000	90.707	0.000	1.749	0.000

Notes. The main entries are tests statistics and p-values for Chow tests to check the null hypothesis that the set of VAR(2) model parameters is constant: for the US monetary policy shift - over the period from 1954Q4 to 2007Q4, and for the financial crisis 2008-2009 – over the period from 1983Q1 to 2015Q3[22].

All the Chow test statistics reject the null hypothesis of parameters stability in the VAR models. We conclude that there are structural changes in the models' parameters in 1980-1982 and in 2008-2009. Therefore, the first period that we study is 1954Q1-1979Q4, the second one - 1983Q1-2007Q4 and the third one - 2010M4-2015M12. Monthly data is used to analyze the dynamics of loans after the financial crisis due to lack of quarterly observations. Given that 1980-1982 and 2008-2009 are the periods of extreme volatility associated with unprecedented monetary policy measures (monetary base control), we exclude them from our study, due to their dynamic characteristics being not indicative for the rest of the sample. We start the third sample in 2010M4 and not earlier, because the data on loans has a break in March and April of 2010,

[21] See Lutkepohl et al. (2006), Candelon and Lutkepohl (2001) and Hendry and Doornik (1997) for details.

[22] For robustness checks we perform the tests for VAR models with different lag orders. These tests also reject the null hypothesis of the models' parameters stability (see Appendix E for details).

when the new reporting requirement issued by the Financial Accounting Standards Board were introduced[23].

4. Results

4.1 Benchmark model

We begin by analyzing the benchmark model. It includes a real activity measure, an inflation measure, loan components (included in the VAR one at a time) and the federal funds rate. Though our VAR specification draws from den Haan et al. (2007), there are some differences with their analysis. First, we estimate the model over several periods taking into account structural breaks dates; second, we increase the size of the sample[24]; third, we perform robustness check of monetary policy shock effects by using alternative policy indicators; and forth, we analyze responses of safe assets and total loans to monetary and real activity shocks. We analyze the results in form of impulse responses and forecast error variance decomposition of disaggregated and total loans and safe assets; 90% bias-corrected bootstrap confidence bands are calculated as in Kilian (1998).

Figures 1-15 in Appendix C plot the responses of business loans, real estate loans, consumer loans[25], total loans and Treasury and agency securities after one-standard deviation shocks to the federal funds rate, real activity and inflation under the benchmark specification of the VAR, i.e. when the federal funds rate is placed last in the VAR. Figures 1-15 in Appendix D plot impulse responses under the alternative specification of the model, i.e. when the federal funds rate is placed first in the VAR. Figures 31-45, Appendix D plot impulse responses for the model with an alternative measure of monetary policy – nonborrowed reserves of depository institutions that are placed the last in the VAR. We estimate the latter version of the model for the samples 1954Q4-1979Q4 and 1983Q1-2007Q4, but not for 2010M4-2015M12, because the values of nonborrowed reserves of depository institutions underwent substantial changes in 2008 that are not generally characteristic to the dynamics of this series[26]. Finally, figures 16-31 in Appendix D plot impulse responses for the model with an alternative measure of monetary policy – 3-month Treasury bill rate that is placed the last in the VAR according to our benchmark model specification.

There are significant differences in responses of loans to shocks in different subsamples. We obtain that significant positive impact of monetary policy contraction on business loans - the effect found in den Haan et al. (2007) – is characteristic for this class of loans only for the period 1983Q1-2007Q4 (Figure 2, Appendix C). Over the periods 1954Q4-1979Q4 and 2010M4-2015M12 a significant negative effect of monetary tightening on business loans is observed (Figures 1 and 3, Appendix C). The alternation of negative and positive effects of monetary policy shocks from one sample to another is obtained in the benchmark and alternative specifications of the model (Figures 1-3, Appendix D). Additional robustness checks show that when 3-month Treasury bill rate is used as a monetary policy measure business loans' increase

[23] Financial Accounting Statements (FAS) 166 and 167 have implications for how banks treat off-balance-sheet special purpose vehicles.
[24] The sample in den Haan et al. (2007) spans from 1977Q1 to 2004Q2.
[25] Due to an upward spike in consumer loans in the beginning of 2010, because new reporting requirement issued by the Financial Accounting Standards Board, were set in place, we estimate the VAR with the consumer loans only until 2009Q4.
[26] For more details, see Statistical Releases from the Federal Reserve: http://www.federalreserve.gov/feeds/h3.html

after monetary tightening significantly, whereas when nonborrowed reserves measure monetary policy actions, this effect is positive but nonsignificant.

The other classes of loans - real estate loans and consumer loans - decrease responding to monetary contraction in all the subsamples, what is consistent to bank lending channel of monetary policy transmission mechanism (Figures 4-9, Appendix C). We demonstrate that the size of these negative response gets smaller with time: over 1954-1979 one standard deviation shock to monetary policy reduces mortgages by 1.65% and consumer loans by 1.84%; over 1983-2007 – by 0.49% and 0.41%, over 2010-2015 – by 0.24% and 0.06% respectively. These findings are robust to VAR specification and to the measure of monetary policy used (Figures 4-9, 19-24 and 34-39, Appendix D). In addition to these negative effects, we find that consumer and real estate loans feature brief and mostly insignificant positive responses to monetary contraction (Figure 5, 6 and 8, Appendix C), which are also shown in den Haan et al. (2007).

Next, we observe that over 1983-2007 total loans go up following monetary contraction, while in subsamples 1954-1979 and 2010-2015 they are reduced after a positive shock to federal funds rate. This dynamics reflects the patterns of loan components (Figures 10-12, Appendix C). This finding, which is robust to specification of VAR and to the measure of the monetary policy used, differs from the results shown in the literature, for example, in Gertler and Gilchrist (1993) and in den Haan et al. (2005), where they document the estimated response for total loans as not robust and not significant. However, this finding is in line with the results of Kashyap and Stein (1995), who also demonstrate that total loans go up after monetary tightening in some of their specifications. We conjecture that a different result emerges in some studies, because structural changes in the model's parameters are not accounted for in these works[27]. As a result, the negative effect of monetary tightening on total loans before 1980's gets merged with the positive impact after 1980's so that the resulting effect is not robust and not significant. In any case, we find that this positive reaction of total loans is not prolonged: after 14 quarters from the shock impact total loans respond negatively to monetary contraction in all the subsamples.

All classes of loans go up following a positive innovation to real economic activity, while Treasury and agency securities holdings are reduced (Figures 1-15, Appendix C). This reveals banks' preference to substitute comparatively safe assets with risky loans in their balance sheets in the times of better economic conditions. Hence, banks' portfolios are reallocated in response to real activity shock in the way that makes portfolios riskier. This inference is valid for all the subsamples analyzed.

We conjecture that puzzling positive response of commercial and industrial loans to monetary contraction in 1983-2007 might be the case of omitted variable bias, i.e. inability of a small monetary policy VAR to capture the critical forces that drive business loans volumes. We extend the set of model's variables to test this hypothesis.

4.2 Extended model

In this section we report the results of extended model estimation over the period 1983-2007, which is completed to understand the workings of monetary transmission mechanism on commercial and industrial loans better. We aim to resolve the puzzling response of this class of loans to monetary contraction over 1983-2007 obtained with the benchmark model. We augment the model with a set of risk and balance sheet variables: macroeconomic uncertainty, portfolio

[27] The samples analyzed at in den Haan et al. (2005) are 1960-2003 for H8 data and 1977-2000 for Call Report Data.

credit risk (measured by charge-off rate on respective class of loans), leverage of corporates, and banks' capital ratio, measured as a ratio of banks' equity capital to total assets. In the benchmark version of the extended model the news-based uncertainty index is used as uncertainty measure; the results of employing alternative uncertainty measures are also available (see Figures 46-65 and Tables 1-20, Appendix D).

The 'perverse' positive response of commercial and industrial loans to **monetary tightening**, observed in the case of the benchmark model, is no longer present, when risk and balance sheet factors are controlled for. In particular, positive innovation to federal funds rate exerts significant negative effect on business loans in the extended model version (Figure 16A, Appendix C). Robustness checks are performed with all the measures of uncertainty discussed above, and they confirm this finding (Figures 46-49, Appendix D). Real estate and consumer loans go down upon monetary contraction in the way they do in the benchmark model version (Figures 17A, 18A and 19A, Appendix C).

We therefore conjecture that positive effect of monetary tightening on business loans in the benchmark model is the case of omitted variable bias, when the effects of important loan volumes' determinants are left out. All of the variables added to the extended model – macroeconomic uncertainty, corporate leverage, portfolio credit risk and banks' capital ratio - are correlated with business loans' volumes significantly and feature significant Granger causality relationships with them (Tables 1-3, Appendix A). Forecast error variance decomposition analysis reveals that a shock to portfolio credit risk contributes up to 24% of business loans' variability, making it the most important determinant of business loans' volumes dynamics (Table 1, Appendix C). We conclude that portfolio credit risk is a critical factor that should be accounted by a model that aims at explaining loan volumes' movements. We conjecture that the benchmark model features a 'perverse' (positive) response of business loans to monetary policy shock due to absence in the benchmark model of a credit risk variable, which is particularly influential for C&I loans. We obtain that monetary tightening leads to significant increases in charge-off rate on C&I loans, macroeconomic uncertainty also goes up (Figure 16B, Appendix C). Higher levels of credit risk and uncertainty, together with a reduced GDP, put a downward pressure on business loans issuance.

This finding that credit risk is the key determinant of business loans' variance stands in contrast with the results of variance decomposition for consumer loans and mortgages. The movements of consumer loans are largely explained by real activity shocks and innovations to inflation (Table 3, Appendix C). For mortgages, cost shocks, shocks to monetary policy and leverage of corporates contribute to explanation of variance (Table 2, Appendix C).

The effect of **charge-off rates** on all the classes of loans is significantly negative (Figures 16A-19A, Appendix C), whereas safe assets react to innovation to the charge-off rate on loans positively (Figure 20, Appendix C). Thereby we infer that banks reallocate their portfolios following positive credit risk shocks by reducing loans issuance and increasing their safe assets holdings.

Unlike responses to credit risk shock, the dynamic patterns of loan components following **macroeconomic uncertainty shock** are heterogeneous. The impact of positive innovation to uncertainty on business loans depends on the nature of uncertainty measure employed. A positive shock to vagueness-type measures of uncertainty, such as news-based uncertainty index or composite index of economic policy uncertainty, make a significant negative effect on issuance of commercial and industrial loans (Figure 16A, Appendix C and Figure 46, Appendix D). A shock to macroeconomic uncertainty measured as volatility of GDP growth (conditional or unconditional) also drives business loans down, but these negative impacts are statistically insignificant (Figures 48-49, Appendix D). The impact of positive innovation to the stock market option-based implied volatility increases C&I loans insignificantly (Figure 47, Appendix D). We therefore conclude that changes in innovations to volatility (of GDP growth or stock market) don't reduce business loans' issuance as much as a spike in the state of "unknownness" does.

To find out what is behind this difference in responses of business loans to different types of uncertainty shocks, we estimate impulse responses of the variables to innovations in uncertainty, using all the uncertainty proxies at hand (Figures 16C and 16D, Appendix C). We obtain that there is a significant difference in responses of leverage of corporates to different types of uncertainty shocks (while all the other variables respond to shocks in a similar way) (Figures 16C and 16D, Appendix C). This critical difference is that corporates respond to positive innovations to volatility by reducing their leverage, while innovations to uncertainty defined as vagueness/unknownness of economic outlook make firms increase their indebtedness. We conjecture that this happens, because when economic perspectives are unclear, firms don't necessarily relate the state of unknownness to only worse economic conditions in future or threats, but also foresee opportunities. Then to secure funding is important for companies, so that benefits of improved economic conditions can be enjoyed. The fact that firms are more indebted puts downward pressure on supply of C&I loans (indebted borrowers are more financially vulnerable) and on demand for C&I loans (indebted firms are less willing to ask for additional borrowings). Hence the significant negative response of business loans to uncertainty shock, when uncertainty is defined as vagueness/unknownness of economic outlook.

In contrast to this, an innovation to volatility measure of uncertainty leads to decrease of the leverage of non-financial corporates. We admit that this effect is present due to firms aiming at reduction of their debt in face of more volatile GDP growth and/or stock market. In this case the possibility of decreasing business returns in future is more evident than in the case of vague economic perspectives. Comparatively low level of leverage does not depress supply and demand for loans as in the case of vagueness-type of uncertainty measure. Hence, there's no significant reduction of C&I loans following innovation to volatility measure of uncertainty.

Real estate loans go down after a positive innovation to uncertainty disregarding the type of the measure of uncertainty employed. Moreover, unlike the case of C&I loans, uncertainty shock (together with shock to banks' capital ratio) is one of the major determinants of mortgages volumes' variance on the horizon of 8 quarters (Table 2, Appendix C).

Interestingly, consumer loans grow upon impact of uncertainty shock; this result is robust to various uncertainty proxies (Figure 18A, Appendix C and Figures 55-57, Appendix D). This positive impact of uncertainty on consumer loans is a brief one, it lasts (stays statistically significant) for 1 quarter following the shock impact. No significant negative effect of uncertainty on consumer loans is found. We conjecture this might be the case of increase in demand for consumer loans in more uncertain macroeconomic environment, when individuals would like to secure borrowed funds due to foreseen possibility of being unable to borrow more in future. We suggest this influence of uncertainty shock on consumer loans needs to be studied in depth in future research.

Banks increase their safe assets holdings following uncertainty shocks (Figure 20, Appendix C and Figures 62-65, Appendix D), thus reallocating assets in their portfolios by substituting risky loans with cash and securities.

Heightened corporate leverage also impacts various classes of loans heterogeneously. While business and real estate loans go down after a shock to leverage, consumer loans show a significant positive response to positive innovation to leverage. Hence, this shock makes banks substitute loans issued to firms with loans issued to individuals due to higher financial fragility of the corporate sector characterized by higher indebtedness. Increase of safe assets holdings in this case does not occur. Forecast error variance decomposition shows that variance of real estate loans' volumes is explained by innovations to corporates' leverage to a considerable extent: 20-29% of mortgages' variance is contributed by this factor in 16-24 quarters horizon (Table 2, Appendix C). Only 6-7% of business loans volumes variance is explained by innovations to leverage of firms (Table 1, Appendix C), for the consumer loans volumes, 1-3% of movements are explained by a leverage shock. Hence, how much debt is incurred by firms relative to their assets, matters primarily for real estate loans[28]. Interestingly, corporates' indebtedness is also a statistically significant determinant of total loans' dynamics: 21-29% of total loans' variance is explained by it on the horizon of 11-24 quarters (Table 4, Appendix C).

The impact of innovation to capital ratio on various classes of loans is different as well: while the effect on business and consumer loans is positive (though statistically insignificant, see Figure 16A and 18A, Appendix C), the influence on real estate loans is statistically significant and negative (Figure 17A, Appendix C). The result obtained for business and consumer loans is consistent with the idea that higher bank equity allows to hold higher volumes of risky assets on its balance sheet as protection from insolvency. Real estate loans decline on impact of balance sheet shock; this negative effect dies out after 5 quarters, and later becomes positive, when banks are in a stronger position to lend. Remarkably, this negative effect of balance sheet shock on mortgages is reflected on the dynamics of total loans, which also go down on impact of a positive shock to banks capital ratio and start growing through the second year. This negative effect of capital ratio that we find for mortgages is in line with finding of Barajas et al. (2015), who use a different VAR specification to estimate the effect of capital ratio of banks on total loans volumes.

Lastly, it is worth mentioning that all the loans' components respond to **cost shock** negatively, while the impact of positive **real activity shock** is positive on all the classes of loans. Augmenting the benchmark model with additional variables does not change the sign of impulse responses to these two macroeconomic shocks. The effect of a positive innovation to real activity on safe assets is negative, what makes an evidence for banks' assets portfolio reallocation after a real activity shock from securities and cash to loans.

5. Interpretation of the results

The results presented here give evidence in favour of bank-lending channel, i.e. that the Federal Reserve can affect bank' loan supply schedules by changing reserves. We show that not only mortgages' and consumer loans' issuance declines following monetary contraction[29] as it has been shown, for example, in den Haan et al. (2007) and in Gertler and Gilchrist (1993). We

[28] In this study we don't distinguish between commercial and residential real estate loans; we conjecture that corporate leverage is a significant determinant of the dynamics of the latter.

[29] The interpretation of consumer and real estate loans reduction following monetary contraction is based on the fact that banks finance their long-term loans with short-term liabilities. Thus, mortgages, characterized by long maturity, and consumer loans with their small degree of flexibility of loan rates, are loans with comparatively low current-period profit margins. Current-period net earnings on these loans go down after monetary tightening, as interest rates on these loans changes by less than short-term interest rate. Hence, banks reduce issuance of consumer and real estate loans following monetary contraction.

demonstrate that C&I loans also go down after a shock to federal funds rate, if the risk and balance sheet variables are controlled for.

We show that importance of risk factors as determinants of C&I loans' dynamics is greater than for mortgages and consumer loans. Particularly, forecast error variance decomposition analysis suggests that credit risk is a critical determinant of business loans' volumes[30], which, together with macroeconomic uncertainty, explains up to 29% of C&I loans' variance. Contrary to this, only up to 17% is explained by all macroeconomic factors together: real activity level, inflation and federal funds rate. This stands in marked contrast with the characteristics of consumer and real estate loans' issuance. Risk factors - uncertainty and portfolio credit risk - explain up to 12% of the variance of mortgages, while macroeconomic factors – up to 43%. For consumer loans' variance up to 26% is explained by risk factors, while macroeconomic factors explain 42%. Hence, comparing with two other classes of loans, the share of variance of business loans explained by risk factors is substantially higher than what is explained by macroeconomic factors. Therefore, unlike for mortgages and consumer loans, it is essential that risk factors are controlled for in a model that aims to provide a satisfactory explanation of the C&I loans' dynamics.

A possible reason for the impact of risk factors being critical for issuance of business loans and not for real estate and consumer loans is that risk associated with C&I loans is generally smaller than risk related to other two classes of loans. First, a rate on loans to corporate customers is normally floating, it is more flexible than a rate on consumer loans, for which the market structure is such that interest rates are less flexible. This allows banks to have the rate on C&I loans be adjusted to altering macroeconomic conditions. Hence, interest rate risk for this type of loans is minimized. Second, commercial and industrial lending is often a lending of relatively short maturity, comparing to other types of loans. This implies lower risk, as the probability of deterioration of borrower's financial conditions over a short period is necessarily lower than over the longer horizon. Besides, shorter maturity increases frequency of loans' extensions, thus, banks revise borrowers' due diligence information and update their contract terms more frequently. This allows banks to re-optimize contract terms for business lending according to changing economic environment and to the financial state of a debtor. Third, closer ties between a bank and its creditors in the case of business loans allow the former to possess timely information about the latter, hereby attenuating informational asymmetries between them. This could be due to relationship lending, which facilitates monitoring of businesses. The outcome is the increased availability of funds to borrowers that have closer ties to lenders, what is found to be of particular relevance for business lending[31]. Forth, issuing business loans is generally less information-intensive than, for example, mortgages, what makes them easier to evaluate. Hence, monitoring costs for the C&I loans are smaller. Thus, commercial and industrial loans are characterized by lower level of risk comparing to mortgages and consumer loans.

When affected by heightened macroeconomic uncertainty or increased credit risk, business loans are likely to lose their perceived status of relatively safe asset, which in other (normal) conditions allows to earn a stable yield with comparatively low risk. Uncertainty and risk factors matter, because they induce banks to change expectations about loans profitability: when risk substantializes (for example, the rate of default on loans goes up), the return on C&I loans declines and/or gets more volatile. To compensate for this decline, risk premium goes up. Empirical evidence in Aksoy and Basso (2014) corroborates this consideration: they show that

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[30] These results are confirmed by cross-correlation and Granger causality tests, see Tables 2 and 3 in Appendix A.

[31] See, among others, Hoshi et al. (1991), Petersen (1999), Petersen and Rajan (1994), Chakraborty and Charles (2006), Bharath et al. (2011) for empirical evidence on that.

an increase in US bank-level expected financial business profitability as measured by the expected mean forecast in earnings per share for major US financial institutions, leads to a significant decline in yield spreads next to variations in real output and inflation. In other words, when banks expect decline of their profits, they charge higher premium for loans issuance, and availability of loans reduces.

Hence, in the conditions of heightened macroeconomic uncertainty and greater credit risk banks would want to revise their portfolios of assets to take into account changed loans characteristics and the fact that business loans cannot be regarded as a safe asset anymore. The terms of business lending are revised more often due to relatively shorter maturity of C&I loans. As a result, the dynamics of business loans is more sensitive to risk factors than the dynamics of other types of loans' issuance. We conjecture that shorter maturity and generally lower riskiness might be the reasons why risk factors are more influential for dynamic regularities of commercial and industrial loans, than in case of real estate and consumer loans.

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Appendix A – Data

The following paragraphs provide details on data definitions, sources and treatment.

Real GDP

Real Gross Domestic Product, Billions of Chained 2009 Dollars, Quarterly, Seasonally Adjusted, downloaded from Fred II (GDPC1), see http://research.stlouisfed.org/fred2/. Source: U.S. Department of Commerce: Bureau of Economic Analysis. Growth variable is annualized quarter to quarter growth rates.

GDP deflator

Gross Domestic Product: Implicit Price Deflator, Index 2009=100, Quarterly, Seasonally Adjusted, downloaded from Fred II (GDPDEF), see http://research.stlouisfed.org/fred2/. Source: U.S. Department of Commerce: Bureau of Economic Analysis.

Federal funds rate

Effective Federal Funds Rate, Percent, Quarterly, Not Seasonally Adjusted, downloaded from Fred II (FEDFUNDS), see http://research.stlouisfed.org/fred2/. Source: Board of Governors of the Federal Reserve System (US).

Short-term interest rate

3-Month Treasury Bill: Secondary Market Rate, average of monthly data, downloaded from Fred II (TB3MS), see http://research.stlouisfed.org/fred2/. Sources: Board of Governors of the Federal Reserve System.

Nonborrowed reserves of depository institutions

Aggregate Reserves of Depository Institutions and the Monetary Base (equals total reserves less total borrowings from the Federal Reserve), Millions of Dollars, Quarterly, Not Seasonally Adjusted. Downloaded from Fred II (TOTRESNS and BORROW), see http://research.stlouisfed.org/fred2/. Source: Board of Governors of the Federal Reserve System (US).

Commercial and industrial loans

Commercial and Industrial Loans, All Commercial Banks, Billions of Dollars, Quarterly, Seasonally Adjusted, downloaded from Fred II (BUSLOANS), see http://research.stlouisfed.org/fred2/. Source: Board of Governors of the Federal Reserve System (US). Deflated with GDP implicit price deflator.

Real estate loans

Real estate loans, All Commercial Banks, Billions of Dollars, Monthly, Not Seasonally Adjusted, downloaded from Data Download Program (H8/H8/B1026NCBDM), see http://www.federalreserve.gov/datadownload/. Quarterly series are averages of monthly data. Source: Board of Governors of the Federal Reserve System (US). Deflated with GDP implicit price deflator.

Consumer loans

Consumer loans, All Commercial Banks, Billions of Dollars, Monthly, Not Seasonally Adjusted, downloaded from Data Download Program (H8/H8/B1029NCBDM), see http://www.federalreserve.gov/datadownload/. Quarterly series are averages of monthly data. Source: Board of Governors of the Federal Reserve System (US). Deflated with GDP implicit price deflator.

Total loans

Loans and leases in bank credit, All Commercial Banks, Billions of Dollars, Monthly, Not Seasonally Adjusted, downloaded from Data Download Program (H8/H8/B1020NCBAM), see http://www.federalreserve.gov/datadownload/. Quarterly series are averages of monthly data. Source: Board of Governors of the Federal Reserve System (US). Deflated with GDP implicit price deflator.

Capital ratio

Calculated as a ratio of Total Equity Capital for Commercial Banks to Total Assets of Commercial Banks. Seasonally Adjusted with X-13ARIMA-SEATS algorithm from the US Census Bureau.

Total Equity Capital for Commercial Banks in the U.S., Thousands of Dollars, Quarterly, Not Seasonally Adjusted, downloaded from Fred II (USTEQC), see http://research.stlouisfed.org/fred2/. Source: Federal Financial Institutions Examination Council.

Total Assets of Commercial Banks in the U.S., Millions of Dollars, Quarterly, Not Seasonally Adjusted, downloaded from Data Download Program (H8/H8/B1151NCBDM), see http://www.federalreserve.gov/datadownload/. Source: Board of Governors of the Federal Reserve System (US).

Charge-off rates

Charge-off rate on business loans, consumer loans, real estate loans and total loans, all commercial banks, Percentage, Quarterly, Seasonally Adjusted, downloaded from Data Download Program (CHGDEL), see http://www.federalreserve.gov/datadownload/. Source: Board of Governors of the Federal Reserve System (US).

Leverage

Calculated as a ratio of Total assets to Net worth of nonfinancial corporate business. Seasonally Adjusted with X-13ARIMA-SEATS algorithm from the US Census Bureau.

Total assets of nonfinancial corporate business, Millions of Dollars, Quarterly, Not Seasonally Adjusted, downloaded from Data Download Program (Z1/Z1/FL102000005.Q), see http://www.federalreserve.gov/datadownload/. Source: Board of Governors of the Federal Reserve System (US).

Net worth of nonfinancial corporate business, Millions of Dollars, Quarterly, Not Seasonally Adjusted, downloaded from Data Download Program (Z1/Z1/FL102090005.Q), see http://www.federalreserve.gov/datadownload/. Source: Board of Governors of the Federal Reserve System (US).

Safe assets

Calculated as a sum of Cash assets and Treasury and agency securities of all commercial banks.

Cash assets, all commercial banks, Millions of Dollars, Monthly, Seasonally Adjusted, downloaded from Data Download Program (H8/H8/B1048NCBAM), see http://www.federalreserve.gov/datadownload/. Quarterly series are averages of monthly data. Source: Board of Governors of the Federal Reserve System (US). Deflated with GDP implicit price deflator.

Treasury and agency securities, all commercial banks, Millions of Dollars, Monthly, Seasonally Adjusted, downloaded from Data Download Program (H8/H8/B1003NCBAM), see http://www.federalreserve.gov/datadownload/. Quarterly series are averages of monthly data. Source: Board of Governors of the Federal Reserve System (US). Deflated with GDP implicit price deflator.

Uncertainty – news-based index

A normalized index of the volume of news articles discussing economic policy uncertainty, constructed by the Economic Policy Uncertainty project, Quarterly, Not Seasonally Adjusted. Downloaded from http://www.policyuncertainty.com/.

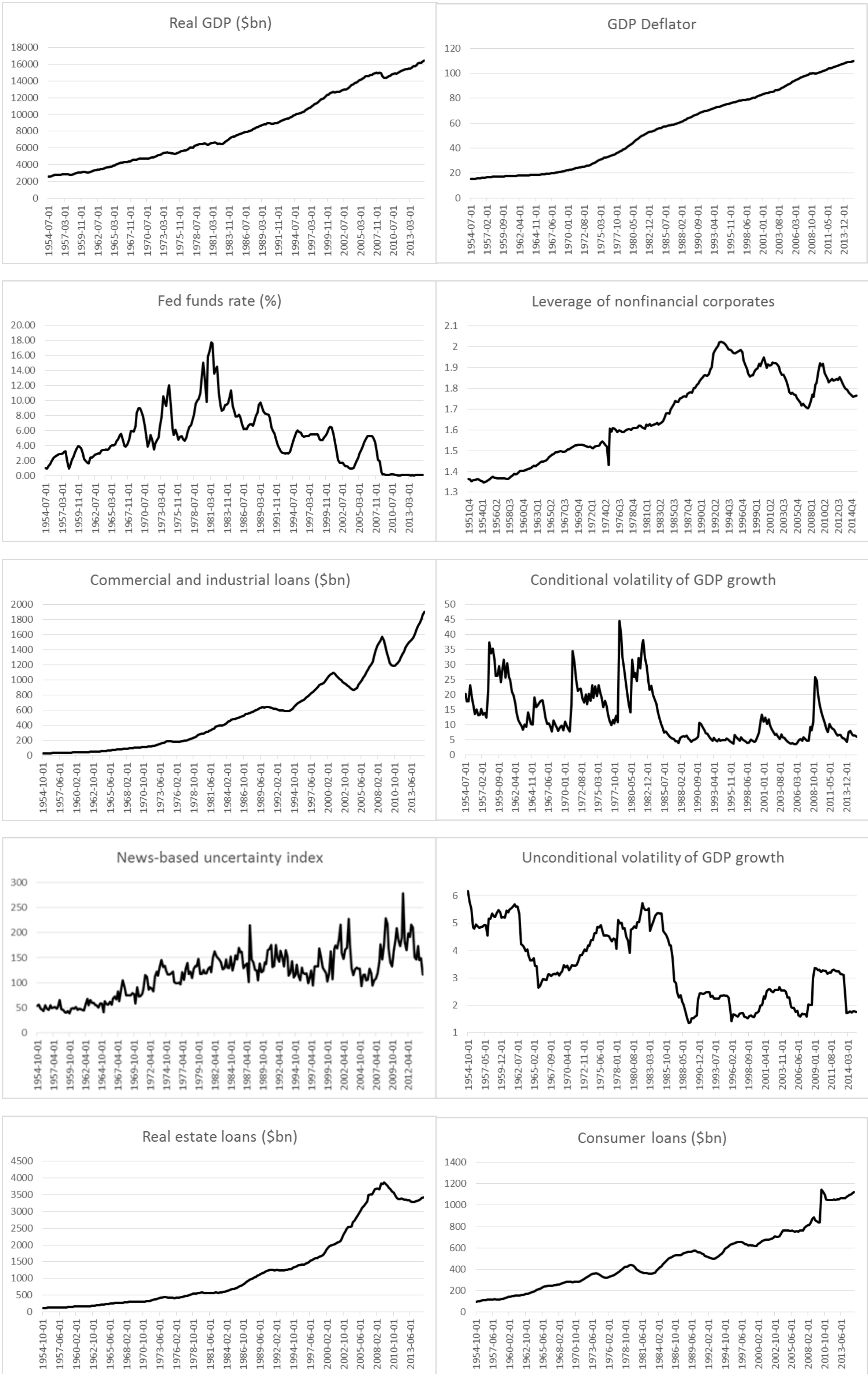
Uncertainty – composite policy uncertainty index

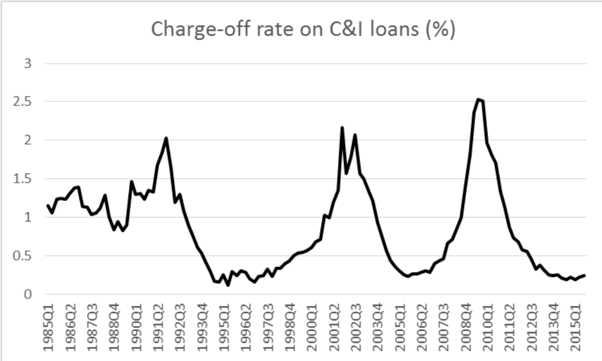
An overall index measuring policy-related economic uncertainty, constructed by the Economic Policy Uncertainty project, Quarterly, Not Seasonally Adjusted. Downloaded from http://www.policyuncertainty.com/.

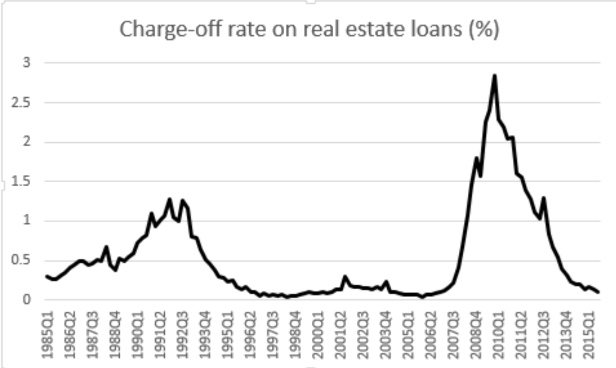
Uncertainty – VXO index, the stock market option-based implied volatility

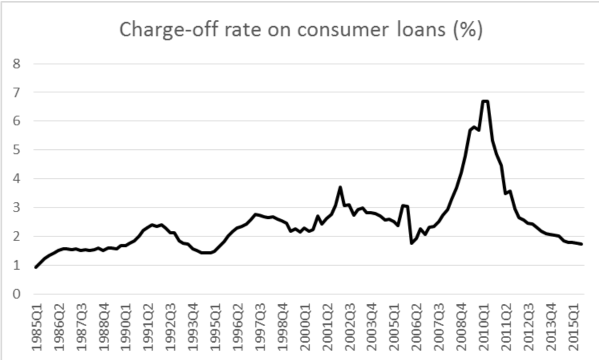
The Chicago Board Options Exchange volatility index VXO, Quarterly (aggregation method - average), Not Seasonally Adjusted, downloaded from Fred II (VIXCLS), see http://research.stlouisfed.org/fred2/. Source: Chicago Board Options Exchange.

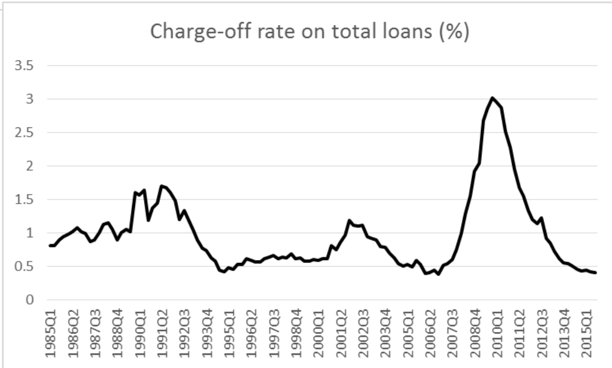
Figure 1. Variables' plots in levels.

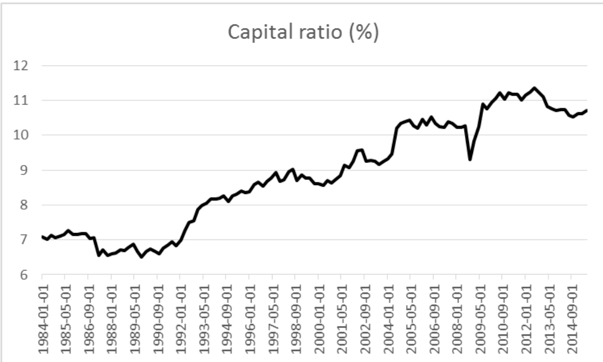


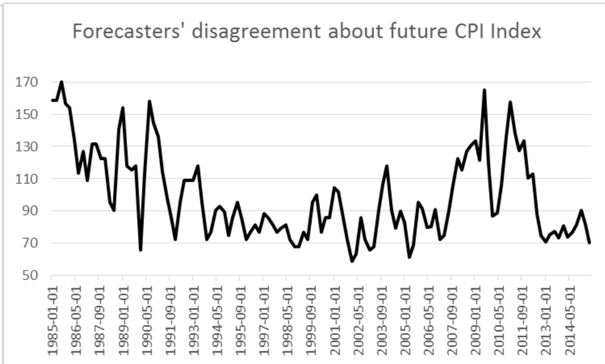

Charge-off rate on C&I loans (%)
0 0.5 1 1.5 2 2.5 3
1985Q1 1986Q2 1987Q3 1988Q4 1990Q1 1991Q2 1992Q3 1993Q4 1995Q1 1996Q2 1997Q3 1998Q4 2000Q1 2001Q2 2002Q3 2003Q4 2005Q1 2006Q2 2007Q3 2008Q4 2010Q1 2011Q2 2012Q3 2013Q4 2015Q1

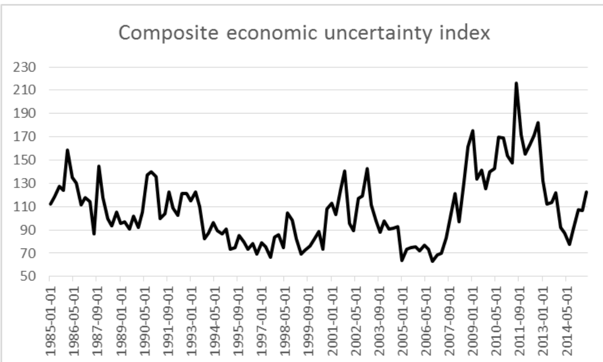

Charge-off rate on real estate loans (%)
0 0.5 1 1.5 2 2.5 3
1985Q1 1986Q2 1987Q3 1988Q4 1990Q1 1991Q2 1992Q3 1993Q4 1995Q1 1996Q2 1997Q3 1998Q4 2000Q1 2001Q2 2002Q3 2003Q4 2005Q1 2006Q2 2007Q3 2008Q4 2010Q1 2011Q2 2012Q3 2013Q4 2015Q1

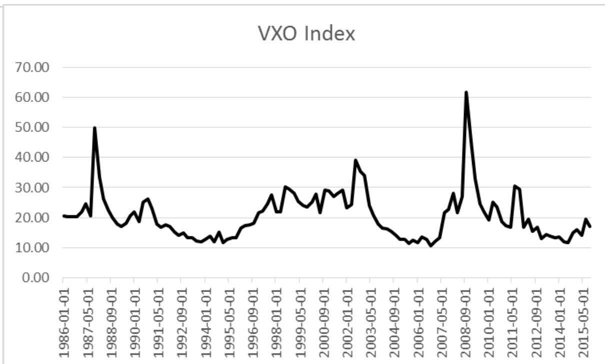

Charge-off rate on consumer loans (%)
0 1 2 3 4 5 6 7 8
1985Q1 1986Q2 1987Q3 1988Q4 1990Q1 1991Q2 1992Q3 1993Q4 1995Q1 1996Q2 1997Q3 1998Q4 2000Q1 2001Q2 2002Q3 2003Q4 2005Q1 2006Q2 2007Q3 2008Q4 2010Q1 2011Q2 2012Q3 2013Q4 2015Q1

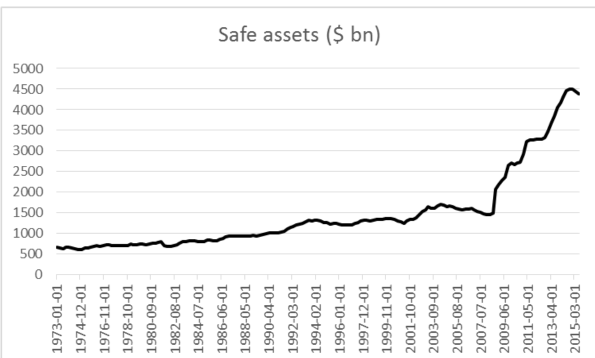

Charge-off rate on total loans (%)
0 0.5 1 1.5 2 2.5 3 3.5
1985Q1 1986Q2 1987Q3 1988Q4 1990Q1 1991Q2 1992Q3 1993Q4 1995Q1 1996Q2 1997Q3 1998Q4 2000Q1 2001Q2 2002Q3 2003Q4 2005Q1 2006Q2 2007Q3 2008Q4 2010Q1 2011Q2 2012Q3 2013Q4 2015Q1


Capital ratio (%)
6 7 8 9 10 11 12
1984-01-01 1985-05-01 1986-09-01 1988-01-01 1989-05-01 1990-09-01 1992-01-01 1993-05-01 1994-09-01 1996-01-01 1997-05-01 1998-09-01 2000-01-01 2001-05-01 2002-09-01 2004-01-01 2005-05-01 2006-09-01 2008-01-01 2009-05-01 2010-09-01 2012-01-01 2013-05-01 2014-09-01


Forecasters' disagreement about future CPI Index
50 70 90 110 130 150 170
1985-01-01 1986-05-01 1987-09-01 1989-01-01 1990-05-01 1991-09-01 1993-01-01 1994-05-01 1995-09-01 1997-01-01 1998-05-01 1999-09-01 2001-01-01 2002-05-01 2003-09-01 2005-01-01 2006-05-01 2007-09-01 2009-01-01 2010-05-01 2011-09-01 2013-01-01 2014-05-01


Composite economic uncertainty index
50 70 90 110 130 150 170 190 210 230
1985-01-01 1986-05-01 1987-09-01 1989-01-01 1990-05-01 1991-09-01 1993-01-01 1994-05-01 1995-09-01 1997-01-01 1998-05-01 1999-09-01 2001-01-01 2002-05-01 2003-09-01 2005-01-01 2006-05-01 2007-09-01 2009-01-01 2010-05-01 2011-09-01 2013-01-01 2014-05-01


VXO Index
0.00 10.00 20.00 30.00 40.00 50.00 60.00 70.00
1986-01-01 1987-05-01 1988-09-01 1990-01-01 1991-05-01 1992-09-01 1994-01-01 1995-05-01 1996-09-01 1998-01-01 1999-05-01 2000-09-01 2002-01-01 2003-05-01 2004-09-01 2006-01-01 2007-05-01 2008-09-01 2010-01-01 2011-05-01 2012-09-01 2014-01-01 2015-05-01


Safe assets ($ bn)
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000
1973-01-01 1974-12-01 1976-11-01 1978-10-01 1980-09-01 1982-08-01 1984-07-01 1986-06-01 1988-05-01 1990-04-01 1992-03-01 1994-02-01 1996-01-01 1997-12-01 1999-11-01 2001-10-01 2003-09-01 2005-08-01 2007-07-01 2009-06-01 2011-05-01 2013-04-01 2015-03-01

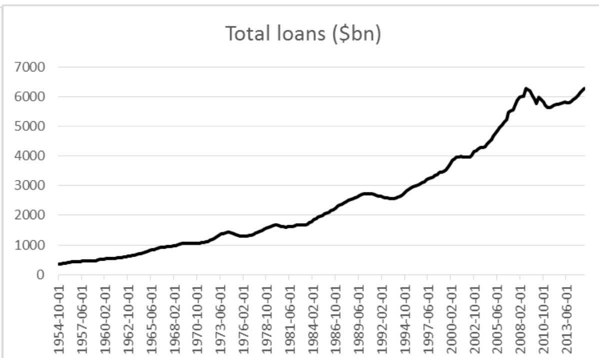

Total loans ($bn)
0 1000 2000 3000 4000 5000 6000 7000
1954-10-01 1957-06-01 1960-02-01 1962-10-01 1965-06-01 1968-02-01 1970-10-01 1973-06-01 1976-02-01 1978-10-01 1981-06-01 1984-02-01 1986-10-01 1989-06-01 1992-02-01 1994-10-01 1997-06-01 2000-02-01 2002-10-01 2005-06-01 2008-02-01 2010-10-01 2013-06-01

Figure 2. Various assets in banks' portfolios, shares of total assets, all commercial banks.

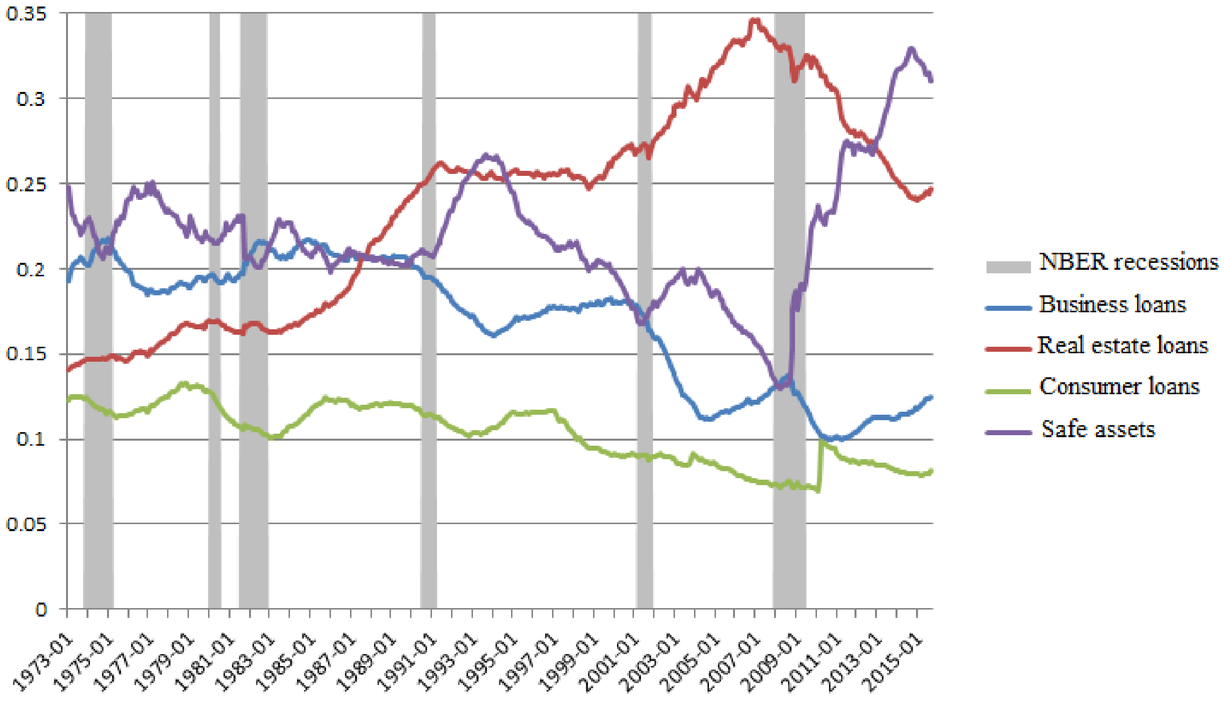


Table 1. Loans and safe assets as shares of total assets in portfolios of commercial banks.

	Data available from	Percentage of total assets
Commercial and industrial loans	1947Q1	10-21%
Real estate loans	1947Q1	14-34%
Consumer loans	1947Q1	7-13%
Safe assets	1973Q1	13-34%
All four asset types		66-79%

Table 2. Variables' correlation structure.

Cross-correlations and lead-lag relationship with	Commercial and industrial loans	Real estate loans	Consumer loans	Safe assets
Real GDP	0.39: 2Q lag	0.26: 1Q lag	0.15: contemp.	-0.22: 3Q lag
GDP deflator	-0.20: 5Q lag	-0.19: 4Q lag	-0.20: 4Q lag	-0.19: 2Q lead
Federal funds rate	0.29: 1Q lead	0.22: 2Q lead	-0.16: 5Q lag	-0.19: 3Q lag
Leverage of corporates	-0.20: 5Q lag	N/S	N/S	N/S
Charge-off rate	-0.71: 1Q lag	-0.62: 4Q lag	0.25: contemp.	0.37: 2Q lead
Capital ratio	-0.35: contemp.	-0.31: contemp.	-0.42: 6Q lag	-0.38: contemp.
Uncertainty: conditional volatility of GDP growth	N/S	N/S	N/S	N/S
Uncertainty: unconditional volatility of GDP growth	-0.25: 5Q lag	-0.17: 1Q lag	N/S	0.28: contemp.
Uncertainty: news-based index	-0.45: 2Q lag	-0.35: 2Q lag	N/S	0.28: contemp.
Uncertainty: forecasters' disagreement	-0.22: 3Q lag	N/S	N/S	N/S
Uncertainty: composite policy uncertainty index (level)	-0.41: 2Q lags	-0.39: 2Q lag	N/S	0.29: 1Q lead
Uncertainty: VXO index	-0.58: 4Q lag	N/S	N/S	0.34: contemp.

Note. The variables' growth rates[32] are analyzed. Lag and lead qualifications are given for the variables in columns (classes of assets) with respect to variables in rows (for example, real GDP); 2Q lag for commercial and industrial loans with real GDP means GDP values lead loan volumes by 2 quarters. N/S stands for statistically non-significant result. Contemp. stand for contemporaneous relationship.

[32] Uncertainty measures, charge-off rates, reported changes in lending standards, in demand for loans and in banks' tolerance of risk are in taken levels. Quarterly data is used.

Table 3. Pairwise Granger causality tests.

Variables and the direction of Granger causation	F-statistic	Prob.
GDP → C&I loans	9.08832	0.0002
C&I loans → GDP	0.75140	0.4727
GDP deflator → C&I loans	3.14953	0.0447
C&I loans → GDP deflator	4.11949	0.0174
Federal funds rate → C&I loans	1.17991	0.3091
C&I loans → Federal funds rate	7.58342	0.0006
Corporate leverage → C&I loans	2.74632	0.0661
C&I loans → Corporate leverage	2.42014	0.0910
Charge-off rate → C&I loans	9.36715	0.0002
C&I loans → Charge-off rate	3.19219	0.0447
Capital ratio → C&I loans	8.59464	0.0003
C&I loans → Capital ratio	3.86757	0.0236
Conditional volatility of GDP growth → C&I loans	0.50366	0.6049
C&I loans → Conditional volatility of GDP growth	3.80796	0.0234
Unconditional volatility of GDP growth → C&I loans	7.46891	0.0007
C&I loans → Unconditional volatility of GDP growth	0.74585	0.4754
VIX index → C&I loans	8.38036	0.0004
C&I loans → VIX index	2.03600	0.1361
News-based uncertainty index → C&I loans	3.72973	0.0254
C&I loans → News-based uncertainty index	12.6213	6.E-06
Forecasters' disagreement about future CPI → C&I loans	1.21896	0.2993
C&I loans → Forecasters' disagreement about future CPI	0.21120	0.8099
Composite economic uncertainty index → C&I loans	2.20456	0.1149
C&I loans → Composite economic uncertainty index	1.41788	0.2464

Notes. The pairwise Granger causality tests are run between the volume of commercial and industrial loans and one of other variables. Those variables, which are found to Granger cause one other, are shown in bold. The null is that one variable does not Granger-cause another variable, 95% significance level is used. The tests are run using 2 lags[33] (quarters) of both variables.

Table 4. Conditional heteroskedasticity of GDP growth.

GARCH (1,1) estimates of parameters values.

Variable	Coefficient	Std.Error	z-statistic	p-value
c	2.11	0.28	7.66	0.00
θ	0.37	0.07	5.42	0.00
ω	0.48	0.29	1.68	0.09
α	0.18	0.04	4.07	0.00
β	0.80	0.04	19.37	0.00

[33] Two lags of the Granger causality tests correspond to the number of lags used in the vector autoregression models, where they are selected using relevant information criteria. It is therefore assumed that the longest time over which one of the variables could help predict another is 2 quarters.

Appendix B

Structural break tests - Chow tests[34]

For the fixed break date that may have occurred in period T_B the model is estimated from the full sample of T observations and from the first T_1 and the last T_2 observations, where $T_1 < T_B$ and $T_2 \leq T - T_B$. The resulting residuals are denoted by $\widehat{u_t}$, $\widehat{u_t^1}$ and $\widehat{u_t^2}$, respectively. The following covariance matrices are calculated: $\widehat{\Sigma_{1,2}} = T_1^{-1}\Sigma_{t=1}^{T_1}\widehat{u_t}\widehat{u_t}' + T_2^{-1}\Sigma_{t=T-T_2+1}^{T}\widehat{u_t}\widehat{u_t}'$, $\widehat{\Sigma_1} = T_1^{-1}\Sigma_{t=1}^{T_1}\widehat{u_t^1}\widehat{u_t^1}'$ and $\widehat{\Sigma_2} = T_2^{-1}\Sigma_{t=T-T_2+1}^{T}\widehat{u_t^2}\widehat{u_t^2}'$. Using this notation, the break-point Chow test statistics is calculated as:

$$\lambda_{BP} = (T_1 + T_2)\log\left|\widehat{\Sigma_{1,2}}\right| - T_1\log\left|\widehat{\Sigma_1}\right| - T_2\log\left|\widehat{\Sigma_2}\right| \sim\chi^2(k),$$

where k the number of restrictions imposed by assuming a constant coefficient model for the full sample period, that is, k is the difference between the sum of the number of coefficients estimated in the first and last subperiods and the number of coefficients in the full sample model. The null hypothesis of the model's parameters constancy is rejected if the value of the test statistic λ_{SS} is large.

The sample-split Chow test statistics is obtained under the assumption that the residual covariance matrix is constant. This statistics also checks the null hypothesis against the alternative that the coefficients of the VAR models may vary and is calculated as:

$$\lambda_{SS} = (T_1 + T_2)[\log\left|\widehat{\Sigma_{1,2}}\right| - \left|T^{-1}\left(T_1\widehat{\Sigma_1} + T_2\widehat{\Sigma_2}\right)\right|]\sim\chi^2(k)$$

The Chow forecast (CF) test tests the null against the alternative that all the coefficients including the residual variance-covariance matrix may vary. It rejects the null hypothesis of constant parameters for the large values of test statistic. The CF statistic is calculated as:

$$\lambda_{CF} = \frac{1-\left(1-R_r^2\right)^{\frac{1}{s}}}{\left(1-R_r^2\right)^{\frac{1}{s}}} * \frac{Ns-q}{nk} \sim F(nk, Ns-q),$$

where n is a number of time series considered, $s = \left(\frac{n^2k^2-4}{n^2+k^2-5}\right)^{\frac{1}{2}}$, $q = \frac{nk}{2} + 1$,

$$N = T - \nu - k - (n-k+1)/2,\ R_r^2 = 1 - \left(\frac{t}{T}\right)^n \left|\widehat{\Sigma_1}\right|\left(\left|\widehat{\Sigma_{1,2}}\right|\right)^{-1}.$$

When the break date is treated as unknown, Chow tests are performed repeatedly for a range of potential break dates T_B, as suggested by Canova (2007) and Lutkepohl (2001). The value of split-sample test statistic is maximized over the interval $[t_1, t_2]$, where the break is suspected to have happened: $\sup_{T_B \in T} T \subset [t_1, t_2]$ [35].

[34] We rely on approach set forth in Canova (2007), Lutkepohl (2001) and Doornik and Hendry (1997) in running structural break tests.

[35] The asymptotic distribution of the sup test statistic is not χ^2, but of a different type (see Andrews (1993), Andrews and Ploberger (1994) and Andrews (2003).

Appendix C

Figure 1. Responses of commercial and industrial loans to shocks in the benchmark model; 1954Q4-1979Q4.

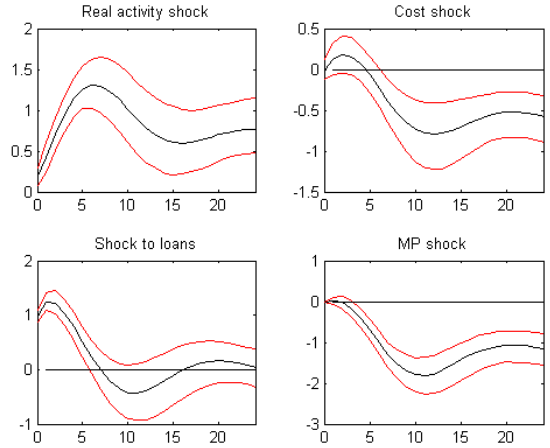


Figure 2.Responses of commercial and industrial loans to shocks in the benchmark model; 1983Q1-2007Q4.

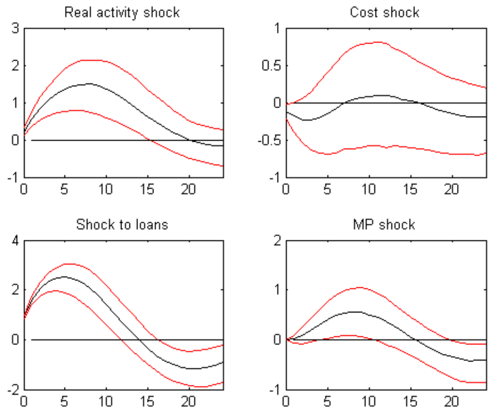
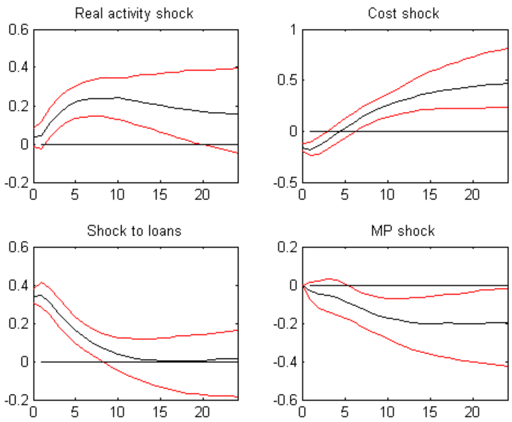


Figure 3.Responses of commercial and industrial loans to shocks in the benchmark model; 2010M4-2015M12.



Note. The impulse responses are based on the benchmark specification: the federal funds rate is a monetary policy measure, X_{2t} is empty (all the variables are in X_{1t}). 90% bias-corrected bootstrap confidence bands are calculated as in Kilian (1998).

Figure 4.Responses of real estate loans to shocks in the benchmark model; 1954Q1-1979Q4.

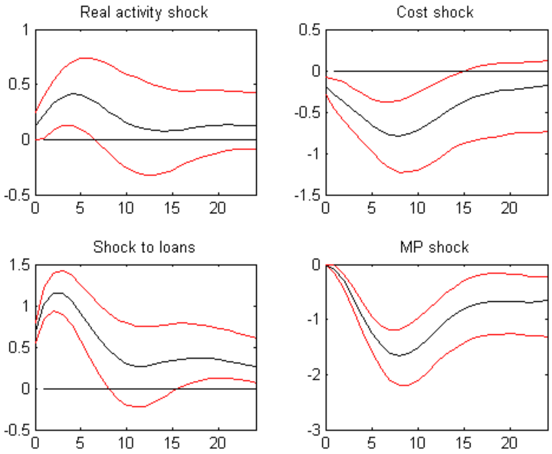


Figure 5.Responses of real estate loans to shocks in the benchmark model; 1983Q1-2007Q4.

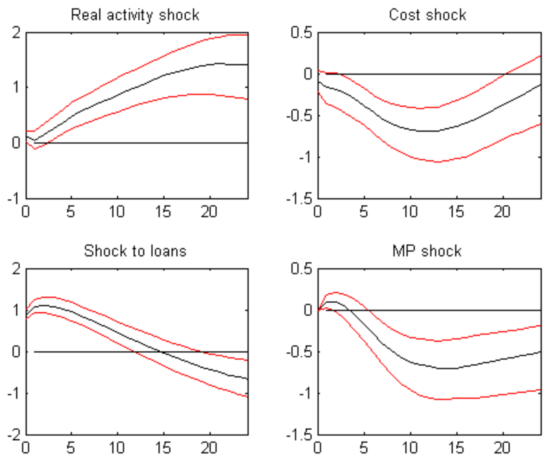
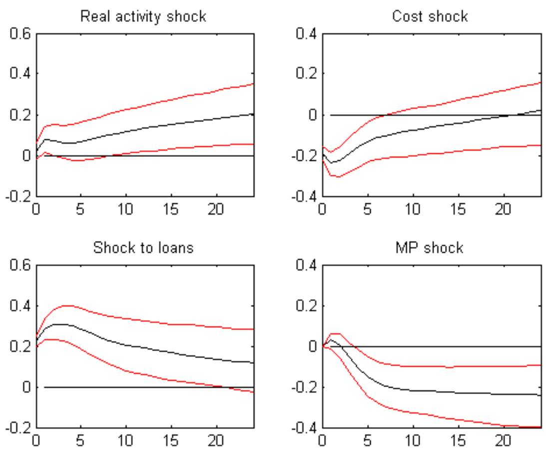


Figure 6.Responses of real estate loans to shocks in the benchmark model; 2010M4-2015M12.



Note. The impulse responses are based on the benchmark specification: the federal funds rate is a monetary policy measure, X_{2t} is empty (all the variables are in X_{1t}). 90% bias-corrected bootstrap confidence bands are calculated as in Kilian (1998).

Figure 7.Responses of consumer loans toshocks in the benchmark model; 1954Q1-1979Q4.

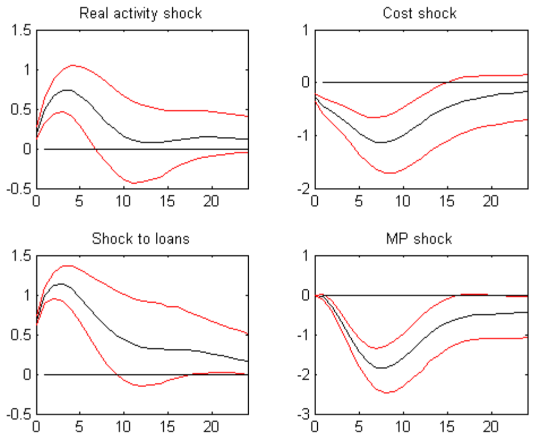


Figure 8.Responses of consumer loans to shocks in the benchmark model; 1983Q1-2007Q4.

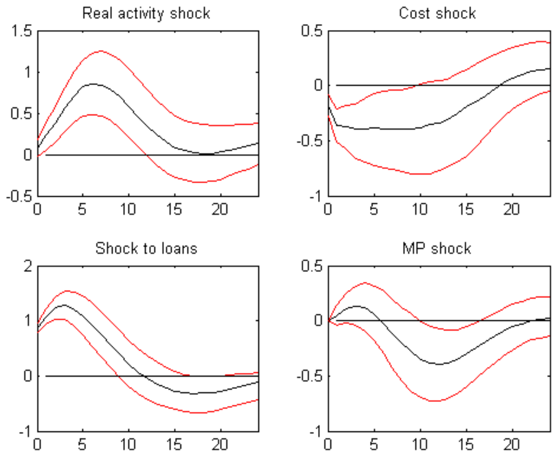
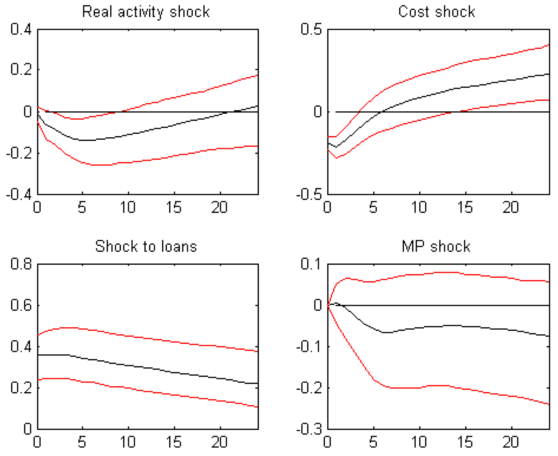


Figure 9.Responses of consumer loans to shocks in the benchmark model; 2010M4-2015M12.



Note. The impulse responses are based on the benchmark specification: the federal funds rate is a monetary policy measure, X_{2t} is empty (all the variables are in X_{1t}). 90% bias-corrected bootstrap confidence bands are calculated as in Kilian (1998).

Figure 10.Responses of total loans to shocks in the benchmark model; 1954Q4-1979Q4.

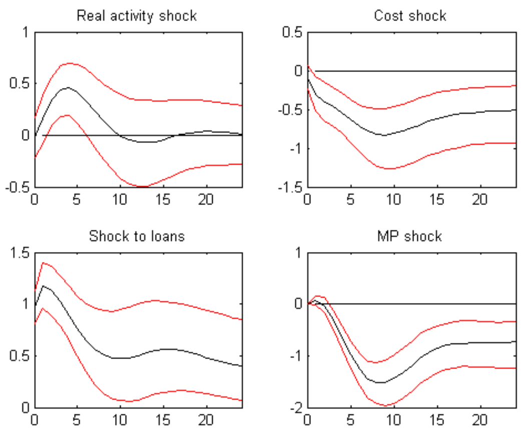


Figure 11.Responses of total loans to shocks in the benchmark model; 1983Q1-2007Q4.

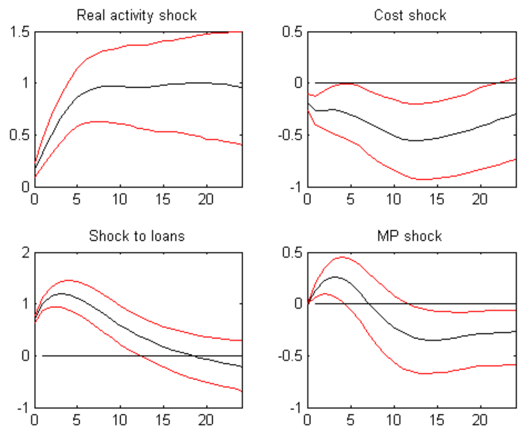
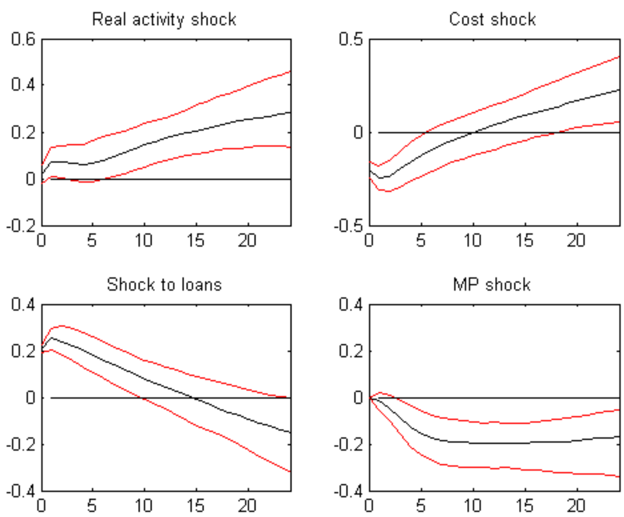


Figure 12.Responses of total loans to shocks in the benchmark model; 2010M4-2015M12.



Note. The impulse responses are based on the benchmark specification: the federal funds rate is a monetary policy measure, X_{2t} is empty (all the variables are in X_{1t}). 90% bias-corrected bootstrap confidence bands are calculated as in Kilian (1998).

Figure 13.Responses of Treasury and agency securities in banks' assets to shocks in the benchmark model; 1954Q4-1979Q4.

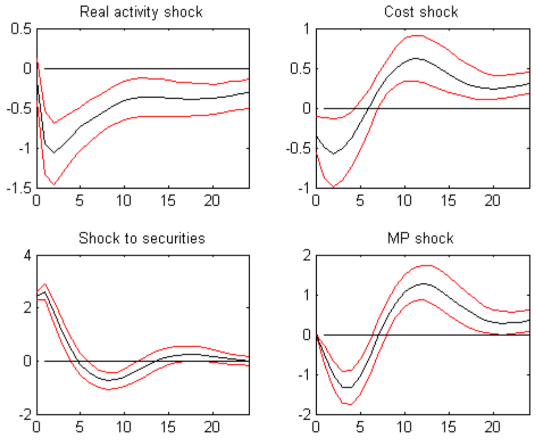


Figure 14.Responses of Treasury and agency securities in banks' assets to shocks in the benchmark model; 1983Q1-2007Q4.

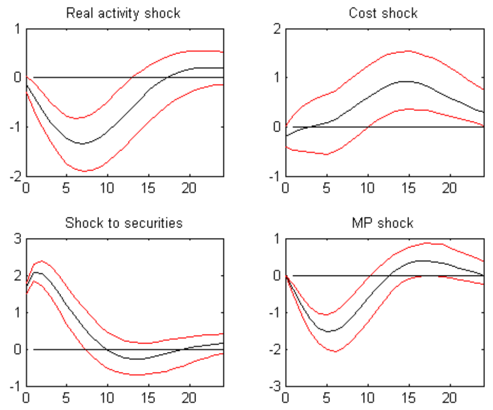
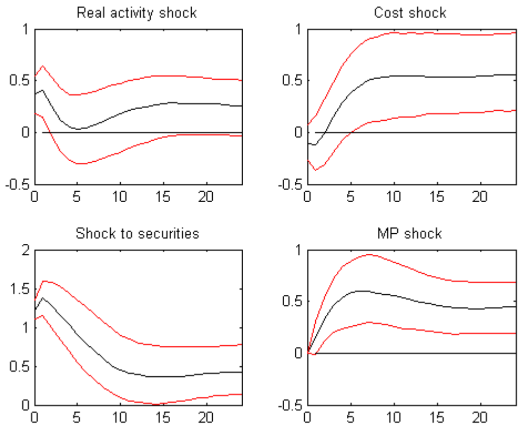
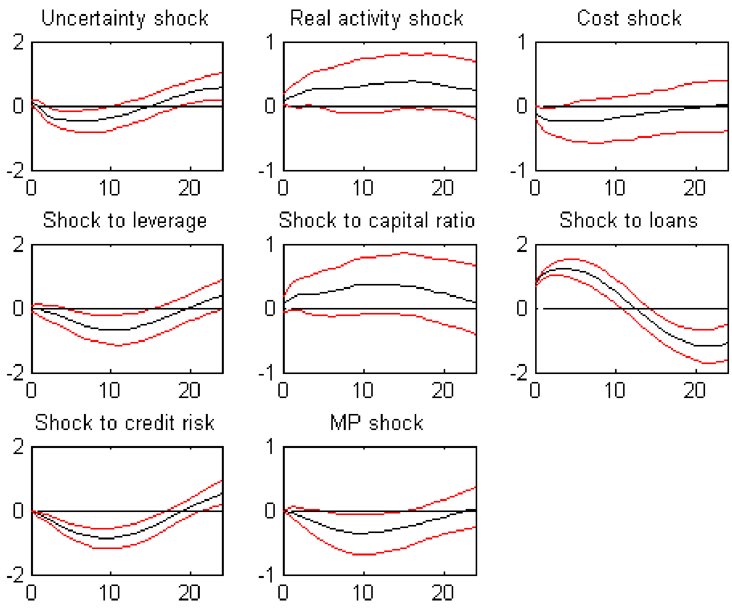


Figure 15.Responses of Treasury and agency securities in banks' assets to shocks in the benchmark model; 2010M4-2015M12



Note. The impulse responses are based on the benchmark specification: the federal funds rate is a monetary policy measure, X_{2t} is empty (all the variables are in X_{1t}). 90% bias-corrected bootstrap confidence bands are calculated as in Kilian (1998).

Figure 16A. Responses of commercial and industrial loans to shocks in extended model, 1985Q1-2007Q4.



Note. The impulse responses are based on the benchmark specification: the federal funds rate is a monetary policy measure, X_{2t} is empty (all the variables are in X_{1t}). 90% bias-corrected bootstrap confidence bands are calculated as in Kilian (1998). According to AIC, the VAR order includes two lags.

Figure 16B. Responses to monetary policy shock (monetary contraction) in extended model with commercial and industrial loans, 1985Q1-2007Q4.

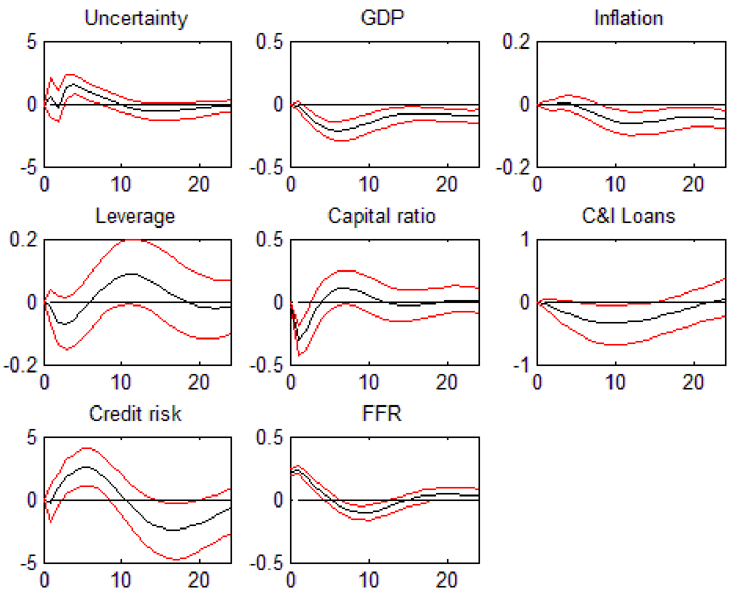


Figure 16C. Responses to uncertainty shock in extended model with commercial and industrial loans, 1985Q1-2007Q4.

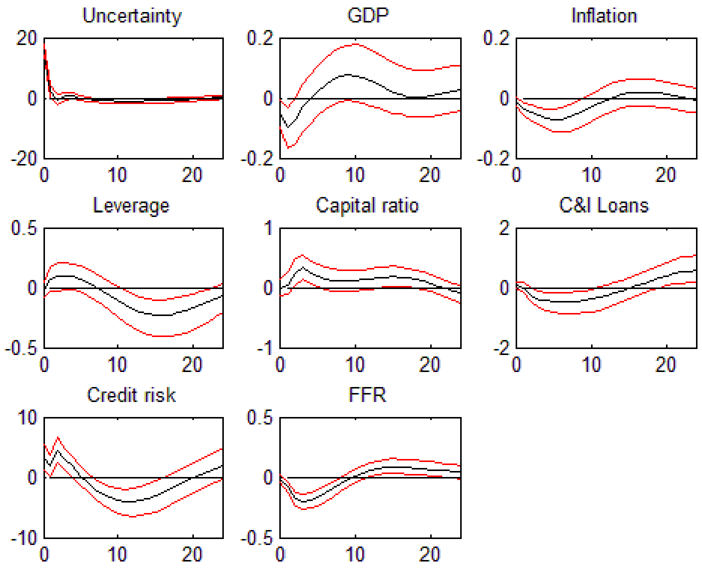


Figure 16D. Responses to uncertainty shock in extended model with commercial and industrial loans, 1985Q1-2007Q4. Alternative uncertainty measure – conditional heteroskedasticity of GDP growth.

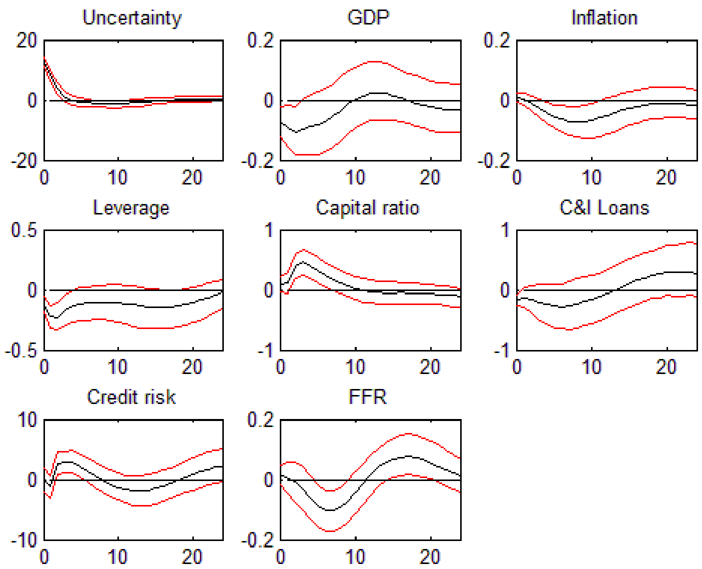
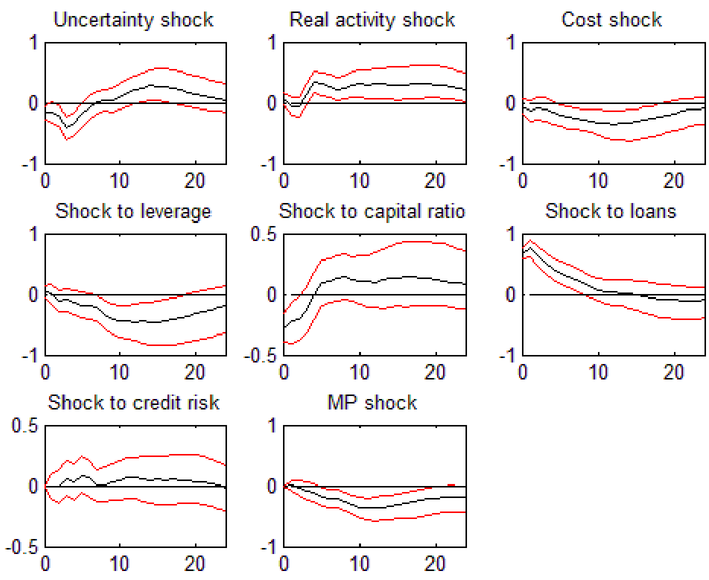


Table 1. Forecast error variance decomposition of commercial and industrial loans in the extended model, 1985Q1-2007Q4.

p/v	Unc	GDP	Infl	Levera	Cap ra	C&I lo	Ch off	FFR
1	0.00	0.01	0.02	0.00	0.01	0.95	0.00	0.00
2	0.00	0.01	0.03	0.00	0.02	0.92	0.01	0.00
3	0.01	0.02	0.03	0.00	0.03	0.89	0.02	0.00
4	0.03	0.02	0.03	0.00	0.03	0.84	0.03	0.01
5	0.04	0.03	0.04	0.01	0.02	0.80	0.05	0.01
6	0.05	0.03	0.04	0.01	0.02	0.76	0.08	0.02
7	0.05	0.03	0.04	0.02	0.02	0.72	0.10	0.02
8	0.06	0.03	0.04	0.03	0.02	0.67	0.12	0.03
9	0.06	0.03	0.04	0.04	0.02	0.63	0.15	0.04
10	0.06	0.03	0.04	0.05	0.02	0.59	0.17	0.04
11	0.06	0.04	0.04	0.06	0.02	0.55	0.19	0.05
12	0.06	0.04	0.04	0.07	0.02	0.51	0.21	0.06
13	0.06	0.04	0.04	0.08	0.03	0.48	0.22	0.06
14	0.05	0.04	0.04	0.09	0.03	0.45	0.23	0.07
15	0.05	0.04	0.04	0.10	0.03	0.43	0.24	0.07
16	0.05	0.05	0.04	0.11	0.03	0.42	0.24	0.08
17	0.05	0.05	0.04	0.11	0.03	0.41	0.24	0.08
18	0.05	0.05	0.04	0.11	0.03	0.41	0.23	0.08
19	0.05	0.05	0.03	0.11	0.04	0.42	0.22	0.08
20	0.05	0.05	0.03	0.11	0.04	0.43	0.21	0.08
21	0.05	0.05	0.03	0.10	0.04	0.45	0.20	0.07
22	0.06	0.05	0.03	0.10	0.04	0.47	0.19	0.07
23	0.07	0.05	0.03	0.09	0.04	0.48	0.18	0.06
24	0.07	0.05	0.03	0.09	0.04	0.50	0.17	0.06

Figure 17A. Responses of real estate loans to shocks in extended model, 1985Q1-2007Q4.



Note. The impulse responses are based on the benchmark specification: the federal funds rate is a monetary policy measure, X_{2t} is empty (all the variables are in X_{1t}). 90% bias-corrected bootstrap confidence bands are calculated as in Kilian (1998). According to AIC, the VAR order includes four lags.

Figure 17B. Responses to monetary policy shock (monetary contraction) in extended model with real estate loans, 1985Q1-2007Q4.

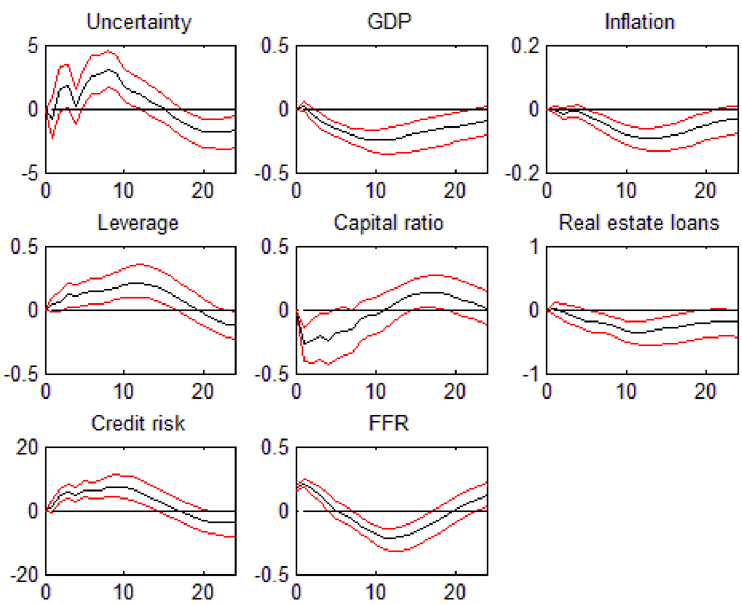
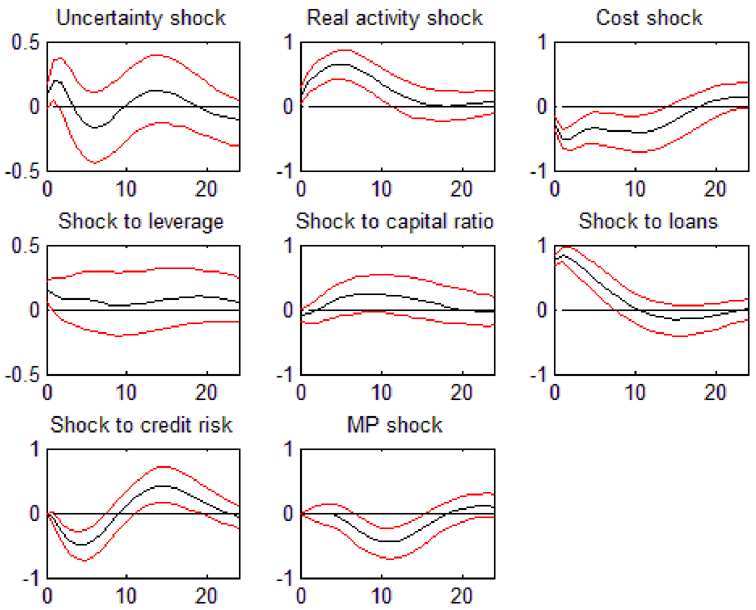


Table 2. Forecast error variance decomposition of real estate loans in the extended model, 1985Q1-2007Q4.

p/v	Unc	GDP	Infl	Levera	Cap ra	Real e	Ch off	FFR
1	0.05	0.01	0.01	0.00	0.14	0.80	0.00	0.00
2	0.04	0.01	0.01	0.00	0.11	0.82	0.00	0.00
3	0.05	0.01	0.02	0.00	0.11	0.81	0.00	0.00
4	0.10	0.01	0.02	0.00	0.10	0.76	0.00	0.00
5	0.12	0.03	0.03	0.00	0.09	0.72	0.00	0.00
6	0.12	0.05	0.04	0.01	0.08	0.69	0.00	0.01
7	0.11	0.06	0.06	0.01	0.07	0.66	0.00	0.02
8	0.10	0.07	0.08	0.02	0.06	0.63	0.00	0.03
9	0.09	0.08	0.10	0.04	0.06	0.59	0.00	0.04
10	0.08	0.09	0.12	0.06	0.06	0.53	0.00	0.06
11	0.07	0.09	0.14	0.09	0.05	0.47	0.00	0.08
12	0.07	0.10	0.15	0.12	0.05	0.41	0.00	0.10
13	0.07	0.10	0.17	0.14	0.05	0.36	0.00	0.12
14	0.06	0.10	0.18	0.17	0.05	0.31	0.00	0.13
15	0.07	0.10	0.19	0.19	0.05	0.27	0.00	0.14
16	0.07	0.09	0.20	0.21	0.05	0.24	0.00	0.14
17	0.07	0.09	0.20	0.22	0.05	0.21	0.00	0.15
18	0.07	0.09	0.20	0.24	0.05	0.19	0.00	0.15
19	0.07	0.09	0.20	0.25	0.06	0.17	0.00	0.15
20	0.07	0.09	0.20	0.26	0.06	0.16	0.00	0.15
21	0.07	0.09	0.20	0.27	0.06	0.15	0.00	0.15
22	0.07	0.10	0.20	0.28	0.06	0.14	0.00	0.15
23	0.06	0.10	0.20	0.29	0.07	0.14	0.00	0.15
24	0.06	0.10	0.19	0.29	0.07	0.13	0.00	0.15

Figure 18A. Responses of consumer loans to shocks in extended model, 1985Q1-2007Q4.



Note. The impulse responses are based on the benchmark specification: the federal funds rate is a monetary policy measure, X_{2t} is empty (all the variables are in X_{1t}). 90% bias-corrected bootstrap confidence bands are calculated as in Kilian (1998). According to AIC, the VAR order includes two lags.

Figure 18B. Responses to monetary policy shock (monetary contraction) in extended model with consumer loans, 1985Q1-2007Q4.

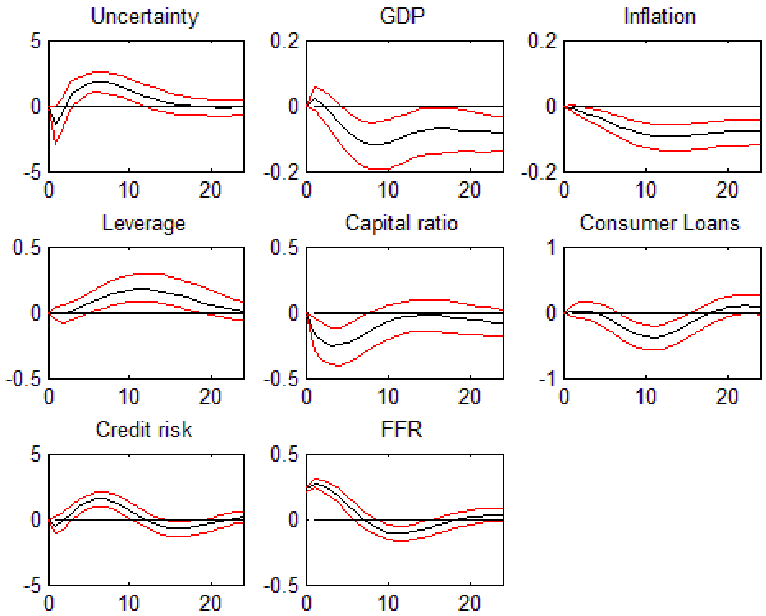
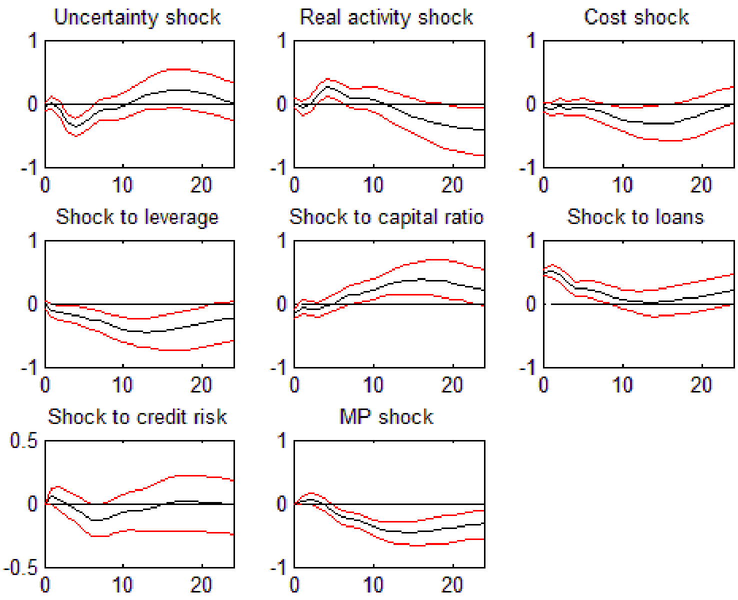


Table 3. Forecast error variance decomposition of consumer loans in the extended model, 1985Q1-2007Q4.

p/v	Unc	GDP	Infl	Levera	Cap ra	Cons l	Ch off	FFR
1	0.00	0.03	0.09	0.01	0.01	0.87	0.00	0.00
2	0.00	0.07	0.14	0.00	0.00	0.78	0.01	0.00
3	0.00	0.09	0.15	0.00	0.00	0.71	0.04	0.00
4	0.00	0.11	0.15	0.00	0.00	0.65	0.08	0.00
5	0.00	0.13	0.14	0.00	0.00	0.60	0.11	0.00
6	0.00	0.15	0.14	0.00	0.00	0.56	0.14	0.00
7	0.01	0.17	0.14	0.00	0.01	0.52	0.15	0.01
8	0.01	0.19	0.14	0.00	0.01	0.48	0.16	0.02
9	0.01	0.20	0.14	0.00	0.02	0.45	0.16	0.03
10	0.01	0.21	0.14	0.00	0.03	0.43	0.15	0.04
11	0.01	0.21	0.14	0.00	0.04	0.41	0.14	0.05
12	0.01	0.21	0.14	0.00	0.05	0.39	0.13	0.07
13	0.02	0.20	0.14	0.01	0.06	0.37	0.13	0.08
14	0.04	0.19	0.14	0.01	0.07	0.35	0.12	0.09
15	0.05	0.18	0.14	0.01	0.07	0.33	0.12	0.09
16	0.07	0.17	0.13	0.02	0.08	0.32	0.12	0.10
17	0.08	0.16	0.13	0.02	0.08	0.30	0.12	0.10
18	0.09	0.16	0.13	0.02	0.09	0.29	0.13	0.10
19	0.10	0.15	0.12	0.02	0.09	0.29	0.13	0.09
20	0.10	0.15	0.12	0.02	0.09	0.28	0.13	0.09
21	0.11	0.15	0.12	0.03	0.09	0.28	0.14	0.09
22	0.11	0.15	0.12	0.03	0.09	0.27	0.14	0.09
23	0.11	0.15	0.12	0.03	0.09	0.27	0.14	0.09
24	0.11	0.15	0.12	0.03	0.09	0.27	0.15	0.09

Figure 19A. Responses of total loans to shocks in extended model, 1985Q1-2007Q4.



Note. The impulse responses are based on the benchmark specification: the federal funds rate is a monetary policy measure, X_{2t} is empty (all the variables are in X_{1t}). 90% bias-corrected bootstrap confidence bands are calculated as in Kilian (1998). According to AIC, the VAR order includes four lags.

Figure 19B. Responses to monetary policy shock (monetary contraction) in extended model with total loans, 1985Q1-2007Q4.

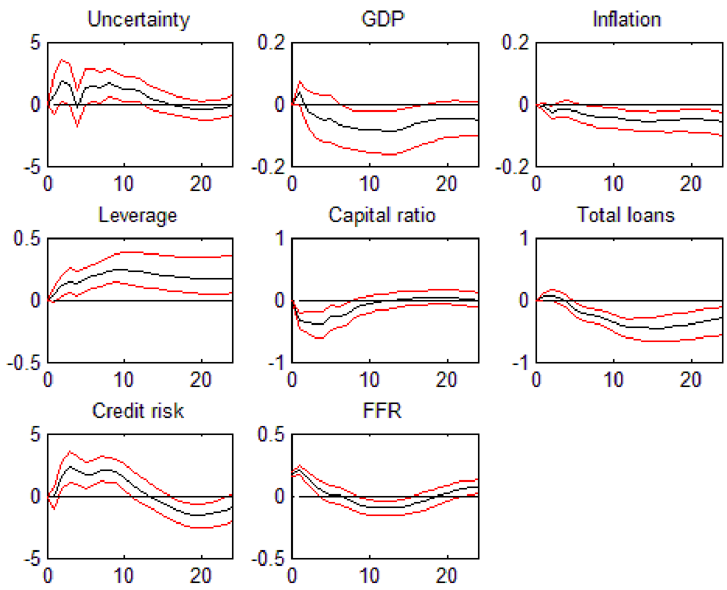
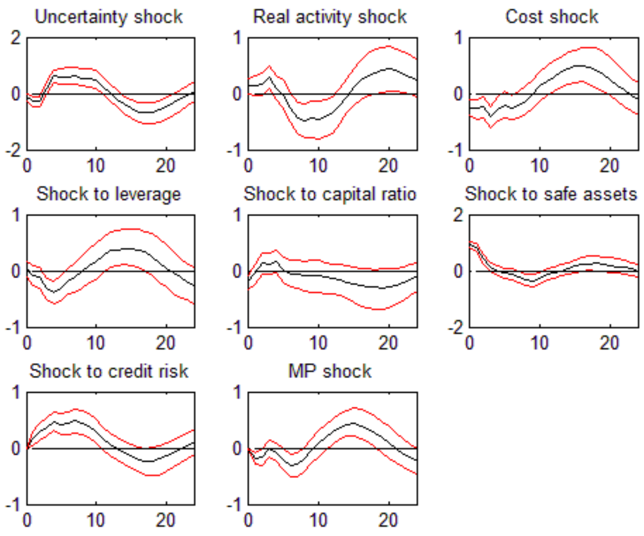


Table 4. Forecast error variance decomposition of total loans in the extended model, 1985Q1-2007Q4.

p/v	Unc	GDP	Infl	Levera	Cap ra	Total	Ch off	FFR
1	0.01	0.00	0.01	0.00	0.09	0.89	0.00	0.00
2	0.00	0.01	0.02	0.02	0.05	0.89	0.00	0.00
3	0.01	0.01	0.01	0.03	0.04	0.88	0.00	0.01
4	0.07	0.02	0.01	0.04	0.04	0.80	0.00	0.01
5	0.15	0.05	0.01	0.05	0.04	0.69	0.00	0.01
6	0.20	0.07	0.01	0.07	0.03	0.61	0.01	0.02
7	0.21	0.07	0.01	0.09	0.03	0.55	0.01	0.03
8	0.21	0.07	0.01	0.11	0.03	0.51	0.02	0.05
9	0.19	0.07	0.02	0.14	0.03	0.47	0.02	0.07
10	0.17	0.06	0.03	0.18	0.04	0.41	0.02	0.09
11	0.15	0.05	0.04	0.21	0.05	0.35	0.02	0.12
12	0.13	0.04	0.05	0.24	0.07	0.30	0.01	0.15
13	0.11	0.04	0.07	0.26	0.09	0.25	0.01	0.18
14	0.09	0.03	0.08	0.28	0.11	0.21	0.01	0.19
15	0.08	0.03	0.08	0.29	0.13	0.17	0.01	0.21
16	0.08	0.03	0.09	0.29	0.14	0.15	0.01	0.21
17	0.07	0.03	0.09	0.29	0.16	0.13	0.01	0.22
18	0.07	0.04	0.10	0.29	0.17	0.11	0.01	0.22
19	0.07	0.04	0.10	0.28	0.18	0.10	0.00	0.22
20	0.07	0.05	0.10	0.28	0.19	0.09	0.00	0.22
21	0.07	0.06	0.10	0.27	0.20	0.08	0.00	0.22
22	0.07	0.07	0.10	0.27	0.20	0.07	0.00	0.22
23	0.07	0.07	0.10	0.26	0.21	0.06	0.00	0.22
24	0.07	0.08	0.09	0.26	0.21	0.06	0.00	0.22

Figure 20. Responses of safe assets to shocks in extended model, 1985Q1-2007Q4.



Note. The impulse responses are based on the benchmark specification: the federal funds rate is a monetary policy measure, X_{2t} is empty (all the variables are in X_{1t}). 90% bias-corrected bootstrap confidence bands are calculated as in Kilian (1998). According to AIC, the VAR order includes four lags.

Table 5. Forecast error variance decomposition of safe assets in the extended model, 1985Q1-2007Q4.

p/v	Unc	GDP	Infl	Levera	Cap ra	Safe a	Ch off	FFR
1	0.02	0.02	0.06	0.00	0.04	0.86	0.00	0.00
2	0.05	0.02	0.07	0.00	0.02	0.80	0.01	0.02
3	0.08	0.03	0.09	0.01	0.02	0.70	0.04	0.02
4	0.07	0.06	0.13	0.04	0.02	0.57	0.09	0.02
5	0.11	0.05	0.13	0.08	0.03	0.44	0.14	0.02
6	0.16	0.04	0.12	0.10	0.02	0.36	0.16	0.02
7	0.21	0.04	0.11	0.10	0.02	0.30	0.18	0.04
8	0.24	0.05	0.10	0.09	0.01	0.25	0.20	0.05
9	0.25	0.08	0.09	0.08	0.01	0.23	0.20	0.06
10	0.27	0.10	0.08	0.07	0.01	0.22	0.20	0.05
11	0.27	0.12	0.07	0.06	0.01	0.21	0.20	0.05
12	0.27	0.14	0.07	0.06	0.01	0.20	0.19	0.05
13	0.27	0.16	0.07	0.06	0.01	0.20	0.18	0.05
14	0.26	0.17	0.08	0.07	0.01	0.19	0.18	0.05
15	0.25	0.16	0.09	0.07	0.02	0.18	0.17	0.06
16	0.25	0.15	0.10	0.08	0.02	0.17	0.16	0.07
17	0.25	0.14	0.11	0.09	0.02	0.16	0.15	0.08
18	0.26	0.13	0.12	0.09	0.03	0.15	0.14	0.08
19	0.27	0.13	0.12	0.09	0.03	0.14	0.13	0.09
20	0.28	0.13	0.12	0.09	0.03	0.14	0.13	0.09
21	0.28	0.13	0.12	0.09	0.04	0.13	0.12	0.08
22	0.29	0.14	0.12	0.08	0.04	0.13	0.12	0.08
23	0.29	0.14	0.12	0.08	0.05	0.13	0.12	0.08
24	0.28	0.15	0.12	0.08	0.05	0.13	0.11	0.08