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Abstract

This paper shows that economic uncertainty proxied by the variance risk premium (VRP) has an important explanatory power for bank credit supply and bank loan demand in the presence of market and economic control variables established in the existing literature. Economic uncertainty associated with higher VRP exerts a negative influence on both loan demand and supply, increases loan spreads, reduces the average loan size and maturity, and increases the proportion of collateralized loan. These effects are particularly substantive in the syndicated loan market and much worse off during economic recessions. We employ two identification strategies: firstly, a structural vector autoregression with sign restrictions; and secondly, the loan-to-bond substitution measure, to isolate the effect of market uncertainty on bank credit supply from loan demand. We find that VRP effectively dominates credit supply and suggest that bank credit shortage during recessions can potentially aggravate economic downturn.

JEL classifications: E44, E51, G01, G21

Keywords: credit standards; bank lending; economic uncertainty; variance risk premium

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1. Introduction

Economic uncertainty is time-varying and can deeply influence financial decisions (Jurado, Ludvigson, and Ng 2015). Uncertainty measures which partly reflect market participants' risk aversion surged during the Global Financial Crisis of 2008-2009 and they remained elevated during most of the recovery period.[1] The variance risk premium (VRP) is a new measure of uncertainty and it has attracted a great deal of attention amongst academic researchers. It is obtained by decomposing the CBOE VIX into stock market volatility (the "physical" expected volatility) and a variance risk premium, which is the premium investors pay to hedge uncertainty in the volatility. This paper studies the effect of VRP on bank lending. To what extent does the variance risk premium predict and influence bank lending? Specifically, how do investors' and banks' perceptions of a higher variance risk premium affect loan demand and supply, the loan volume, its price and non-price terms? These are important considerations not previously documented in the bank lending literature.[2]

There are at least three main economic interpretations of the VRP. It is viewed as a time-varying risk aversion (Rosenberg and Engle 2002, Bollerslev, Gibson, and Zhou 2011, Bekaert, Hoerova, and Lo Duca 2013), it is associated with economic uncertainty (Bollerslev, Taichen, and Zhou 2009, Dreschler and Yaron 2011, Bali and Zhou 2016), and it is also referred to as ambiguity aversion (Dreschler 2013, Miao, Wei, and Zhou 2012, Neamtiu et al. 2014)[3]. Regardless of how VRP is defined, the model-free VRP is a leading contender of economic uncertainty, and in our analysis we show that it wields deleterious effects on the credit market.

During high VRP, firms do not have complete confidence in their perceived pay-off probability measures of their irreversible investment, so for this reason they postpone the pursuit of additional loans for investment purposes (Nishimura and Ozaki 2007). While past research has

[1] There are different measures of uncertainty surrounding the economy (Jurado, Ludvigson, and Ng 2015), stock market (Bloom 2009) and economic policy uncertainty (Baker, Bloom, and Davis 2016). For the last two decades the general consensus has been that the level of uncertainty increased.

[2] The work of Ritz and Walther (2015) examines the effects of funding uncertainty on commercial banks' behavior during the 2007-9 financial crisis, covering many aspects of banking activities. These include lending volume, balance sheet, profitability, competition in retail deposits and the wider implication of the "zero lower bound" unconventional monetary policy on banks' behavior. Our work examines the effects of economic uncertainty on bank lending over a quarter century of data and does not merely focus on the recent financial crisis.

[3] The VRP contains information about systematic variance risk which correlates with periods of high economic uncertainty, particularly during economic recessions and it is a good indicator of ambiguity in economic outlook. Drechsler (2013) provides a theoretical link between the variance risk premium and Knightian uncertainty (Knight 1921), in which the premium arises out of investors hedging against ambiguity concerns.

investigated the effect of uncertainty on firms' investment rate (e.g., Ericsson and Lotfaliei 2016, Neamtiu et al. 2014), to the best of our knowledge no empirical research has yet examined the effect of VRP on loan demand. Equally, the VRP has adverse effects on the allocation of banks' loanable funds. Since banks must acquire costly information on borrowers before extending loans to new or existing customers, uncertainty about economic conditions (and the likelihood of loan default) will clearly affect their lending strategies. We expect that when the economic environment and financial market are tranquil, bank managers will be able to predict returns from each potential project more easily and channel funds towards projects with higher expected returns. In contrast, when the economic environment and financial market are in turmoil, bank managers' ability to predict returns accurately will be hindered, thus leading to more conservative lending behavior across all banks. Furthermore, as shown by Van Tassel and Vogt (2016), the risk appetite of financial intermediaries is highly correlated with variance risk. In times of greater economic uncertainty, the difficulties in predicting the returns of irreversible investments would mean that banks as loans suppliers face uncertainty about borrowers' ability to service loans, thus altering their risk-taking behavior and reducing bank credit supply.

To test these hypotheses we use quarterly U.S. aggregated bank-level data covering a quarter-century period taken from four databases. Using the Senior Loan Officer Opinion Survey (SLOOS) on Bank Lending Practices dataset, we use changes in bank lending standard and banks' perception of demand for commercial and industrial (C&I) loans for different categories of firms over the last quarter. This is done to proxy for bank credit supply, loan price and non-price terms, and bank credit demand. For completeness and robustness, we also use the Survey of Terms of Business Lending (STBL) dataset and the Loan Pricing Corporation's (LPC) LoanConnector database to test our hypotheses. The former covers new business loans issued in a single week during the mid-month of the quarter when the survey is conducted, while the latter involves syndicated loans. SLOOS together with STBL survey data have been used by many studies to identify credit supply shocks and credit demand shocks (e.g., Bassett et al. 2014, Black and Rosen 2016, Hirtle 2009, Ivashina and Scharfstein 2010, Lown and Morgan 2006). Using a number of econometric modelling frameworks which control for the endogeneity nature of uncertainty and lead-lag relationships between the variables of interest, our results provide unanimously strong support for the hypothesis that economic uncertainty affects the allocation of banks' loanable funds and decreases loan demand. We find a clear negative association between uncertainty (natural

logarithm of VRP) and supply of bank credit; an increase of one standard deviation in uncertainty leads to an 9.3% net increase in domestic banks reporting more stringent credit standards for large and medium firms. The effect of uncertainty on loan demand is of a similar order of magnitude. This *prima facie* evidence does not distinguish the supply side effect from the demand side effect, thus making it difficult to assess which effect on supply or on demand is larger. We use two methods to disentangle the effect of uncertainty on loan supply from loan demand, namely a structural vector autoregression (SVAR) model with sign restrictions and a novel identification strategy following Kashyap, Stein, and Wilcox (1993) and Becker and Ivashina (2014). The latter involves loan-to-bond substitution in which firms are able to substitute from loans to bonds (and/or commercial paper) as an alternative source of funding. Kashyap, Stein, and Wilcox (1993) and Becker and Ivashina (2014) show evidence that firms have a propensity to switch from loans to bonds when there is a contraction in bank credit supply. Our results confirm the dominant economic uncertainty effect on credit supply relative to loan demand.

The effect of uncertainty on loan volume is equally substantive. For a standard deviation increase in uncertainty, the reduction in C&I loans is about $12.76 billion, while a larger reduction is manifested in quarterly loan syndicated volume by as much as $50.34 billion (i.e. about 25% lower than the average syndicated loan volume). Regarding loan spreads, the effect is also statistically and economically significant, with a standard deviation increase in uncertainty giving rise to 25.08 basis points increase in syndicated loan spreads (i.e. about 16% higher than the average spreads). Based on the simultaneous equation framework, we find a similar order of magnitude and the same sign for the impact of uncertainty on loan volume and spreads. As the VRP adversely influences both bank credit demand and supply, its negative impact on loan volume is not surprising; and its positive impact on loan spreads implies that the supply side is more sensitive to uncertainty as compared to the demand side. This is consistent with results from the SVAR and loan-to-bond substitution approach.

Heightened economic uncertainty also brings about more conservative non-price credit terms. Using the syndicated loan market as an illustration, for a standard deviation increase in uncertainty the average loan size is about $28.77 million lower than its mean size of $206.69 million. Furthermore the average loan maturity is about 3 months shorter than an average maturity of 4 years, and there is a 4% increase in the proportion of the loan that is secured by collateral in a market with 30% of the loan collateralized. While we observe that uncertainty peaks with

economic recessions, there is some evidence of statistically significant difference in the effects of uncertainty on loan spreads, non-price loan terms and loan quantum between recession and non-recession periods. It is suggested here that uncertainty which coincides with economic downturn tends to wield a larger effect on both loan demand and supply.

Our paper pertains to the growing literature on the VRP, although those studies tend to focus on the correlation between the VRP and asset pricing.[4] Some papers use the VRP as an indicator of market uncertainty to explore its impact on financial decision-making.[5] Here we show that the VRP wields a considerable impact on bank lending. Our work is also related to a larger body of literature on the links between bank lending, macroeconomy, monetary policy and credit cycle.[6] In this paper, we provide a different perspective on how the credit market may be affected by factors like the volatility-based VRP in addition to macroeconomic factors and policy, which could equally exacerbate the business cycle and increase systemic risk. Unlike Valencia (2017) we focus on a specific and different concept of uncertainty, and explore its effects on not only loan supply but also loan demand and loan terms. We also show that the VRP which measures economic uncertainty tends to peak with economic recessions, and that the information contained in the VRP has greater predictive power over bank lending than the standard measure of stock market uncertainty, for example the VIX. Finally, our work is also related to bank risk-taking behavior, which is governed by a number of factors.[7] Our focus on bank risk-taking behavior and loan

[4] Recent evidence points to the superior predictive power of the VRP for stock market returns (Bali and Zhou 2016, Bollerslev et al. 2014, Bollerslev, Tauchen, and Zhou 2009, Drechsler and Yaron 2011), Treasury bonds (Mueller et al. 2016), credit default swaps (Cao, Yu, and Zhong 2010, Wang, Zhou, and Zhou 2013) and credit spreads (Ubukata and Watanabe 2014).

[5] Neamtiu et al. (2014) and Ericsson and Lotfaliei (2016) provide evidence for a negative relationship between the VRP and firms' investment. Neamtiu et al. (2014) also demonstrate that the VRP is positively associated with cash holdings.

[6] Puri, Rocholl, and Steffen (2011) and Acharya and Mora (2015) show that the US financial crisis induced a contraction in loan supply and dampened the banks' ability to provide liquidity to businesses. Valencia (2017) examines the effect of aggregate uncertainty, including dispersion of forecasts, stock market realized volatility, bank lending standards outlook, volatility of forecast errors, and incidence of natural disasters, on the supply of credit while the evidence suggests that aggregate uncertainty significantly reduces credit supply. Peek, Rosengren, and Tootell (2003), Lown and Morgan (2006), and Bassett et al. (2014) all document a significant correlation between bank credit supply and macroeconomy. With this striking relationship, Ivashina and Scharfstein (2010) and Becker and Ivashina (2014) show that credit supply is highly pro-cyclical. Tight monetary policy may also induce a fall in the supply and demand for bank loans through the lending (Bernanke and Blinder 1988) and balance sheet channels (Bernanke and Gertler 1995).

[7] Conventionally, monetary policy decisions could affect banks' risk-taking (Rajan 2006, Borio and Zhu 2012, Buch, Eickmeier, and Prieto 2014, Dell'Ariccia, Laeven, and Suarez 2017). Specifically, a fall in the policy rate induces a reduction in returns of particularly low risk investments. In ensuring that the average return on assets is kept constant, bank managers will shift into riskier credit market segments, a strategy which increases the likelihood of financial instability. Another view relates to the institutional memory hypothesis, in which the risk-taking behavior of banks

performance is centered on economic uncertainty, which sheds light on a new stylized fact about the counter cyclicality observed between bank credit supply and economic uncertainty.

The remainder of our paper is organized as follows. In the next section we explain the construction of the VRP. In Section 3 we discuss the data and variables used that proxy for loan demand and loan supply. We present the methods and empirical results in Section 4 focusing on the effect of uncertainty on loan volume, loan demand and supply, and loan pricing. Section 5 presents an alternative identification strategy to demonstrate that the effect of uncertainty on loan supply is indeed larger than on loan demand, which bear important policy implications. In Section 6, we examine the impact of uncertainty on non-price loan terms and test whether the effects are different during recession and non-recession periods. Section 7 concludes the paper with a summary of the main themes covered here.

2. Constructing the Variance Risk Premium

To construct the VRP measure, we use the model-free implied variance, VIX^2 published by the Chicago Board Options Exchange (CBOE). This is also referred to as the risk neutral variance. The VRP is obtained by subtracting the expected variance (*ERV*), also known as the objective measure of expected variance, from the model-free implied variance (i.e. $VRP_t = VIX_t^2 - ERV_t$).

To obtain the expected variance, it is customary to compute the realized monthly variance from the squared 5-minute returns. Realized monthly variance (*RV*) which is calculated from intraday data provides more accurate ex-post observations of the actual variance compared to daily data (Andersen et al. 2001, Barndorff-Nielsen and Shephard 2002). Following Drechsler (2013), Bekaert, Hoerova, and Lo Duca (2013), Wang, Zhou, and Zhou (2013), and Bali and Zhou (2016), we adopt a linear forecast of the objective or statistical expectation of the return variance:

$$ERV_t = \widehat{RV}_{t+1} = \hat{\beta}_0 + \hat{\beta}_1 VIX_t^2 + \hat{\beta}_2 RV_t$$

determines the fluctuations in bank loan supply and performance, especially the high correlation that is observed between problem loans and the aggregate business cycle (Berger and Udell 2004, Bouwman and Malmendier 2015). The hypothesis argues that bank loan officers have difficulties in recognizing potential loan problems to the extent that there is an easing of credit standards with the passing of time from the bank's last loan "bust". The "institutional memory" problem is aggravated by the proportion of officers who have never experienced a loan bust; it is further compounded by the atrophying skills of experienced officers as their memory of the experience from the last problem loan lapses.

such that the expected variance is simply the time *t* forecast of realized variance from *t* to *t+1* based on the estimated coefficients of the above regression. Resulting coefficients from the two-variable projection are as follows:

$$RV_t = \underset{(0.937)}{-0.120} + \underset{(0.000)}{0.324}VIX^2_{t-1} + \underset{(0.001)}{0.380}RV_{t-1} + \varepsilon_t$$

The p-values reported in parentheses are obtained using Newey-West heteroskedasticity and autocorrelation consistent standard errors. On the basis that we have quarterly data for the loan-related variables, the quarterly measures of the VRP are obtained by averaging the monthly VRP.

-Figure 1 about here -

Figure 1 depicts a plot of the implied variance (VIX^2), the VRP and the natural logarithm of VRP (*logVRP*), which is our measure of uncertainty. This figure makes clear that both the implied variance and measure of uncertainty provided by *logVRP* accurately capture the impact of key events, regardless of whether they are economic, financial or socio-political events. It is also interesting to note that during the three NBER-dated recessions the VRP peaked, suggesting that recession is often associated with greater uncertainty. Nevertheless, there are instances when the VRP peaks do not coincide with economic downturns, implying that the VRP contains information about the level of uncertainty which may not stem from economic events.

One may question the use of VRP as a measure of uncertainty over the commonly used measure of stock market uncertainty like VIX. *VRP* is significantly correlated to VIX^2 (0.91) and is less correlated with *ERV* (0.73). This outcome implies that *VRP* and *ERV* may capture different risk components embedded in VIX^2. We further consider the dynamic relationships amongst *logVRP*, the implied variance given by VIX^2 and the expected variance *ERV*. A VAR of lag order 2 (as determined by the Akaike information criterion) is fitted to the three series and the Granger causality test is conducted to test the predictive power of each series on the others. To conserve space, the results are reported in the Appendix. *logVRP* has predictive power over both VIX^2 and *ERV* as suggested by the Granger causality test at the 5% significance level (see Table A1), but both VIX^2 and *ERV* do not possess predictive power over *logVRP*. These results indicate that *logVRP* is a superior measure of systematic variance risk which is not captured in both VIX^2 and *ERV*. Table A2 further confirms our belief that the VRP provides information about economic uncertainty which is not found in the commonly used measure of stock market uncertainty, VIX^2.

When loan demand and loan supply for large and medium firms are regressed on both VIX^2 and *logVRP*, only the coefficient of *logVRP* is statistically significant while that of VIX^2 is not statistically significant. This is despite the fact that in a regression which uses VIX^2 as a measure of stock market uncertainty and in the absence of *logVRP*, the former could predict both loan demand and supply.[8]

3. Data

3.1 Loan data

The key sources of data used in the analysis are derived from four different datasets with each dataset covering different characteristics of the bank lending market. Our strategy for studying the effect of economic uncertainty on bank lending is to show these effects are robust and are consistently documented in the four different types of loan datasets. The first data is the Federal Reserve's Senior Loan Officer Opinion Survey (SLOOS) of Bank Lending Practices, a quarterly survey of major banks throughout the U.S. This survey queries banks about changes in their lending standards during the quarter preceding the date the survey is conducted for major categories of loans to households and businesses beginning with the April 1990 survey. It also asks banks about changes in demand for most of those types of loans starting with the October 1991 survey. We only focus on their responses to the questions regarding C&I loans.[9] There are 73 domestic banks and 24 U.S. branches and agencies of foreign banks participate in the January 2016 survey. While the number of participating banks varies over time, those banks are usually the largest in each of the 12 Federal Reserve Districts.[10] Answers of foreign banks are not used in the

[8] While it may be argued that both *VRP* and VIX^2 are highly correlated it is possible the results in Table A2 are influenced by the problem of multicollinearity. Nevertheless, the classic multicollinearity problem would suggest that both *logVRP* and VIX^2 would not be statistically significant despite the relatively high adjusted-R^2. We do not find this evidence.

[9] SLOOS started in the 1960s and questions about C&I loans became standardized in the second quarter of 1990 (Cunningham 2006).

[10] According to Bassett et al. (2014) the panel of domestic respondents as of Sep 30, 2011 contained 55 banks, 34 of which had assets worth $20 billion or more. The combined assets of respondent banks totaled $7.5 trillion and accounted for 69% of the $10.9 trillion in total assets of domestically chartered institutions. Respondent banks also held between 40% and 80% of total commercial bank loans outstanding in each major category, which are queried in the survey, with most categories falling in the upper end of that range. Banks are added or replaced as needed and the mergers of very large U.S. banks in recent decades have brought about changes in the sample. The response rate of lenders is very close to 100%. Taken together, these statistics indicate that the sample of banks accurately and broadly reflects trends in credit availability and loan demand for the whole banking industry.

analysis. The data sample is from 1990Q2 to 2016Q1, which covers banks' stances concerning lending policies between 1990Q1 and 2015Q4.

The second dataset is the LPC LoanConnector database on loan syndication provided by Thomson Reuters. We extract information on the U.S. syndicated loan market from this database. Loans in our sample must meet the following criteria: i) U.S.-dollar denominated loans; ii) distribution method is syndication or club deal; iii) syndicated in the U.S.; iv) syndicated by banks; v) belong to term loans or revolving loans; and vi) facility start date is between 1990 and 2015.

The third dataset is the Federal Reserve's Survey of Terms of Business Lending (STBL). The STBL data provide information concerning price, certain non-price terms of C&I loans and the gross *new* C&I loans (in US dollars) made to businesses during the first full business week of the mid-month of each quarter (February, May, August, and November). This information is available for all commercial banks, domestic banks, large domestic banks, small domestic banks, and US branches and agencies of foreign banks. The sample period is from 1997Q2 to 2015Q4. The panel for the survey is a stratified sample although the data are at the aggregate level. During the sample period, the authorized panel size for the survey is 348 domestic banks and 50 U.S. branches and agencies of foreign banks. Our analysis focuses on the answers of domestic banks. One important distinction between the STBL data and the SLOOS data is that the former provides quantitative information on lending terms during the first business week of the mid-month of each quarter, while the latter provides qualitative information on the changes in banks' lending standards for the past three months (i.e. last quarter) from the time the survey is conducted.[11]

The final dataset is the Flow of Funds data published by the Federal Reserve Board. Each quarter the Federal Reserve gathers capital market flows data from a variety of internal and commercial sources. Following Kashyap, Stein, and Wilcox (1993) and Becker and Ivashina (2014), we use the dataset to construct two time series which represent two different classes of aggregate non-farm, non-financial corporate debt. The bank debt series is the sum of Depository Institution Loans Not Elsewhere Classified and Other Loans and Advances. The public debt series is the sum of Corporate Bonds and Commercial Paper. The sample period is from 1990Q1 to

[11] In the regression analysis, when the dependent variable derives from STBL, the *logVRP* is the value at the end of the month preceding the survey week.

2015Q4. We use these two series of corporate debt to quantify the relative fluctuations in demand and supply for bank credit.

3.2 Measures of loan supply, loan demand and loan spreads

In contrast to more quantitative surveys on commercial loan rates, the SLOOS is more qualitative in nature. Loan officers are asked whether their standards for approving commercial credit have tightened or eased since the quarter before:

"Over the past three months, how have *your banks' credit standards* for approving loan applications for C&I loans or credit lines – excluding those to finance mergers and acquisitions – to large and middle market firms (and to small firms) changed?"[12]

The importance of credit standards stems from the unique nature of the bank lending market. Unlike other markets where prices do all the adjusting to keep the market clear, loan rates may be secondary to standards of credit worthiness and other non-price terms in the allocation of bank credit. Here, banks' "credit standards" include both price and non-price lending terms, such as loan volume, collateral requirements, non-interest rate charges, loan limits, covenants and maturity. Bassett et al. (2014) utilize changes in these bank lending standards as a proxy for changes in credit supply. On the demand side, the question asked is:

"Apart from normal seasonal variation, how has *demand for C&I loans* changed over the past three months? (Please consider only funds actually disbursed as opposed to requests for new or increased lines of credit.)"

Participating banks answer both questions using a qualitative scale ranging from 1 to 5. In the case of lending policies, the possible answers are 1=eased considerably; 2=eased somewhat; 3=about unchanged; 4=tightened somewhat; and 5=tightened considerably. As for the changes in loan demand, the possible answers are 1=increased considerably; 2=increased somewhat; 3=about unchanged; 4=decreased somewhat; and 5=decreased considerably.

Loan supply is proxied by computing the net percentage of domestic banks tightening credit standards for C&I loans to large and medium firms. This is the number of loan officers

[12] Referring to large and middle market firms, they are defined as firms with annual sales of $50 million or more. For small firms their annual sales amount to less than $50 million.

reporting tightening standards (i.e. the combined response for scales 4 and 5) less the number reporting easing (i.e. the combined response for scales 1 and 2) divided by the total number reporting. To distinguish changes in loan supply for large and medium firms from small firms, we use a different suffix for the loan supply variable (i.e. *Standard_LM* as opposed to *Standard_S*). Loan demand is proxied by computing the net percentage of domestic banks reporting stronger demand for C&I loans from large and medium firms. This is the number of loan officers reporting increased loan demand (i.e. the combined response for scales 1 and 2) less the number reporting decreased demand (i.e. the combined response for scales 4 and 5) divided by the total number reporting. Changes in loan demand for large and medium firms are denoted by *Demand_LM*, while that for small firms is denoted by *Demand_S*.

We also consider loan pricing (i.e. loan spreads) inferred from the question concerning changes in loan supply arising from tightening price-related credit standards for C&I loans to large and medium firms. For this purpose, we utilize the survey question:

"For applications for C&I loans or credit lines – other than those to be used to finance mergers and acquisitions – from large and middle-market firms and from small firms that your bank currently is willing to approve, how have the *terms of those loans* changed over the past three months?"

Specifically, the term of the loans that we use is the spread of loan rates over the participating bank's cost of funds. As such wider spreads signify tightened pricing credit terms while narrower spreads signify eased pricing credit terms. The possible answers to this question are similar to those of the lending policies. The loan supply variable which is associated with pricing credit terms is defined as the net percentage of domestic banks increasing spread of loan rates over banks' cost of funds to firms, with large and medium firms, and small firms denoted by *Spr_LM* and *Spr_S*, respectively. The STBL survey provides the actual measure of loan spreads (here denoted as *Loan_Spr*) which is the domestic banks' C&I loan rate spread over intended federal funds rate. For the LPC loan syndication data, the loan spread is a weighted average measure of the loan rate spread over LIBOR (*Spr_Synd*).

3.3 Other non-price loan terms and loan volume

Other than loan demand, supply, and spreads, we also evaluate the effects of market uncertainty on the loan volume, loan size, loan maturity, and the proportion of loan that is secured

by collateral. For the loan volume, we gather the change in aggregate outstanding C&I loans measured in billion dollars which is denoted *ΔCI_Loan* from the Federal Reserve Statistical Release H8. An equivalent measure of loan volume is the total syndicated loan volume (*Synd_Loan*) which is measured in billion dollars and obtained from the LPC. The credit standards relating to non-price loan terms which are obtained from the SLOOS and pertain to large and medium firms are the following: the net percentage of domestic banks which tightens the standard on maximum size of credit lines (*LoanSize_LM*), tightens the standard on maximum maturity of loans or credit lines (*Maturity_LM*), and tightens the standard on collateralization requirement (*Secured_LM*). The equivalent of these variables obtained from the STBL are the average loan size (*LoanSize*) measured in thousands of dollars, the average maturity days weighted by loan amount (*Maturity*), and the percentage of loan amount secured by collateral (*Secured*). The equivalent of these variables in the syndicated loan market are the average loan size (*LoanSize_Synd*) measured in millions of dollars, the average maturity months weighted by loan amount (*Maturity_Synd*), and the percentage of loan amount secured by collateral (*Secured_Synd*).

3.4 Macroeconomic variables and other control variables

Empirical research on bank lending shows that in practice aggregate macroeconomic variables influence both loan demand and supply. We include the federal funds rate (*FF_Rate*), which is a commonly used measure of monetary policy, the GDP growth rate (*GDP*) as a measure of business cycle condition, and inflation (*CPI*). In addition, we control for credit spreads (*Credit_Spr*) which is defined as the difference between the yields of Baa and Aaa corporate bonds. Angbazo, Mei, and Saunders (1998) show that the loan spreads are sensitive to changes in spreads in the (competing) corporate bond market. We also include the term spread (*Term_Spr*) which is defined as the difference between 10-year and 1-year Treasury yields since it is well regarded as a leading indicator and possesses information on future economic conditions. Finally, we also control for consumers' sentiment about the economy using the University of Michigan Consumer Sentiment Index (*CSI*). These control variables have been commonly used in the literature (e.g., Berger and Udell 2004, Black and Rosen 2016, Buch, Eickmeier, and Prieto 2014, Lown and Morgan 2006, Vickery 2008). The definitions and sources of all variables used in this article are reported in Table A3.

Preliminary regression of the change in loan volume on *logVRP* and macroeconomic control variables indicate that many of the control variables are not statistically significant at conventional significance levels. The lack of statistical significance in the macroeconomic variables could be caused by the multicollinearity problem (the correlations between these variables are shown in Panel A of Table 2). To circumvent this issue, we perform principal component analysis (PCA) on all the control variables and obtain six orthogonal factors, which we use as control covariates in subsequent regressions.

3.5 Descriptive Statistics

Table 1 contains basic statistics of the regression dataset. The average quarterly VRP is 18.26 (percentage-squared) which is very close to the mean value of 18.47 reported in Bali and Zhou (2016). The median VRP is 15.18 while the highest and lowest are 77.25 and 5.42, respectively. Its distribution becomes less skewed after taking a natural logarithm. The average *Standard_LM* is 5.91%, which implies that on average domestic banks are tightening credit standards for C&I loans to large and medium firms; they seem to only tighten their standards on loan size and loan collateral. The average *Demand_LM* is -0.2%, suggesting that for the period 1991Q3-2015Q4, on average domestic banks observe a slight decline in loan demand. In Table 1, we can also find that the distributions of the variables from SLOOS are more skewed than that from the other data sources. The possible reason may be because the SLOOS is more qualitative in nature. For this reason, we also use LPC, STBL, and Flow of Funds data to confirm our results albeit the SLOOS data are extensively used in previous studies.

Table 2 presents the correlation matrix for the variables of interest. In Panel A the correlation (0.63) between our two loan volume measures, Δ*CI_Loan* and *Synd_Loan*, are positive and significant. Bank lending standards and loan demand display a negative and significant relationship (-0.7). The uncertainty measure, *logVRP*, is negatively related to loan volume, Δ*CI_Loan* and *Synd_Loan*, and loan demand. The correlations are -0.41, -0.39, and -0.53, respectively, and they are all statistically significant at the 1% level. As well, *logVRP* is highly correlated with bank lending standards and loan spreads (correlations are 0.59 and 0.67, respectively). These are all consistent with our expectations and imply that heightened economic uncertainty will dampen both bank credit demand and supply. Table 2 shows the correlations between our six control variables and as be seen in the table, most of these variables are highly

correlated. High correlations between these variables would mean the regression suffers from the multicollinearity problem, so therefore we use PCA to deal with it. In Panel B of Table 2, we show the correlations between the variables of interest and the six orthogonal factors obtained from PCA. It is apparent that the bank lending variables and market uncertainty are most correlated with the second and third principal components (*Factor2* and *Factor3*).

-Tables 1 and 2, and Figures 2 and 3 about here -

Figure 2 shows the time series plot of the loan volume given by the change in C&I loans obtained from the Federal Reserve Statistical Release H8 and the quarterly syndicated loan volume. The two series are juxtaposed against the uncertainty measure given by *logVRP*. It can be seen that there is an inverse relationship between the syndicated loan volume and uncertainty. This inverse relationship is not as apparent for the change in C&I loans prior to 2000. Nevertheless in the period after 2000Q1, greater uncertainty is associated with smaller changes in C&I loans. Figure 3 illustrates the dynamic of loan supply given by *Standard_LM*, loan demand given by *Demand_LM* and the uncertainty measure, *logVRP*. An increase in credit standard which is associated with a fall in loan supply closely matches the fall in loan demand. At the same time, during periods when uncertainty peaks we observe a fall in loan demand and loan supply for which this is reflected by an increase in credit standard. The fall in loan demand is most acute over the 2001 recession and the global financial crisis.

4. The impact of uncertainty on bank loans

4.1 Single-equation regression framework

The basic empirical approach is to execute a time-series regression relating loan quantity, loan demand and supply, and loan spreads to uncertainty measure. Specifically, we estimate the following regression:

$$Loan\ variable_t = \alpha + \beta logVRP_{t\text{-}1} + \boldsymbol{X\Gamma} + \varepsilon_t, \qquad (1)$$

where $Loan\ variable_t$ comprises $Loan\ quantity = \{\Delta CI\_Loan, Synd\_Loan\}$, *Standard_LM* (or *Standard_S*) for loan supply and *Demand_LM* (or *Demand_S*) for loan demand, and *Loan Spread* = {*Spr_LM, Spr_S, Loan_Spr, Spr_Synd*}. Here, $\boldsymbol{X}$ is the data matrix of six orthogonal factors which are obtained from the principal component of the macroeconomic variables. $\boldsymbol{\Gamma}$ is the corresponding vector of coefficients for the orthogonal factors. Using one quarter lag of *logVRP*

helps mitigate possible reverse causality of loan variables on the VRP. During a crisis period, uncertain credit availability presents a major source of uncertainty that could translate into a higher VRP. The above predictability regression framework is similar to that of Fama and French (1989). For robustness and to accommodate the lead-lag relationship between variables of interest, we also estimate a structural vector autoregressive model in Section 4.3.

-Table 3 about here -

Table 3 Panel A shows the response of loan quantity as measured by Δ*CI_Loan* and *Synd_Loan* to uncertainty (*logVRP*).[13] The coefficients on *logVRP* are -21.93 and -86.49 for Δ*CI_Loan* and *Synd_Loan* regressions, respectively, are statistically significant implying loan quantity decreases as uncertainty peaks. To quantify the impact of uncertainty on loan quantity, consider an increase in uncertainty by a standard deviation of the *logVRP*, this being approximately 21.6% more in the level of uncertainty above its mean. This is associated with a decline in the C&I loans by about $12.76 billion and about $50.34 billion in the quarterly syndicated loan volume (i.e. a 25% reduction of the mean syndicated loan volume). Clearly, the impact of uncertainty on loan volume is economically significant.

Table 3 Panel B reports the impact of uncertainty on loan demand and supply. The coefficient associated with *logVRP* is statistically significant at the 1% level. A standard deviation increase in uncertainty is associated with about 9.3% net increase in credit standards for C&I loans given to large and medium firms, implying a fall in loan supply. Van der Veer and Hoeberichts (2016) show an economically relevant "level effect"; that is, a one point increase in the level of a bank's lending standards has the effect of reducing the Netherlands banks' quarterly growth rate of business lending by about 2% annually. If this was true with the U.S. loan market, the 9.3% credit reduction would have translated to a 18.6% fall in business lending growth rate, which is economically significant.[14] The effect on loan supply for small firms is smaller with only about 7.6% net increase in credit standards as *logVRP* increases by one standard deviation. On the demand side, a standard deviation increase in uncertainty results in a fall in loan demand by about

[13] The control variables (i.e. six orthogonal factors) are included in the regression but not reported in Tables 3 and 4 for brevity.

[14] Van der Veer and Hoeberichts (2016) were able to estimate the influence of a level effect – defined as a one-point non-interest tightening of credit standards – on quarterly growth rate of business lending. The precision of their estimate is made possible by the availability of bank level data which permit control for bank-specific fixed effects. This is difficult to estimate for aggregate level data.

9.1% (9.5%) for large and medium (small) firms. We estimate a simultaneous equation model of loan demand and supply allowing for possible omitted variable bias and the endogeneity nature of loan demand and supply. The model is estimated using three-stage least squares (3SLS). The results reported in the Appendix Table A4 indicate a statistically significant fall in large and medium firms loan demand (supply) by about 8.7% (6.8%), which is associated with a standard deviation increase in uncertainty. These results imply that both loan demand and loan supply curves shift leftwards as VRP increases.

We further investigate the association between the reason for tighter lending standards and economic uncertainty (*logVRP*). The SLOOS asks loan officers to choose various reasons when reporting tighter standards or terms. During the sample period the reasons why we collect include the following: (i) less aggressive competition from other banks or non-bank lenders, (ii) deterioration in the bank's current or expected capital position, (iii) increase in defaults by borrowers in public debt markets, (iv) increased concerns about the effects of legislative changes, supervisory actions or changes in accounting standards, (v) worsening industry-specific problems, (vi) deterioration in the bank's current or expected liquidity position, (vii) less favorable or more uncertain economic outlook, (viii) reduced tolerance for risk, or (ix) decreased liquidity in the secondary market for these loans. The correlation between the one period lagged *logVRP* and uncertain economic outlook is as strong as the correlations with reasons (i), (iii), (v), (viii) and (ix). The regression of tightened standards associated with the specific reason on the one period lagged *logVRP* while controlling for the six orthogonal factors, shows a statistically significant relationship between economic uncertainty and all the tightening standard reasons. Interestingly, the coefficient for lagged *logVRP* has a large and the same order of magnitude for uncertain economic outlook as those of reasons (i), (ii) and (iii). These results are not reported here for brevity but are available from the authors upon request.

Table 3 Panel C shows the effect of uncertainty on loan spreads. Columns (1) and (2) show that an increase in uncertainty is associated with wider spreads or a tightening of pricing credit terms. The net percentage of domestic banks' increasing spread of loan rates to large and medium (small) firms over banks' cost of funds increases by 24.2% (16.4%). This outcome is consistent with our findings in Column (1) of Panel B which shows that loan officers report tightening of their lending standards including loan spread as economic uncertainty increases. More importantly, it can be inferred from the increase in pricing credit terms that the cutback in loan supply dominates

the fall in loan demand. In other words, the effect of uncertainty on loan supply appears to be larger than on demand. One caveat is that the data from SLOOS are qualitative in nature; they are not the actual loan spread. We use the data from STBL and LPC to fill this gap. We also identify the dominating effect of uncertainty on loan supply over demand in a simultaneous equation framework using both loan volume and spreads, which is discussed below. For robustness, we further determine the dominating effect of uncertainty on loan supply over demand using two identification strategies involving firms' switching from loans to bonds as a contraction in bank credit supply in Section 4.2, and the SVAR model with sign restrictions in Section 4.3.

Both STBL and LPC data provide actual loan spreads data, which permit quantifying the additional cost of financing to firms from the bank lending market when economic uncertainty peaks. Column (3) reveals that a standard deviation increase in uncertainty translates to a 9 basis points increase in domestic banks' C&I loan rate spread over the intended federal funds rate. Additionally, Column (4) shows that for that same increase in uncertainty, the effect on weighted average loan spreads in the syndication loan market is an increase by about 25 basis points. Both increments in loan spreads are statistically significant and translate to about 16% (4%) increment above the mean loan spreads of the syndicated loans (business loans). To account for the impact of uncertainty on loan spreads while controlling for its effect on loan volume, we estimate a simultaneous equation model of loan spreads and loan volume using the syndicated loan data and controlling for the factors obtained from the PCA. The results, which are reported in the Appendix Table A5, indicate that a standard deviation increase in uncertainty decreases the quarterly volume of syndicated bank loans by about $60.33 billion (i.e. about a one-third reduction of its mean volume). Along with the contraction in loan volume, the weighted average loan spreads increase by about 23 basis points (i.e. about 14% higher than the mean spreads). Allowing for possible interaction between loan volume and spreads gives rise to a steeper increase in the cost of financing. To summarize, economic uncertainty significantly influences both bank credit supply and demand; it reduces loan volume and increases loan spreads, which implies the supply side is more sensitive to the VRP.

-Table 4 about here -

Table 4 reports the effects of economic uncertainty on non-price loan terms (see Panel A) and its impact in and outside of economic recessions (see Panels B and C). The data for SLOOS

reflect the tightening of loan credit terms with respect to loan size, maximum maturity of loans and the collateralization requirements although no specific information is reflected in the data on the actual increase of these terms. By contrast, the STBL and LPC loan syndication data provide the actual decrease in average loan size, the average maturity in days or months, and the percentage of the loan amount that is secured by collateral. We estimate equation (1) but with the dependent variable replaced by different measures of non-price loan terms. Referring to Panel A and focusing on lending standards for large and medium firms (i.e. columns (1) to (3)), we discover that greater economic uncertainty results in tightening of the non-price credit terms; the loan size granted to large and medium firms tend to fall with shorter maturity and there are greater collateralization requirements. For syndicated loans (columns (7) to (9)), a standard deviation increase in uncertainty dampens the average loan size by about $29 million relative to the average syndicated loan size of about $207 million. This is a reduction in maturity of about 3 months for a mean maturity of slightly more than 4 years, and an increase in the proportion of the loan secured by collateral by about 4% for the market average of 30% of the loan which is collateralized. For STBL data (columns (5) to (7)), the effect of uncertainty on the maturity of gross new business loans is statistically significant, reducing it by 59 days (for a mean of 662 days). There is no statistically significant effect of uncertainty on loan size and the percentage of loan amount secured by collateral. To sum up, the evidence confirms that in most cases, economic uncertainty exerts significant effects on non-price loan terms, not only loan quantity and spreads.

Figures 2 and 3 show that the VRP peaks in two of the three NBER-dated recessions, which leads to the possibility that economic recessions may engender an appreciably larger effect of the VRP on bank lending market. To test this prediction we estimate a variant of regression (1):

$$Y_t = \alpha + \beta_1 logVRP_{t-1} \times D_{REC} + \beta_2 logVRP_{t-1} \times (1\text{-}D_{REC}) + \boldsymbol{X\Gamma} + \varepsilon_t, \qquad (2)$$

where all the variables are defined in the same way as equation (1). Here, D_{REC} = 1 for the NBER recession dates 1990:3-1991:1, 2001:1-2001:4 and 2007:4-2009:2, and 0 otherwise. The effects of uncertainty measured during recession and non-recession periods are captured by the coefficients β_1 and β_2, respectively. Table 4 Panel B reports the estimation results for the non-price loan terms while Panel C for loan quantity and spreads. It can be seen that the effects of VRP during recession and non-recession periods on all measures of loan quantity, price and non-price terms are statistically significant at the 5% level except for loan size and collateral requirements for the

STBL data and loan maturity for the SLOOS data. In general, the coefficient estimates are larger during recession compared to non-recession periods, suggesting that uncertainty during economic recessions is more detrimental to the loan market. The null hypothesis of H_0: $\beta_1 = \beta_2$ is rejected in the case of *Standard_LM, Standard_S, Demand_S, Spr_LM, Spr_S, LoanSize_LM, Maturity_LM and Secured_LM*. To some degree this supports the contention that greater uncertainty associated with recessions has a more appreciable effect on loan quantity, price and non-price terms.

4.2 Disentangling the effect of uncertainty on loan demand and supply

Given that we observe periods of greater uncertainty are associated with the pro-cyclical behavior of bank loans, we need to isolate movements in loan supply in a time series context in order to assess the influence VRP has on loan demand and supply.[15] We follow Kashyap, Stein, and Wilcox (1993) and Becker and Ivashina (2014) and use the substitution between bank loan and public debt at the aggregate level to disentangle the supply effect from the demand effect. The idea is that in periods of greater economic uncertainty, besides bank credit supply and demand decrease, one should expect the demand for non-bank sources of credit to decline as well, leading to a reduction in the volume of bonds and commercial paper issues. However, if the result of heightened uncertainty leads to a greater reduction in the supply of bank loans than the fall in the demand for bank loans, one might expect a smaller decline (or even an increase) in bonds and commercial paper issuance to the extent that firms have some ability to substitute between the two sources of finance (i.e. loans versus public debt). In other words, if there is a contraction in both loan supply and demand, and the contraction in loan supply is greater than that in loan demand, this will lead to an excess demand in the loan market, in which case some firms will shift their loan demand to bond demand. Some firms issue bonds to substitute for loans given that bonds are cheaper and are readily accessible than loans at that time. The revealed choice of debt at the aggregate level is used as a proxy for the intensity in the variation of bank credit supply. The loan-to-bond substitution measure becomes our identification strategy to determine whether uncertainty exerts a bigger influence on loan supply or demand.

[15] In the literature on the cyclicality of credit supply (Bernanke and Gertler 1989, Diamond and Rajan 2005) and effects of monetary policy on credit conditions (Kashyap, Stein, and Wilcox 1993), it is widely agreed that credit is pro-cyclical. However, it is empirically difficult to show that this pro-cyclical nature could be explained by banks not willing to lend (a supply shift), firms not willing to borrow (a demand shift), or both during an economic downturn or when monetary policy is contractionary.

We construct the time series of aggregate U.S. non-farm, non-financial corporate debt from Flow of Funds data which are reported by the Federal Reserve Board. The bank debt series comprises data on Bank Loans Not Elsewhere Classified and Other Loans and Advances. The public debt series consists of both Corporate Bonds and Commercial Paper. There are two measures of loan-to-bond substitution: firstly, we define *Loan-Bond* as the difference in the growth rates between bank debt and public debt and secondly, we define *Loan/Debt* as the change in the ratio of bank debt to the sum of bank debt and public debt, which is consistent with Kashyap, Stein, and Wilcox's (1993) construction of the variable "mix".

The estimated regression takes the following form:

$$Z_t = \alpha + \beta logVRP_{t\text{-}1} + \boldsymbol{X\Gamma} + \varepsilon_t, \qquad (3)$$

where $Z = \{\Delta Loan\_FoF, \Delta Bond\_FoF, Loan\text{-}Bond, Loan/Debt\}$. The term $\boldsymbol{X\Gamma}$ is defined in the same way as in regression (1). Similar to ΔCI_Loan, $\Delta Loan\_FoF$ is the change in bank debt and $\Delta Bond\_FoF$ is the change in public debt. The coefficient of interest is β in the regression with loan-to-bond substitution measure as the dependent variable. Considering the case where the dependent variable is *Loan-Bond*, a negative β coefficient implies that the growth rate of public debt surpasses that of bank loan when economic uncertainty heightens. The effect of uncertainty is to reduce both loans and bond issuance so that they both exhibit negative growth rates. To the extent that businesses are able to substitute loans for bonds, one should observe that the bond growth rate is lower in absolute terms than the growth rate regarding bank loans. In other words, the substitution effect from loans to bonds, which captures the shift in loan demand, offsets the negative growth rate in bond issuance. If the fall in loan demand is less than the fall in loan supply conditioned on higher uncertainty, we would expect a negative *Loan-Bond* value or a negative β coefficient. If, on the other hand, the regression yields a positive β coefficient, then the growth rate of bank loan surpasses that of public debt. In such a case, the effect of uncertainty on loan demand outweighs supply.

For the dependent variable of *Loan/Debt*, a negative β coefficient implies $\Delta\left(\frac{Loan}{Loan + Bond}\right) < 0$ as economic uncertainty increases. Higher uncertainty which reduces loan supply would lead firms to substitute from loans into bonds and result in a lower $\frac{Loan}{Loan + Bond}$ ratio compared to last period so that $\Delta\left(\frac{Loan}{Loan + Bond}\right) < 0$. Here, the substitution effect from loans to bonds which captures the shift in loan demand offsets the fall in bond issuance arising from uncertainty.

The negative β coefficient suggests that the fall in loan demand conditioned on higher uncertainty is less than the loan supply. The reverse is true if the regression yields a positive β coefficient.

–Table 5 about here –

The estimation results are reported in Table 5. Columns (1) and (2) report that the VRP has a negative impact on both bank debt and public debt; the coefficients are -26.07 and -2.89, respectively. One standard deviation increase in uncertainty causes a contraction in bank loans by about $15 billion while public debt only falls by about $2 billion albeit it is statistically insignificant. This is indicative that the effect of uncertainty on bank loan is larger than on public debt. Columns (3) and (4) show the results for the loan-to-bond substitution measures. For both measures, the coefficient of *logVRP* is statistically significant at the 5% level and it is negative (the coefficients are -1.47 for the *Loan-Bond* regression and -0.33 for the *Loan/Debt* regression), thus supporting the hypothesis that economic uncertainty exerts a larger influence on loan supply than demand.[16]

4.3 The SVAR model

To circumvent the problem of simultaneity bias and the lack of causality or identification in the treatment of the loan variables and economic uncertainty, we follow the literature which attempts to identify credit supply shocks in macroeconometric frameworks, mainly in the context of SVARs (Bijsterbosch and Falagiarda 2015, Gambetti and Musso 2017, Hristov, Hulsewig, and Wollmershauser 2012). Consider the VAR model in reduced form:

$$Y_t = B_0 + B_1 Y_{t-1} + \ldots + B_p Y_{t-p} + \varepsilon_t, \qquad (4)$$

where Y_t is a vector including economic uncertainty (*logVRP*), real GDP growth (*GDP*), consumer price growth (*CPI*), the Federal fund rate (*FF_rate*), loan spreads (*Loan_Spr* or *Spr_Synd*), and loan volume growth (Δ*CI_Loan* or *Synd_Loan*). ε_t is a Gaussian white noise vector of innovations with covariance matrix Σ. Based on the Bayesian information criterion,[17] a lag order of one and

[16] Our regression results are conservative estimates regarding the relative effect of uncertainty on loan demand and supply. Consider the case where firms, which are not captured in the substitution effects but for some reason are now able to access the commercial paper market. We would expect the offsetting effect on the growth rate of bond issuance and on the level of bond to be even stronger. In other words, the result is expected to be even more significant when such firms are included in the loan-to-substitution measure.

[17] We check both the Akaike information criterion (AIC) and the Bayesian information criterion (BIC). The former usually suggests longer lag orders. Given the large size of SVAR (six equations) and the limited sample size (104 observations before taking lags), we choose the lag orders determined by the BIC.

two is chosen for the STBL and loan syndication data, respectively. Note that for this analysis, we do not employ the SLOOS data as precise loan quantity and spreads are unavailable.[18]

Two schemes are employed to identify structural shocks: a Cholesky recursive causal ordering (zero restrictions) as documented in Sims (1980) and the sign restrictions in Uhlig (2005). Both schemes permit quantifying the effects of adverse uncertainty shocks on loan quantity and spreads. Nonetheless, the former scheme is subject to the usual caveat that there is no empirical or statistical basis for the choice of the causal orderings (i.e. orthogonalizing transformations) so that one must appeal to a priori knowledge.[19] For brevity, we only discuss the results of the latter scheme.[20] Identification of the structural shocks is achieved ex-post by imposing sign restrictions on impulse response functions (Uhlig 2005). At the outset we need to determine the number of sign restrictions to identify the structural shocks. While the identification of additional shocks such as aggregate demand, aggregate supply and credit supply shocks (see, e.g., Bijsterbosch and Falagiarda 2015, Gambetti and Musso 2017, Hristov, Hulsewig, and Wollmershauser 2012) contributes to a better identification of the economic uncertainty shocks under scrutiny, it is important to ensure that the orthogonality between these structural shocks is satisfied. In other words, the imposed sign restrictions must be mutually exclusive to uniquely identify the structural shocks (Fry and Pagan 2011).

For our purpose, however, uncertainty shocks are predicted to be highly correlated with the aggregate demand and aggregate supply shocks, as well as the credit supply shocks. In light of these considerations, we set sign restrictions focusing mainly on monetary policy shocks and economic uncertainty shocks. A positive economic uncertainty shock leads to a decrease in output, loan quantity and an increase in *logVRP* but its effects on inflation, short-term interest rate, and loan spread are unrestricted. For a contractionary monetary policy shock, it leads to a fall in output, inflation and an increase in short-term interest rate, while its effects on *logVRP*, loan quantity, and

[18] While there are specific questions in the survey about "demand" for credit, nonetheless the answers given to these questions may not be independent of changes in credit standards. Lenders, therefore, might observe fewer loan applications as a result of restrictive lending standards to the extent that the causal relationship between supply and demand of credit is not clear from the answers to the survey.

[19] Generally, practitioners of SVAR methods appeal to plausible stories about which variables could or could not affect which other variables in the course of the periodicity of the data. This approach is tenuous because sometimes equally plausible stories can be told for competing causal orderings.

[20] The SVAR estimation with Cholesky decomposition amounts to estimating the reduced form VAR, which shows that uncertainty has a statistically significant negative impact on loan quantity and positive impact on spreads. These results are available from the authors upon request.

spreads are unrestricted. Table 6 summarizes the set of sign restrictions we impose on the impulse responses.

–Table 6 about here –

To obtain impulse response functions that satisfy our sign restrictions, assume that ϑ is the unique lower triangular Cholesky matrix such that $\vartheta\vartheta' = \Sigma$. For any orthogonal matrix ξ we have $\Sigma = \vartheta\vartheta' = \vartheta\xi\xi'\vartheta'$. Therefore, $\vartheta\xi$ can be used to construct a new decomposition. We then check whether the generated impulse response functions satisfy simultaneously the restrictions imposed. ξ is determined by means of rotation matrices, as described by Canova and De Nicolo (2002). If a particular rotation matrix generates impulse responses compatible with our sign restrictions, the impulse responses are stored. Otherwise, we discard them. Restrictions are imposed for one quarter on the impulse responses. Similar to Uhlig (2005) and Hristov, Hulsewig, and Wollmershauser (2012), our SVAR model is estimated with Bayesian methods using a Normal-Wishart prior and 500 impulse responses which satisfy the set of sign restrictions are generated. The median (solid line) as well as 16% and the 84% quantiles (dotted lines) for the sample of impulse responses are plotted in Figures 4 and 5.

–Figures 4 and 5 about here –

Panels A and B of Figure 4 shows the impulse responses to a positive (standard deviation) uncertainty shock and an expansionary monetary policy shock, respectively for the syndicated loans. Results for the data from the Federal Reserve Statistical Release H8 are reported in Figure 5. The impulse response functions to uncertainty shocks over the entire sample period look intuitive. The effect of a positive uncertainty shock increases the *logVRP* in the first three quarters, increases the loan spreads in the second quarter and decreases the loan volume upon initial impact. The delayed response documented by an increase in loan spreads arising from positive economic uncertainty shocks is broadly consistent with our findings based on the other methods, and point to greater responsiveness of loan supply to uncertainty than loan demand. A similar pattern of results for the impulse responses is observed based on the Federal Reserve Statistical Release H8 data. The only exception is that the significance of the response of loan spread to heightened economic uncertainty is marginal because the impulse response function displays a large confidence interval. However, this impulse response function can be biased by the definition of *Loan_Spr* which measures the weighted new-loan spreads during the first business week of the mid-month of each quarter while the *ΔCI_Loan* reports the change in total C&I loan during a full

quarter.[21] This mismatch between loan quantity and price could have dampened the significance in the impulse response results. Although the effect of heightened economic uncertainty is to significantly decrease real output growth, the influence on inflation is statistically insignificant. The impulse response functions of monetary policy shocks exhibit plausible patterns and are broadly in line with the findings reported in related studies, for example Bekaert, Hoerova, and Lo Duca (2013), Breitenlechner, Scharler, and Sindermann (2016), and Uhlig (2005).

5. Summary and Conclusion

The goal of this paper is to examine the relationship between economic uncertainty, which is proxied by the variance risk premium, and bank loans. We provide a new perspective on the determinants of bank credit demand and supply and its implications for financial and economic stability. The global financial crisis has elevated the VRP to an unprecedented level, and with the rise in economic uncertainty both banks and firms are more averse to lending and borrowing. The effects of greater uncertainty on bank lending are further demonstrated through both loan spreads and loan non-price terms.

In this paper, we argue that economic uncertainty should have clear effects on the allocation of loanable funds over and above the movements of macroeconomic aggregates or the constraints posed by monetary policy-makers' actions. We provide robust evidence using different methods and four different datasets that economic uncertainty significantly affects the allocation process, and the effects on both loan demand and bank credit supply are negative. Furthermore, there is clear evidence to suggest during times of greater economic uncertainty both banks and firms will behave more conservatively but the effects are larger on bank credit supply than on loan demand. The magnitude of effects on loan quantity, spreads, and non-price loan terms that we find in this paper are quantitatively and qualitatively important: the reduction in quarterly syndicated loan volume is $50 billion which is 25% lower than the average loan volume, 25 basis points higher in spreads which is 16% above its mean level. This is quite substantial in economic terms implying that the VRP matters and it deserves attention by financial practitioners and policy-makers. It is evident from the results of our analysis that the stability of the economic environment and financial

[21] The Federal Reserve Statistical Release H8 does not provide loan interest rate or loan spread information. Therefore we use loan spread from STBL as a proxy.

market will favor more efficient allocation of loanable funds, promote bank lending and sustain loan demand.

Our study provides new insights on two important analyses focusing on monetary policy and its effects on loan supply (Bassett et al. 2014, Kashyap, Stein, and Wilcox 1993) and bank risk-taking behavior (Bekaert, Hoerova, and Lo Duca 2013, Buch, Eickmeier, and Prieto 2014). By identifying the role played by the VRP in predicting bank credit supply and the extant findings that monetary policy affects the level of economic uncertainty (or risk aversion as termed by Bekaert, Hoerova, and Lo Duca 2013), future studies should examine the role played by the VRP as a transmission channel through which monetary policy operates to affect bank credit supply and the real economy.

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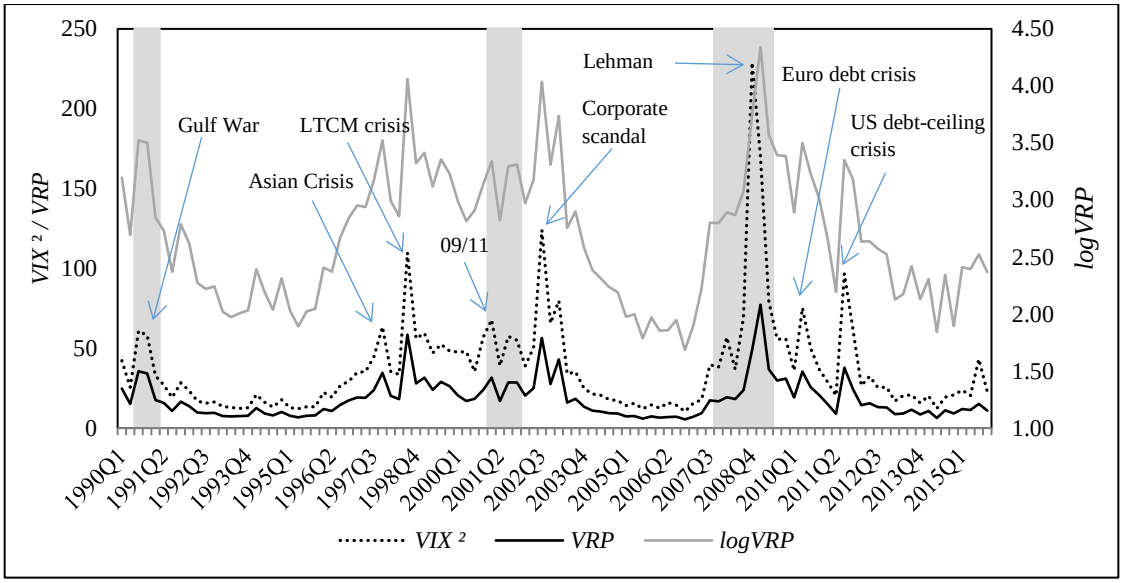


FIG. 1. Time series plot of uncertainty measure and the implied variance.

NOTES: The plot shows the quarterly implied variance (VIX_t^2), the uncertainty measure (VRP) and the logarithmic VRP (*logVRP*). The right-hand side axis is for *logVRP*. Shaded areas indicate NBER recession dates: 1990:3-1991:1, 2001:1-2001: 4 and 2007:4-2009:2.

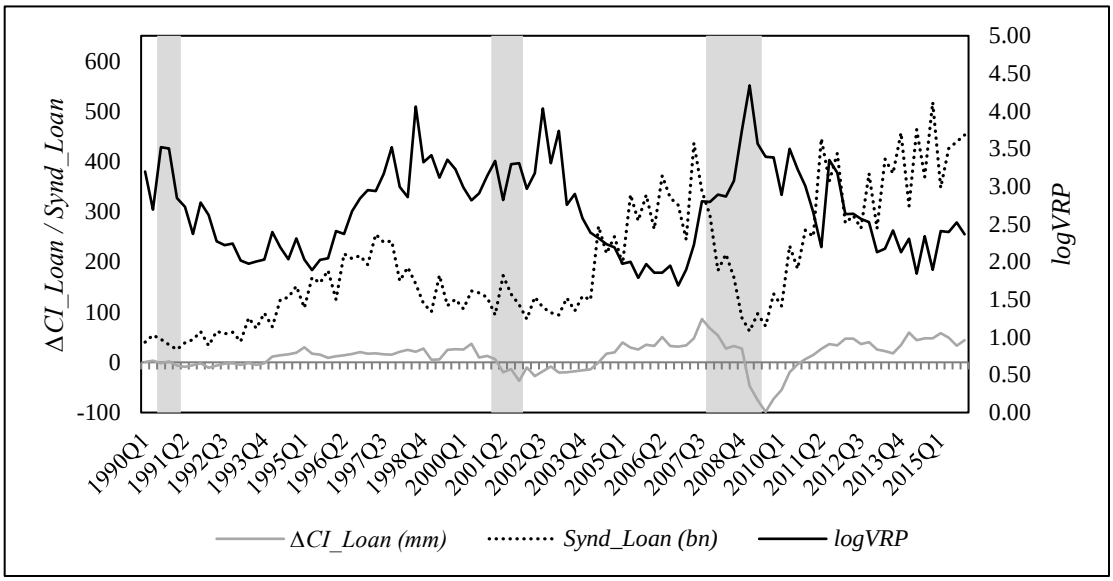


FIG. 2. Time series plot of Δ*CI_Loan*, *Synd_Loan*, and *logVRP*.

NOTES: The figure plots the time series of the change in C&I loans (Δ*CI_Loan*), the volume of syndicated loans (*Synd_Loan*) and the logarithmic VRP (*logVRP*). The right-hand side axis is for *logVRP*. Shaded areas indicate NBER recession dates: 1990:3-1991:1, 2001:1-2001: 4 and 2007:4-2009:2.

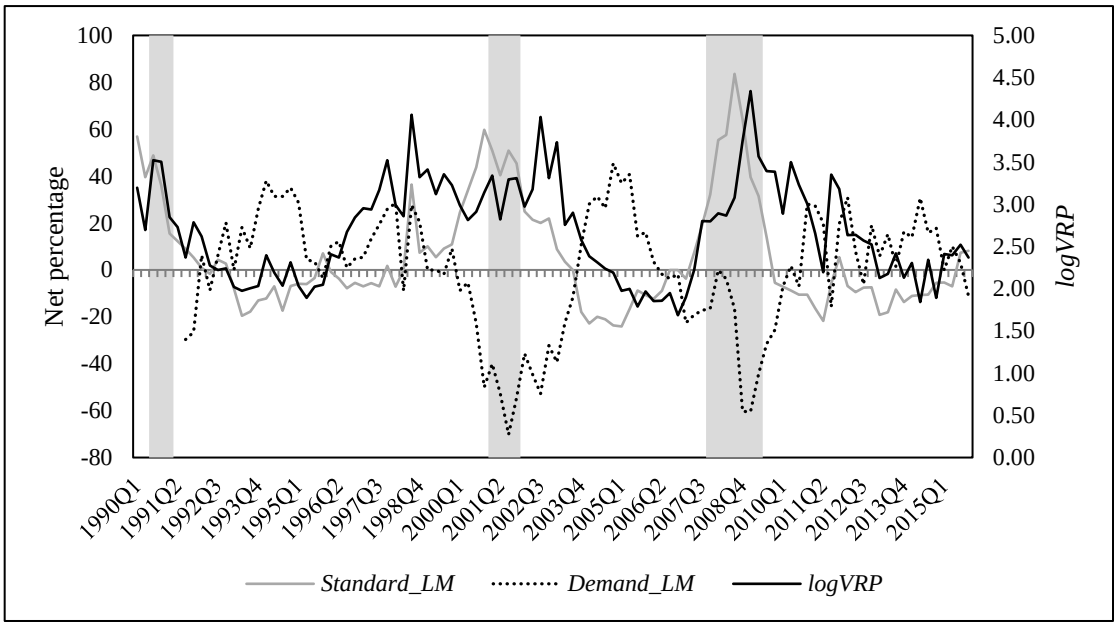
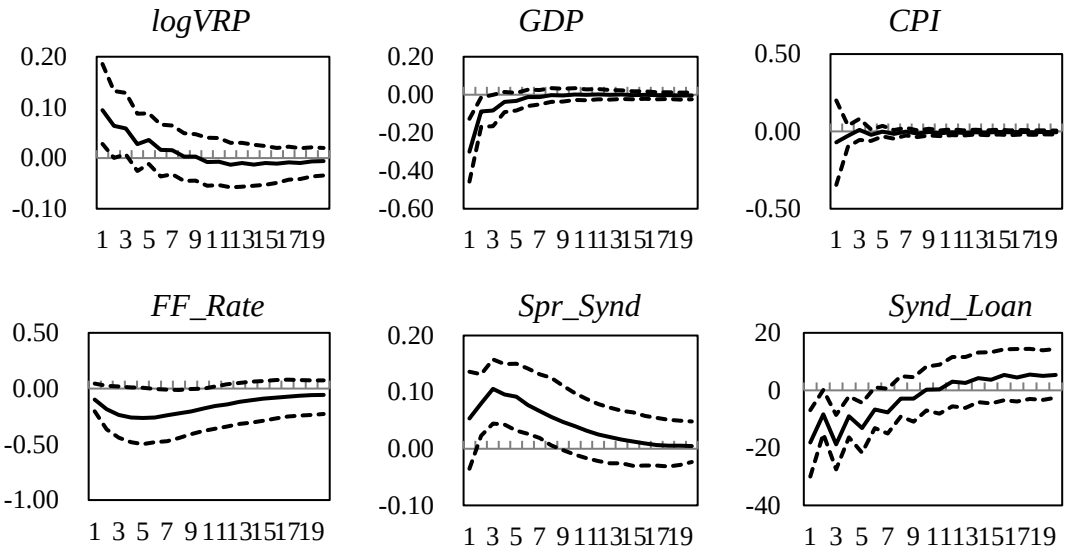


FIG. 3. Time series plot of *Standard_LM*, *Demand_LM*, and *logVRP*.

NOTES: This graph displays the net percentage of domestic banks reporting tightening standards for C&I loans to large and medium firms (*Standard_LM*), the net percentage of domestic banks reporting stronger demand for C&I loans from large and medium firms (*Demand_LM*), and the logarithmic VRP (*logVRP*). The right-hand side axis is for *logVRP*. Shaded areas indicate NBER recession dates: 1990:3-1991:1, 2001:1-2001: 4 and 2007:4-2009:2.

Panel A: Impulse responses to a positive uncertainty shock



Panel B: Impulse responses to a contractionary monetary policy shock

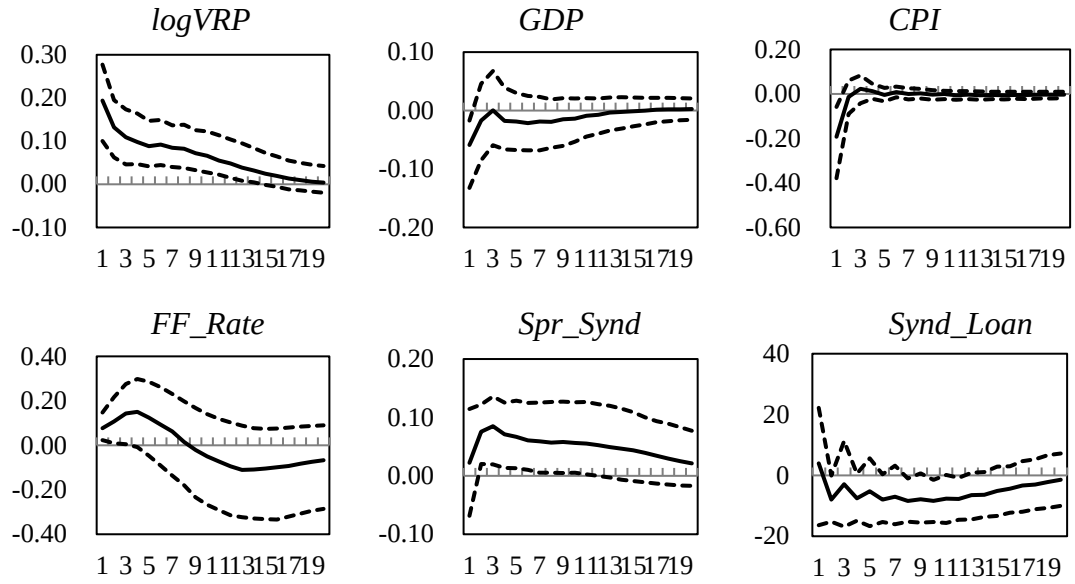
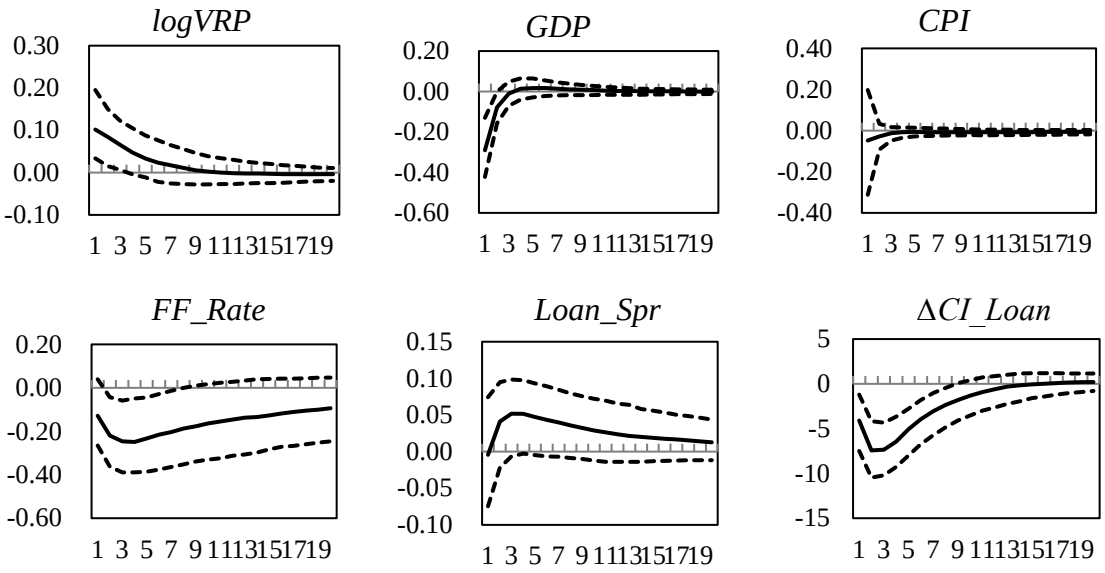


FIG. 4: Structural VAR with sign restrictions for the syndicated loan market.

NOTES: The solid line is the median impulse responses and the dotted lines represent the 16% and 84% quantiles of the posterior distribution of the 500 draws.

Panel A: Impulse responses to a positive uncertainty shock



Panel B: Impulse responses to a contractionary monetary policy shock

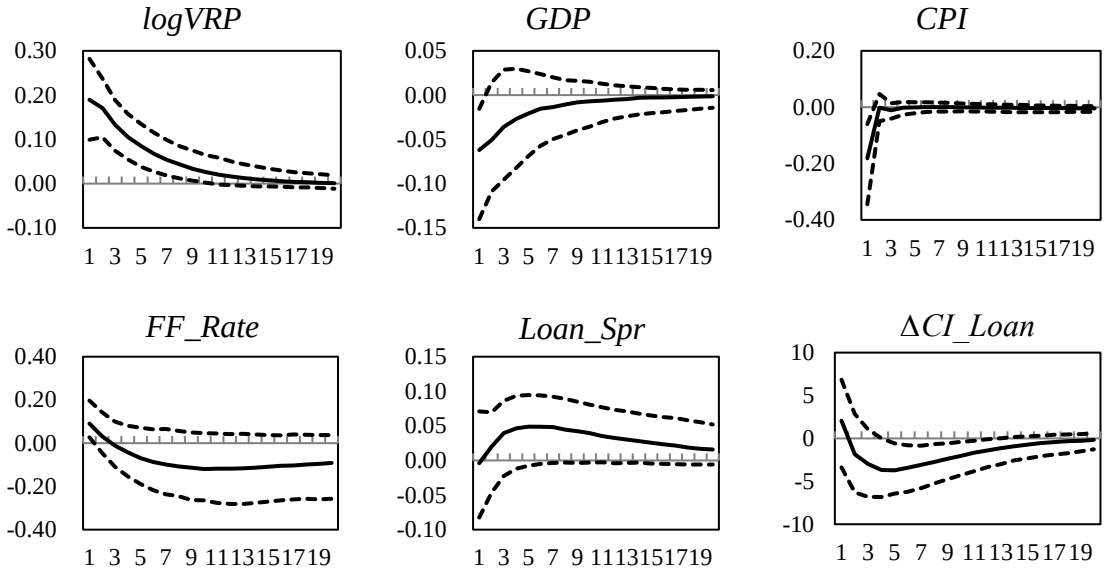


FIG. 5: Structural VAR with sign restrictions for the H8 C&I loan data.

NOTES: The solid line is the median impulse responses and the dotted lines represent the 16% and 84% quantiles of the posterior distribution of the 500 draws.

TABLE 1

Summary statistics

	Sample period	Obs.	Unit	Mean	Median	Std.	Min.	Max.
Δ*CI_Loan*	1990:1-2015:4	104	Billions	12.686	16.504	29.378	-98.558	86.128
VRP	1990:1-2015:4	104	%-squared	18.261	15.184	12.347	5.421	77.252
logVRP	1990:1-2015:4	104	--	2.690	2.663	0.582	1.686	4.341
FF_Rate	1990:1-2015:4	104	%	3.144	3.195	2.444	0.073	8.250
GDP	1990:1-2015:4	104	%	0.598	0.658	0.619	-2.135	1.871
CPI	1990:1-2015:4	104	%	0.609	0.634	0.623	-3.477	2.599
Credit_Spr	1990:1-2015:4	104	%	0.005	0.000	0.258	-1.030	1.720
Term_Spr	1990:1-2015:4	104	%	0.014	-0.020	0.397	-1.030	1.130
CSI	1990:1-2015:4	104	--	0.020	0.350	6.804	-19.100	22.200
Standard_LM	1990:1-2015:4	104	%	5.906	-2.600	23.189	-24.100	83.600
Standard _S	1990:1-2015:4	104	%	5.515	-1.800	19.864	-24.100	74.500
Demand_LM	1991:3-2015:4	98	%	-0.203	3.200	25.788	-70.200	45.500
Demand_S	1991:3-2015:4	98	%	0.515	5.300	22.974	-63.500	38.900
Spr_LM	1990:1-2015:4	104	%	-10.574	-30.150	43.532	-70.400	98.200
Spr_S	1990:1-2015:4	104	%	-8.139	-17.150	33.920	-57.800	92.700
LoanSize_LM	1990:1-2015:4	104	%	2.123	-5.400	21.068	-30.900	69.100
Maturity_LM	2005:2-2015:4	43	%	-3.619	-8.600	19.707	-25.500	61.800
Secured_LM	1990:1-2015:4	104	%	6.463	0.000	17.793	-16.700	60.000
Loan_Spr	1990:1-2015:4	104	%	2.291	2.180	0.500	1.560	3.490
Δ*Loan_FoF*	1990:1-2015:4	104	Billions	9.974	13.960	44.729	-149.850	146.370
Δ*Bond_FoF*	1990:1-2015:4	104	Billions	37.671	30.555	35.680	-38.340	142.980
Loan-Bond	1990:1-2015:4	104	%	-0.801	-0.439	3.024	-8.949	8.225
Loan/Debt	1990:1-2015:4	104	%	-0.187	-0.106	0.699	-2.146	1.944
LoanSize	1997:2-2015:4	75	Thousands	379.587	362.000	86.757	228.000	666.000
Maturity	1997:2-2015:4	75	Days	661.773	633.000	142.889	404.000	1,050.000
Secured	1997:2-2015:4	75	%	49.109	48.000	7.968	31.200	66.100
Synd_Loan	1990:1-2015:4	104	Billions	198.179	168.924	123.184	25.448	517.754
Spr_Synd	1990:1-2015:4	104	%	1.612	1.507	0.616	0.774	3.740
LoanSize_Synd	1990:1-2015:4	104	Millions	206.685	199.464	58.695	116.593	357.316
Maturity_Synd	1990:1-2015:4	104	Months	51.326	52.917	6.700	29.847	69.698
Secured_Synd	1990:1-2015:4	104	%	30.067	29.628	8.140	12.072	55.524

NOTES: The actual quarter covered in the survey is used to express the sample period for SLOOS data instead of using the release survey quarter. Variable definitions are provided in Table A3.

TABLE 2

Correlation matrix

	Synd_Loan	*Spr_Synd*	*Spr_LM*	*Standard_LM*	*Demand_LM*	*logVRP*	*FF_Rate*	*GDP*	*CPI*	*Credit_Spr*	*Term_Spr*	*CSI*
Panel A: correlations between VRP, bank loans, and other macro variables												
Δ*CI_Loan*	0.629***	-0.427***	-0.337***	-0.137	0.411***	-0.414***	0.089	0.059	-0.041	0.366***	-0.201**	-0.102
Synd_Loan		0.052	-0.522***	-0.366***	0.314***	-0.387***	-0.428***	0.074	-0.151	0.099	-0.195**	0.058
Spr_Synd			0.199**	0.112	-0.349***	0.441***	-0.692***	-0.313***	-0.186*	-0.219**	0.129	0.047
Spr_LM				0.896***	-0.707***	0.668***	0.273***	-0.393***	0.020	0.127	0.393***	-0.147
Standard_LM					-0.696***	0.589***	0.314***	-0.431***	0.014	0.242**	0.399***	-0.182*
Demand_LM						-0.532***	-0.005	0.472***	0.148	-0.077	-0.373***	0.223**
logVRP							0.009	-0.234**	-0.080	0.048	0.224**	-0.162
FF_Rate								0.151	0.316***	0.043	0.100	-0.124
GDP									0.233**	-0.223**	-0.233**	0.183*
CPI										-0.512***	0.114	-0.235**
Credit_Spr											-0.108	-0.178*
Term_Spr												0.055

	Factor1	*Factor2*	*Factor3*	*Factor4*	*Factor5*	*Factor6*
Panel B: correlations after principal component analysis						
Δ*CI_Loan*	-0.143	0.088	-0.327***	0.101	0.051	0.228**
Synd_Loan	-0.218**	-0.266***	-0.068	-0.248**	0.178*	0.152
Spr_Synd	-0.261***	-0.189*	0.458***	-0.529***	0.088	-0.065
Spr_LM	-0.057	0.471***	0.260***	0.198**	-0.107	-0.027
Satndard_LM	-0.106	0.547***	0.221**	0.245**	-0.099	0.049
Demand_LM	0.207**	-0.431***	-0.336***	0.023	0.020	0.187*
logVRP	-0.106	0.244**	0.171*	-0.018	0.041	-0.139

NOTES: *Factor1*, *Factor2*, …, *Factor6* are six principal components obtained from the Federal funds rate (*FF_Rate*), real GDP growth rate (*GDP*), percentage change in CPI (*CPI*), Baa-Aaa corporate bond yield spread (*Credit_Spr*), 10-1 year Treasury yield spread (*Term_Spr*), and the change in the Index of Consumer Sentiment from the University of Michigan (*CSI*) by using principal component analysis. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are provided in Table A3.

TABLE 3

The effect of economic uncertainty on bank lending

Panel A: Loan Quantity

	(1)	(2)
	ΔCI_Loan	*Synd_Loan*
$logVRP_{t-1}$	-21.925	-86.490
	(0.000)	(0.000)
adj. R^2	0.319	0.330

Panel B: Loan Standard (Supply) and Demand

	(1)	(2)	(3)	(4)
	Standard_LM	*Standard_S*	*Demand_LM*	*Demand_S*
$logVRP_{t-1}$	15.986	13.031	-15.639	-16.346
	(0.000)	(0.000)	(0.001)	(0.000)
adj. R^2	0.553	0.548	0.415	0.488

Panel C: Loan Spreads

	(1)	(2)	(3)	(4)
	Spr_LM	*Spr_S*	*Loan_Spr*	*Spr_Synd*
$logVRP_{t-1}$	41.498	28.194	0.160	0.431
	(0.000)	(0.000)	(0.003)	(0.000)
adj. R^2	0.610	0.516	0.679	0.746

NOTES: The regression follows equation (1): $Loan\ variable_t = \alpha + \beta logVRP_{t-1} + \boldsymbol{X\Gamma} + \varepsilon_t$ where $\boldsymbol{X}$ comprises the six principal components obtained from the Federal funds rate (*FF_Rate*), real GDP growth rate (*GDP*), percentage change in CPI (*CPI*), Baa-Aaa corporate bond yield spread (*Credit_Spr*), 10-1 year Treasury yield spread (*Term_Spr*), and the change in the Index of Consumer Sentiment from the University of Michigan (*CSI*) and their coefficients are not reported in the table. Variable definitions are provided in Table A3. P-values reported in parentheses are based on Newey-West heteroskedasticity and autocorrelation consistent standard errors. There are 103 observations.

TABLE 4

The effects of uncertainty on loan terms (quantity, price, non-price) during recession and non-recession periods

Panel A: Effect of uncertainty on non-price loan terms

	(1) *LoanSize_LM* (SLOOS)	(2) *Maturity_LM* (SLOOS)	(3) *Secured_LM* (SLOOS)	(4) *LoanSize* (STBL)	(5) *Maturity* (STBL)	(6) *Secured* (STBL)	(7) *LoanSize_Synd* (LPC)	(8) *Maturity_ Synd* (LPC)	(9) *Secured_ Synd* (LPC)
$logVRP_{t-1}$	19.119	11.628	15.536	-10.320	-101.668	-0.314	-49.438	-5.045	6.963
	(0.000)	(0.029)	(0.000)	(0.512)	(0.000)	(0.814)	(0.000)	(0.000)	(0.000)
Obs.	103	43	103	75	75	75	103	103	103
adj. R^2	0.601	0.404	0.545	0.019	0.474	0.254	0.354	0.462	0.329

Panel B: Effect of uncertainty on non-price loan terms in recession and non-recession periods

$logVRP_{t-1}$	22.731***	12.421***	18.997***	-17.602	-109.612	-0.144	-51.154	-5.478	7.760
$\times D_{REC}$	(0.000)	(0.001)	(0.000)	(0.286)	(0.000)	(0.918)	(0.000)	(0.000)	(0.000)
$logVRP_{t-1}$	16.036	-0.792	12.581	-6.695	-97.713	-0.399	-47.973	-4.675	6.282
$\times (1 - D_{REC})$	(0.000)	(0.868)	(0.000)	(0.699)	(0.000)	(0.779)	(0.000)	(0.000)	(0.000)
Obs.	103	43	103	75	75	75	103	103	103
adj. R^2	0.651	0.670	0.615	0.025	0.470	0.243	0.349	0.464	0.340

Panel C: Effect of uncertainty on loan quantity and price in recession and non-recession periods

	(1) ΔCI_Loan (H8)	(2) *Synd_Loan* (LPC)	(3) *Standard_LM* (SLOOS)	(4) *Standard_S* (SLOOS)	(5) *Demand_LM* (SLOOS)	(6) *Demand_S* (SLOOS)	(7) *Spr_LM* (SLOOS)	(8) *Spr_S* (SLOOS)	(9) *Loan_Spr* (STBL)	(10) *Spr_Synd* (LPC)
$logVRP_{t-1}$	-23.419	-89.499	20.720***	17.842***	-18.381*	-20.346***	49.515***	36.285***	0.138	0.432
$\times D_{REC}$	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.011)	(0.000)
$logVRP_{t-1}$	-20.649	-83.919	11.944	8.923	-13.526	-13.265	34.652	21.284	0.173	0.430
$\times (1 - D_{REC})$	(0.001)	(0.000)	(0.000)	(0.000)	(0.009)	(0.001)	(0.000)	(0.000)	(0.003)	(0.000)
Obs.	103	103	103	103	98	98	103	103	104	103
adj. R^2	0.317	0.324	0.628	0.656	0.427	0.531	0.639	0.614	0.679	0.743

NOTES: Panel A reports the results for the regression: $Y_t = \alpha + \beta logVRP_{t-1} + \boldsymbol{X\Gamma} + \varepsilon_t$ while Panels B and C report the results for the regression: $Y_t = \alpha + \beta_R logVRP_{t-1} \times D_{REC} + \beta_{NR} logVRP_{t-1} \times (1 - D_{REC}) + \boldsymbol{X\Gamma} + \varepsilon_t$ where Y_t is one of the variables reported in the first row of Panels A and C and $\boldsymbol{X}$ comprises the six principal components obtained from the Federal funds rate (*FF_Rate*), real GDP growth rate (*GDP*), percentage change in CPI (*CPI*), Baa-Aaa corporate bond yield spread (*Credit_Spr*), 10-1 year Treasury yield spread (*Term_Spr*), and the change in the Index of Consumer Sentiment from the University of Michigan (*CSI*). The coefficients on $\boldsymbol{X}$ are not reported in the table. D_{REC} is a recession dummy which equals 1 for the NBER recession dates: 1990:3-1991:1, 2001:1-2001: 4 and 2007:4-2009:2, and 0 otherwise. Variable definitions are provided in Table A3. P-values reported in parentheses are based on Newey-West heteroskedasticity and autocorrelation consistent standard errors.

TABLE 5

Results of loan-to-bond substitution approach

	(1)	(2)	(3)	(4)
	ΔLoan_FoF	*ΔBond_FoF*	*Loan-Bond*	*Loan/Debt*
$logVRP_{t-1}$	-26.071	-2.888	-1.465	-0.331
	(0.002)	(0.701)	(0.010)	(0.012)
Factor1	0.898	-0.244	-0.082	-0.021
	(0.724)	(0.924)	(0.549)	(0.515)
Factor2	2.388	-1.996	0.092	0.022
	(0.538)	(0.430)	(0.693)	(0.688)
Factor3	-9.671	6.827	-0.799	-0.188
	(0.009)	(0.040)	(0.001)	(0.001)
Factor4	11.226	-8.501	0.641	0.144
	(0.014)	(0.033)	(0.022)	(0.028)
Factor5	-2.475	6.953	-0.352	-0.066
	(0.642)	(0.128)	(0.316)	(0.420)
Factor6	11.451	-3.828	0.788	0.190
	(0.168)	(0.512)	(0.077)	(0.064)
Intercept	80.385	45.372	3.158	0.708
	(0.000)	(0.029)	(0.045)	(0.054)
Obs.	103	103	103	103
adj. R^2	0.257	0.051	0.237	0.234

NOTES: The regression model is

$$Y_t = \beta_0 + \beta_1 logVRP_{t-1} + \beta_2 Factor1_t + \beta_3 Factor2_t + \beta_4 Factor3_t + \beta_5 Factor4_t + \beta_6 Factor5_t + \beta_7 Factor6_t + \varepsilon_t$$

where Y_t is one of following variables: the change in the sum of Depository Institution Loans Not Elsewhere Classified and Other Loans and Advances (*ΔLoan_FoF*); the change in the sum of Commercial Paper and Corporate Bonds (*ΔBond_FoF*); the difference in the growth rates between *Loan_FoF* and *Bond_FoF* (*Loan-Bond*); the change in the ratio of *Loan_FoF* to the sum of *Loan_FoF* and *Bond_FoF* (*Loan/Debt*). *Factor1*, *Factor2*, …, *Factor6* are six principal components obtained from the Federal funds rate (*FF_Rate*), real GDP growth rate (*GDP*), percentage change in CPI (*CPI*), Baa-Aaa corporate bond yield spread (*Credit_Spr*), 10-1 year Treasury yield spread (*Term_Spr*), and the change in the Index of Consumer Sentiment from the University of Michigan (*CSI*). Variable definitions are provided in Table A3. P-values reported in parentheses are based on Newey-West heteroskedasticity and autocorrelation consistent standard errors.

TABLE 6

Sign restrictions in SVAR models

Shock	Responses to a shock					
	logVRP	*GDP*	*CPI*	*FF_Rate*	*Loan_Spr / Spr_Synd*	*ΔCI_Loan / Synd_Loan*
Uncertainty	+	−	unrestricted	unrestricted	unrestricted	−
Monetary policy	unrestricted	−	−	+	unrestricted	unrestricted

Notes: Sign restrictions are imposed for one quarter on the impulse responses to contractionary shocks for monetary policy and positive economic uncertainty shocks.

Appendix

TABLE A1
Granger causality test results

Causality		χ^2 (P-value)
from	to	
ERV	VIX^2	2.054 (0.358)
logVRP	VIX^2	10.479 (0.005)
VIX^2	*ERV*	29.168 (0.000)
logVRP	*ERV*	8.723 (0.013)
VIX^2	*logVRP*	3.523 (0.172)
ERV	*logVRP*	0.300 (0.861)

NOTES: This table reports the results of Granger causality tests. The vector autoregressive model is

$$VIX_t^2 = \alpha_0 + \alpha_1 VIX_{t-1}^2 + \alpha_2 VIX_{t-2}^2 + \alpha_3 ERV_{t-1} + \alpha_4 ERV_{t-2} + \alpha_5 logVRP_{t-1} + \alpha_6 logVRP_{t-2} + \varepsilon_t$$

$$ERV_t = \beta_0 + \beta_1 VIX_{t-1}^2 + \beta_2 VIX_{t-2}^2 + \beta_3 ERV_{t-1} + \beta_4 ERV_{t-2} + \beta_5 logVRP_{t-1} + \beta_6 logVRP_{t-2} + \varsigma_t$$

$$logVRP_t = \gamma_0 + \gamma_1 VIX_{t-1}^2 + \gamma_2 VIX_{t-2}^2 + \gamma_3 ERV_{t-1} + \gamma_4 ERV_{t-2} + \gamma_5 logVRP_{t-1} + \gamma_6 logVRP_{t-2} + \xi_t$$

The lag length is determined by the Bayesian information criterion (BIC). Variable definitions are provided in Table A3.

TABLE A2

Regressions of loan supply and demand on *logVRP* and VIX^2

	(1) *Standard_LM*	(2) *Demand_LM*	(3) *Standard_LM*	*Demand_LM*
logVRP			13.307	-15.955
			(0.022)	(0.098)
VIX^2	0.395	-0.342	0.142	-0.040
	(0.000)	(0.001)	(0.216)	(0.841)
Factor1	2.822	-0.818	0.442	1.920
	(0.032)	(0.661)	(0.770)	(0.434)
Factor2	7.559	-6.992	8.135	-8.231
	(0.000)	(0.003)	(0.000)	(0.001)
Factor3	3.416	-6.729	3.038	-6.322
	(0.014)	(0.002)	(0.032)	(0.004)
Factor4	6.662	-0.990	6.320	-0.863
	(0.000)	(0.638)	(0.000)	(0.686)
Factor5	-2.850	1.904	-3.497	3.395
	(0.173)	(0.390)	(0.120)	(0.136)
Factor6	5.013	4.600	5.125	3.948
	(0.307)	(0.190)	(0.286)	(0.255)
Intercept	-9.025	11.750	-35.246	42.883
	(0.000)	(0.005)	(0.001)	(0.022)
Obs.	104	98	104	98
adj. R^2	0.590	0.426	0.609	0.445

NOTES: The regression model is

$$Y_t = \beta_0 + \beta_1 logVRP_t + \beta_2 VIX_t^2 + \beta_3 Factor1_t + \beta_4 Factor2_t + \beta_5 Factor3_t + \beta_6 Factor4_t + \beta_7 Factor5_t + \beta_8 Factor6_t + \varepsilon_t$$

where Y_t is either *Standard_LM*, *Standard_S*, *Demand_LM*, or *Demand_S*. *Factor1*, *Factor2*, …, *Factor6* are six principal components obtained from the Federal funds rate (*FF_Rate*), real GDP growth rate (*GDP*), percentage change in CPI (*CPI*), Baa-Aaa corporate bond yield spread (*Credit_Spr*), 10-1 year Treasury yield spread (*Term_Spr*), and the change in the Index of Consumer Sentiment from the University of Michigan (*CSI*). Variable definitions are provided in Table A3. P-values reported in parentheses are based on Newey-West heteroskedasticity and autocorrelation consistent standard errors.

TABLE A3
Variable definitions and data sources

Variable	Definition
Key and control independent variables	
VRP	Quarterly average of the monthly variance risk premium (or end-of-the-month variance risk premium when the dependent variable is from STBL).
logVRP	The natural logarithm of *VRP*.
Δ*CI_Loan*	Change in total commercial and industrial loans.
FF_Rate	Quarterly average in federal funds rate.
GDP	Percentage change in real GDP (seasonally adjusted).
CPI	Percentage change in Consumer Price Index (seasonally adjusted).
Credit_Spr	Change in the difference between the yields of Baa and Aaa corporate bonds.
Term_Spr	Change in the difference between the yields of 10-year and 1-year Treasury bonds.
CSI	Change in the Index of Consumer Sentiment from the University of Michigan.
SLOOS data	
Standard_LM	Net percentage of domestic banks tightening standards for C&I loans to large and medium firms.
Standard _S	Net percentage of domestic banks tightening standards for C&I loans to small firms.
Demand_LM	Net percentage of domestic banks reporting stronger demand for C&I loans from large and medium firms.
Demand_S	Net percentage of domestic banks reporting stronger demand for C&I loans from small firms.
Spr_LM	Net percentage of domestic banks increasing spreads of C&I loan rates over banks' cost of funds to large and medium firms.
Spr_S	Net percentage of domestic banks increasing spreads of C&I loan rates over banks' cost of funds to small firms.
LoanSize_LM	Net percentage of domestic banks tightening standard on maximum size of credit lines to large and medium firms.
Maturity_LM	Net percentage of domestic banks tightening standard on maximum maturity of loans or credit lines to large and medium firms.
Secured_LM	Net percentage of domestic banks tightening standard on collateralization requirements to large and medium firms.
STBL data	
LoanSize	Average loan size.
Loan_Spr	Domestic banks' C&I loan rate spreads over intended federal funds rate.
Maturity	Average maturity days weighted by loan amount.
Secured	Percent of loan amount secured by collateral.
LPC syndicated loan data	
Synd_Loan	Quarterly volume of syndicated bank loans.
Spr_Synd	Weighted average loan spreads over LIBOR in the syndicated loan market.
LoanSize_Synd	Average loan size in the syndicated loan market.
Maturity_Synd	Average maturity months weighted by loan amount in the syndicated loan market.
Secured_Synd	Percent of loan amount secured by collateral in the syndicated loan market.
Flow of Funds data	

Δ*Loan_FoF*	Change in Non-financial corporate business debt from Flow of Funds data on Depository Institution Loans Not Elsewhere Classified and Other Loans and Advances.
Δ*Bond_FoF*	Change in Non-financial corporate business debt from Flow of Funds data on Commercial Paper and Corporate Bonds.
Loan-Bond	The growth rate of *Loan_FoF* minus the growth rate of *Bond_FoF*.
Loan/Debt	Change in the ratio of *Loan_FoF* to the sum of *Loan_FoF* and *Bond_FoF*.

NOTES: The computation of *VRP* uses *VIX* which is obtained from CBOE website and intraday S&P500 index which is taken from Tick Data. LPC syndicated loan sample comprises U.S.-dollar denominated loans which are syndicated in the US. These loans are distributed through syndication or club deal, and the loans are term loans or revolving loans. All data other than those otherwise specified are obtained from the Federal Reserve Bank of St Louis. Data for *LoanSize_LM*, *Maturity_LM*, *Secure_LM* and *Loan_Spr* are obtained from Federal Reserve Board Statistical Release. LPC LoanConnector data are from Thomson Reuters.

TABLE A4

Regression results for simultaneous equations model of loan supply and demand

	Standard_LM	*Demand_LM*
$logVRP_{t-1}$	11.724	-14.974
	(0.019)	(0.039)
Standard_LM		-0.004
		(0.991)
Demand_LM	-0.279	
	(0.297)	
Factor1		2.947
		(0.094)
Factor2	8.126	-10.180
	(0.010)	(0.023)
Factor3	0.875	-4.999
	(0.642)	(0.015)
Factor4	5.414	
	(0.000)	
Factor6		6.643
		(0.082)
Intercept	-26.113	38.986
	(0.047)	(0.028)
Obs.	98	98
adj. R^2	0.613	0.458

NOTES: The simultaneous equations model is

$$Standard\_LM_t = \alpha_0 + \alpha_1 logVRP_{t-1} + \alpha_2 Demand\_LM_t + \alpha_3 Factor2_t + \alpha_4 Factor3_t + \alpha_5 Factor4_t + \varepsilon_{1t}$$

$$Demand\_LM_t = \beta_0 + \beta_1 logVRP_{t-1} + \beta_2 Standard\_LM_t + \beta_3 Factor1_t + \beta_4 Factor2_t + \beta_5 Factor3_t + \beta_6 Factor6_t + \varepsilon_{2t}$$

The choice of exogenous variables is based on Panel B of Table 2. *Factor1*, *Factor2*, …, *Factor6* are six principal components obtained from the Federal funds rate (*FF_Rate*), real GDP growth rate (*GDP*), percentage change in CPI (*CPI*), Baa-Aaa corporate bond yield spread (*Credit_Spr*), 10-1 year Treasury yield spread (*Term_Spr*), and the change in the Index of Consumer Sentiment from the University of Michigan (*CSI*). Variable definitions are provided in Table A3. P-values are shown in parentheses.

Table A5

Simultaneous equations model for syndicated loan quantum and spreads.

	Synd_Loan	*Spr_Synd*
$logVRP_{t-1}$	-103.658	0.389
	(0.001)	(0.000)
Synd_Loan		-0.001
		(0.566)
Spr_Synd	32.495	
	(0.507)	
Factor1	-15.842	-0.120
	(0.103)	(0.000)
Factor2	-24.366	-0.167
	(0.014)	(0.000)
Factor3		0.222
		(0.000)
Factor4	-17.389	-0.357
	(0.392)	(0.000)
Factor5	25.587	
	(0.065)	
Intercept	425.535	0.671
	(0.000)	(0.113)
Obs.	103	103
adj. R^2	0.351	0.746

NOTES: The simultaneous equations model is

$$Synd\_Loan_t = \alpha_0 + \alpha_1 logVRP_{t-1} + \alpha_2 Spr\_Synd_t + \alpha_3 Factor1_t + \alpha_4 Factor2_t + \alpha_5 Factor4_t + \alpha_6 Factor5 + \varepsilon_{1t}$$

$$Spr\_Synd_t = \beta_0 + \beta_1 logVRP_{t-1} + \beta_2 Synd\_Loan_t + \beta_3 Factor1_t + \beta_4 Factor2_t + \beta_5 Factor3_t + \beta_6 Factor4_t + \varepsilon_{2t}$$

The choice of exogenous variables is based on Panel B of Table 2. *Factor1*, *Factor2*, …, *Factor6* are six principal components obtained from the Federal funds rate (*FF_Rate*), real GDP growth rate (*GDP*), percentage change in CPI (*CPI*), Baa-Aaa corporate bond yield spread (*Credit_Spr*), 10-1 year Treasury yield spread (*Term_Spr*), and the change in the Index of Consumer Sentiment from the University of Michigan (*CSI*). The model is estimated using three-stage least squares. Variable definitions are provided in Table A3. P-values are shown in parentheses.