Monetary Policy and Corporate Debt Structure

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Abstract

This paper evaluates and compares the effects of conventional and unconventional monetary policies on the corporate debt structure in the United States. It does so by using a vector autoregression in which policy shocks are identified through high-frequency external instruments. Our results show that both monetary policies shift the firms' composition of external financing, though in a different way. An expansionary conventional (unconventional) monetary policy leads to a rise (decline) in loans and a decline (rise) in debt securities issuance. Our results suggest that unconventional monetary policy operated not through a bank lending channel, but rather through a portfolio rebalancing channel.

Keywords: Corporate debt structure, Monetary policy, Proxy-SVARs.

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I Introduction

The composition of corporate credit in the United States has profoundly changed since the Great Recession. Adrian, Colla, and Shin (2013) highlight a decline in bank loans to non-financial corporations and a simultaneous increase in the corporate bonds issuance. At the same time, the Federal Reserve began to implement unconventional monetary policy measures to improve firms' financing conditions and stimulate the real economy. The coincidence of both events motivates us to investigate the following questions. Has monetary policy contributed to the change in the corporate debt structure that occurred after 2008? And more generally, do conventional and unconventional monetary policies affect corporate bonds and loans in a similar way? It is important to investigate the impact of monetary policy on firms' debt choices for, at least, two reasons. First, if a monetary tightening decreases bank loans but stimulates corporate bond issuance, then the effectiveness of monetary policy is hampered and the availability of *total* corporate credit (bonds and loans included) becomes crucial for understanding monetary policy transmission.[1] Second, a better understanding of similarities and differences in transmission mechanisms across monetary policy regimes is not only essential for policymakers, but it would also help generating improved business cycle monetary models.

In this paper we study the transmission mechanism of structural monetary policy shocks on borrowing activities of non-financial corporations. To do so, we employ a class of vector autoregressions (VARs) in which monetary policy shocks are identified with high frequency external instruments, along the lines of Stock and Watson (2012) and Mertens and Ravn (2013). VARs are estimated using U.S. data at monthly frequency from 1990 to 2015 and includes the 1-year and 10-year U.S. zero coupon bond yields, the unemployment rate, consumer prices, a credit spread, and an external debt instrument directly drawn from the "Financial Accounts of the United States". Our external instruments are based on high-

[1] Among others, Becker and Ivashina (2014) show that firms switch from loans to bonds following a more restrictive conventional monetary policy stance.

frequency jumps (or more commonly called surprises) in the term structure of interest rates around Federal Open Market Committee (FOMC) announcements. By doing so, we are able to isolate the behavior of monetary policy as much as possible and to disentangle conventional and unconventional monetary policy shocks as they operate at different points on the term structure. More specifically, conventional surprises capture unexpected current and short-term future changes to the target federal funds rate, while unconventional surprises reflect shifts in long-term interest rates that are mainly driven by large-scale asset purchases. Hence, our VARs make possible to trace out the dynamics effects of the two types of shocks on borrowing activities of non-financial corporations.

Our results show that conventional and unconventional monetary shocks shift the firms' composition of external financing, though in a different way. Whereas expansionary innovations to conventional monetary policy caused by target and forward guidance surprises induce a rise in loans and a decline in debt securities issuance, exactly the opposite is the case for innovations to unconventional monetary policy that are principally due to asset purchases announcements. By decomposing each debt instrument, we show that (i) the movements in loans primarily reflect changes in bank and mortgage loans, and (ii) movements in debt securities are mainly driven by changes in corporate bonds and municipal securities.

Our results point toward the conclusion that conventional monetary policy works through a bank lending channel, as conventional monetary easing increases the availability of loans and reduces securities issuance. By contrast, unconventional policy measures, and asset purchases in particular, stimulate debt securities issuance and decrease loans, which is suggestive of a substitution effect from bank loans toward bonds, in line with a portfolio rebalancing channel of unconventional monetary policy rather than a bank lending channel. Overall, our results highlight that monetary policy has different effects on intermediated and direct credit.

To provide further evidence on the underlying transmission mechanisms of both types of monetary policy shocks, we re-estimate several VARs, in which we add additional variables on credit prices. This analysis suggests that asset purchases operated through (i) a risk taking channel — i.e., more incentives for investors to search for higher yields in more risky projects — which has been triggered by spread compression between risky and safe assets, and (ii) a duration risk channel — i.e., decline in duration risk in the hands of investors, reducing longer-term yields — which is the result of a reduced availability of longer-duration assets.

The reminder of the paper is organized as follows. Section II places our paper with respect to the existing literature. Section III presents a brief evolution of U.S. corporate debt structure. Section IV explains our empirical framework. Section V presents the results of the paper. Section VI concludes.

II Related Literature

This paper belongs to the literature that shows that firms move towards bond market financing following a conventional monetary tightening. Notable examples include Kashyap, Stein, and Wilcox (1993) and Becker and Ivashina (2014). This substitution between bank credit and securities is in line with papers on the bank lending channel of monetary policy (e.g., Kashyap and Stein, 1995, 2000; Jimenez, Ongena, Peydro, and Saurina, 2012). We differ from these papers in that we (i) compare the effects of conventional and unconventional monetary policy on corporate debt structure, (ii) conduct a time series structural VAR estimation, (iii) use aggregate data, drawn from the flow of funds, (iv) identify monetary policy with high-frequency instruments. Furthermore, our class of linear VAR models does not allow us to capture asymmetric effects of shocks, whereby the impulse response to a structural shock depends on the sign of that shock. By contrast, Kashyap, Stein, and Wilcox (1993) focus exclusively on episodes where the Federal Reserve opted for a tighter monetary policy.

Our paper connects to the broader literature studying the impact of unconventional monetary policy on the corporate debt structure. Some recent papers show that unconventional monetary easing contributed to increase in corporate bond issuance (e.g., Lo Duca, Nicoletti, and Vidal Martínez, 2016; Foley-Fisher, Ramcharan, and Yu, 2016; De Santis and Zaghini, 2019). This increase in bonds issuance is consistent with the portfolio rebalancing channel of central bank asset purchases, where the investors shift some of their portfolios into other assets, such as corporate bonds, thus reducing their yields (e.g., Gagnon, Raskin, Remache, and Sack, 2011; Krishnamurthy and Vissing-Jorgensen, 2011, 2012; D'Amico, English, López-Salido, and Nelson, 2012; Swanson, 2017). The evidence on the effects of central bank asset purchases on bank lending is rather mixed as they operate through several, sometimes off-setting channels. Studying the bank lending channel of the Federal Reserve's large-scale asset purchases, Rodnyansky and Darmouni (2017) find positive effects of the first and third round of quantitative easing (QE) on lending and no impact for the second round.[2] However, Chakraborty, Goldstein, and MacKinlay (2020) show that the banks benefiting from the Federal Reserve's MBS purchases increase mortgage origination, and at the same time, reduce commercial lending.[3] Hence, the Federal Reserve's MBS purchases seem to crowd out other types of loans, and in particular the loans to non-financial corporations. Another unintended effect of the central banks asset purchases on bank lending concerns the potential substitution of bank loans by corporate bond financing. For the euro area, and using micro-level data, Arce, Gimeno, and Mayordomo (2017) and Grosse-Rueschkamp, Steffen, and Streitz (2019) show the ECB corporate bond purchases made firms substitute bank loans with bond debt.[4] Fatouh, Markose, and Giansante (2019) present a model where lower bond yields caused by QE encourage the U.K. firms to substitute away from bank borrowing to bond issuance. Although our methodology and data set differ, the evidence shown in our paper is

[2]Focusing on the United Kingdom, Butt, Churm, McMahon, Morotz, and Schanz (2014) find no evidence that asset purchases in the United Kingdom operated via the bank lending channel. Using Japanese data Bowman, Cai, Davies, and Kamin (2015) find a positive but small effect of the Bank of Japan's QE on lending. With Spanish data, García-Posada and Marchetti (2016) show that the European Central Bank (ECB)'s very long term refinancing operations had a positive moderate-sized effect on the supply of bank credit to firms.

[3]The effect of Treasury purchases found by Chakraborty, Goldstein, and MacKinlay (2020) is either positive or insignificant in most cases. Their results suggest that Treasury purchases did not cause a large positive stimulus to the economy through the bank lending channel.

[4]Balloch (2018) documents a related effect on corporate debt structure with Japanese bond market development in the 1980s. She shows that firms that obtained access to the bond market used bond issuance to pay back bank debt.

supportive of this transmission channel.

Finally, our paper is related to an increasing literature studying the impact of monetary policy shocks using a VAR model with high-frequency external instruments. Notable examples include Gertler and Karadi (2015), Li and Zanetti (2016), Altavilla, Brugnolini, Gürkaynak, Motto, and Ragusa (2019), Caldara and Herbst (2019), and Jarociński and Karadi (2020). With respect to these papers, we study the role of conventional and unconventional monetary policy on corporate debt structure. The use of external instruments presents numerous advantages for researchers, as compared to traditional identification schemes. First we are able to measure the instantaneous impact of a policy surprise on market interest rates due to the event study framework. There is strong evidence from the event-study literature that various interest rates and asset returns respond immediately and substantively to monetary policy announcements (e.g., Kuttner, 2001; Gürkaynak, Sack, and Swanson, 2005). Second, we do not make make the unrealistic assumption that monetary policy has no immediate (i.e., within month) effect on certain macroeconomic variables, as assumed with recursive and non-recusive identifications (e.g., Leeper, Sims, and Zha, 1996; Christiano, Eichenbaum, and Evans, 1999). Third, it is unnecessary to consider the target federal funds rate as a policy indicator, which is not applicable at the effective lower bound.

III The Evolution of U.S. Corporate Debt Structure

To analyze the impact of monetary policy on corporate debt structure, we make extensive use of the data from the "Financial Accounts of the United States" (Z.1), which include data on transactions and levels of financial assets and liabilities, by sector and financial instrument. In particular, we extract time series data on total liabilities of non-financial corporate business sector (L.103). To better illustrate the corporate debt instruments we focus on in this paper, we present in Table 1 a sample data directly drawn from Z.1. for the second quarter of 2015. The data are in billions of current dollars.

As can be seen from the table, the liabilities of non-financial corporate business sector on financial assets amount to $16622.7 billion, half of which is in a form of debt: $5388.9 billion of debt securities and $2555.1 billion of loans. The remaining liabilities include: payment of trade and tax payables, foreign direct investment in U.S., and miscellaneous liabilities. However, since our analysis focuses on the main instruments of external financing, debt securities and loans, we do not provide any further details on other liabilities.

To have a better understanding of what each category of debt means, we look at their composition. Loans to non-financial corporate sector include: (i) depository institution loans not elsewhere classified ("bank loans"); (ii) mortgages; and (iii) other loans and advances ("other loans"). Depository institution loans not elsewhere classified are primarily loans from U.S.-chartered depository institutions, foreign banking offices in the U.S., banks in U.S.-affiliated areas, and credit unions. Mortgages include commercial mortgages. "Other loans and advances" include loans made by finance companies, savings institutions, and credit unions but also other entities. This category is an important component as the non-financial corporations receive loans not only from depository institutions, but also from insurance companies and pension funds, other financial institutions, other non-financial corporates, governments and creditors resident in the rest of the world. Other loans and advances are the most representative with $1141.5 billion, followed by bank loans ($833 billion), and mortgages ($580.6 billion).

Regarding debt securities, they include (i) commercial paper; (ii) municipal securities; and (iii) corporate bonds. While corporate bonds represent an overwhelming majority of securities, with $4673 billion in 2015.Q2, the amounts of municipal securities and commercial papers stand at only $536.5 billion and 179.3$ billion, respectively. It is worth mentioning that municipal securities issued by the non-financial corporate business are principally industrial revenue bonds. Most of the time, they are issued by a state or local government on behalf of a non-financial company for a particular project, such as a toll bridge or turnpike.

When subdividing debt into its short- and long-term components, short-term debt (i.e., bank loans, other loans, and commercial paper, according to Z.1 classification) accounts only for 27% of total debt, while long-term debt (i.e., mortgages, corporate bonds, municipal securities) for 73%.

Now that we have provided a detailed description of the composition of total debt for non-financial corporates, we can put it into a historical perspective. Panel A of Figure 1 shows the time series of loans and debt securities in tandem with the "bond share", defined as the ratio of debt securities to the sum of debt securities and loans, over the period 1990-2015. Panels B and C of the same figure report the time series of loans and debt securities sub-components.

Several comments deserve to be made with respect to Figure 1. While in 1990, the amount of loans and debt securities of non-financial corporates appear to be almost equivalent (bond share of about 47%), the share of securities in total debt had constantly and remarkably increased since 1990 to account for two-thirds of debt in 2015. During the economic recessions of 1990-1991 and 2008-2009, the U.S. economy was marked by a sharp rise in bond share, though both types of financing decline. Interestingly, the loan series appear to hike by early 2005, thus showing a procyclical pattern. The fact that bonds and loans display very divergent patterns over business cycle phases is very much in evidence (see, for example, Grjebine, Szczerbowicz, and Tripier (2018) for further analysis).

Regarding each category of loans, one can see from Panel B that their relative importance evolved over time as well. Indeed, the proportion of other loans to all outstanding loans granted to non-financial corporates increased from about one third in 1990 to almost 50% in 2015, thus accounting for the largest share of loans. Bank loans share in total loans diminished from 46% in 1990 to 20% in 2010 and recovered to 36% in 2015. Although graphically it seems that mortgage share remained constant over the time frame, it represented 21% in 1990 then increased from 2002 to attain 35% in the end of 2006 and descended to 18% in 2018. Regarding the components of debt securities (Panel C), their relative importance does not appear to have dramatically changed since 1990. While corporate bonds have always been the overwhelming component, the share of municipal securities to total securities tend to modestly increase since the early 2000s.

To sum up, this section provided evidence of shifts in the composition of external financing over time. The objective of the next sections is to understand the role of monetary policy in this shift.

IV Empirical Framework

This section outlines the empirical approach that is used to estimate the impact of conventional and unconventional monetary policies on U.S. corporate debt structure. Over the last decades, VAR models have been widely employed to estimate the effects of monetary policy shocks on the economy. Identified VAR modeling allows to analyze and interpret the data while avoiding potentially "incredible restrictions" on the structure of the economy. In this paper, we follow this long tradition and use the VAR framework to better understand the transmission mechanism of both conventional and unconventional monetary policy.

We employ a class of VAR models with the following form:

$$y_t = \sum_{i=1}^{\rho} B_i y_{t-i} + C_y + v_t, \qquad t = 1, \ldots, T, \tag{1}$$

where y_t includes the following variables $y_t \equiv [zc1_t, zc10_t, u_t, p_t, ebp_t, d_t]'$; $zc1_t$ is the 1-year U.S. zero-coupon yield; $zc10_t$ is the 10-year U.S. zero-coupon yield; u_t is the unemployment rate; p_t is the logarithm of the consumer price index; ebp_t is the Gilchrist and Zakrajšek (2012)'s excess bond premium; and d_t is the logarithm of an interpolated monthly corporate debt variable chosen among the following ones:

- Loans (bank loans, mortgages, others)
- Debt securities (municipal securities, commercial paper, corporate bonds)

Appendix A provides a detailed description of the data. The overall sample period is 1990:M1 to 2015:M12. Because of the relatively short number of observations compared to the number of variables, we present a sequence of VARs rather than a single one. Indeed, including all variables at once would lead to a problem of degrees-of-freedom. Following the monthly monetary VAR literature, we set the lag order to $\rho = 12$.

We assume that $\upsilon_t = A\varepsilon_t$ where ε_t has the following distribution:

$$p(\varepsilon_t) = \text{normal}(\varepsilon_t|0, I), \tag{2}$$

with I is an $n \times n$ identity matrix, and $\text{normal}(x|\mu, \Sigma)$ denotes the multivariate normal distribution of x with mean μ and variance Σ. This implies that υ_t has the following distribution $p(\upsilon_t) = \text{normal}(\upsilon_t|0, AA')$. The variable ε_t represents all structural shocks hitting the economy. Finally, C_y contains the constant terms; and T is the sample size.

Our approach to identification of monetary policies is based on the use of external instruments, z_t, along the lines of Stock and Watson (2012) and Mertens and Ravn (2013). More specifically, we employ the Bayesian method developed by Drautzburg (2020) with a flat prior. Under the assumption that the proxy is a valid instrument, the VAR identifies the impulse responses functions from the covariance of forecast errors and the instrument. See Appendix B for more details.

In order to isolate as much as possible the behavior of monetary policy and its effects, we use directly intradaily information, from which we can directly infer monetary policy surprises associated with Federal Open Market Committee (FOMC) announcements. We consider two separate measures of U.S. monetary policy surprises:

- *Conventional* monetary policy surprise (CMP-S). It is measured by the change in the three month ahead fed funds futures, from 10 minutes before the time of a FOMC or other monetary policy announcement to 20 minutes afterward.[5] Following Hanson and

[5]We use "standard HFI suprises" from Jarociński and Karadi (2018) that extend Gertler and Karadi (2015)-type surprises until 2016. We do not use Jarociński and Karadi (2018) "monetary policy shocks" that isolate further a monetary policy shock from a potential information shock in our main analysis, as we do not dispose of a similar measure for unconventional monetary policy surprises. However, we test it for

Stein (2015) and Gertler and Karadi (2015), our approach directly captures the two-dimensional aspect of conventional policy — the "target" surprise or the unanticipated component of the change in the current federal funds rate target, and the "path" surprise or the unanticipated component of the future policy rates that are independent of the current target rates. This second factor, emphasized by Gürkaynak, Sack, and Swanson (2005), captures Federal Reserve's communication policy, which have become more and more intensive affter the target rate hit its effective lower bound (ELB) in late 2008.

- *Unconventional* monetary policy surprise (UMP-S). It is captured by the residual from a regression of the change in the 10-year Treasury futures yield around the time of the announcement onto the CMP-S surprises.[6] We compute it only over the period associated with asset purchases and the ELB period (October 2008-December 2015). In line with Rogers, Scotti, and Wright (2018), we purge the unconventional monetary policy instrument from the conventional monetary policy developments, so as to capture changes in long-term interest rates associated with the FOMC announcements related to large-scale asset purchases.[7]

Some recent papers show that high-frequency changes in interest rates on the days of monetary policy announcements can also capture information shocks (e.g., Cieslak and Schrimpf, 2018; Jarociński and Karadi, 2018; Miranda-Agrippino and Ricco, 2018; Nakamura and Steinsson, 2018; Cesa-Bianchi, Thwaites, and Vicondoa, 2020). Here, we do not attempt to further disentangle monetary announcements. We leave this extension for future work.

Figure 2 shows the time series of conventional surprises over the period February 1994 (when the FOMC began announcing its decisions after committee) to December 2015, and

conventional monetary policy and the effects on corporate debt structure remain qualitatively the same.

[6]Unconventional monetary policies have been shown to affect longer-maturity rates (e.g., Wright, 2012; Gilchrist, López-Salido, and Zakrajšek, 2015; Rogers, Scotti, and Wright, 2018).

[7]We use Rogers, Scotti, and Wright (2018)'s unconventional monetary policy surprises: 10-year Treasury futures changes from 15 minutes before the time of the announcement to 1 hour and 45 minutes afterward to calculate our UMP-S. Our results on the UMP effects on corporate debt structure remain qualitatively unchanged if we use directly 10-year Treasury futures changes without cleansing them of the short rate effects.

the time series of unconventional surprises over the ELB period (October 2008—December 2015). The series are shown monthly and are constructed by adding up the intraday surprises occurring in month t on the days with monetary policy announcements. The surprises are set to zero when there is no monetary policy announcements within month. Positive values of the instruments mean unexpected tightenings. As can be seen from Figure 2, there are conventional surprises in the ELB period though their magnitude is relatively smaller than that before the ELB.

To sum up, we have two different instruments that we use to identify two types of monetary policy shocks. We transform intradaily instruments into monthly instruments to match the frequency of VARs by summing them. We estimate and identify each policy shock separately. Monetary policy shocks identified through our structural VARs are constructed to be accommodating surprises, where conventional shocks induce a within-month decline in 1-year yields, and unconventional shocks imply a within-month fall in 10-year yields.

V Empirical Results

We consider the effects of the two types of monetary policy shocks on a number of variables, showing impulse responses out to 36 months. The results shown are based on $10,000$ draws. We discarded the first ten percent draws as burn-in ($N_1 = 1,000$) so that to keep $N_2 = 9,000$ draws. In all reported results, we show exclusively the responses of corporate debt variables, d_t. Note that the behavior of the variables in the baseline models (i.e., VARs omitting d_t) remains essentially unchanged to the inclusion of the additional variable in the subsequent VARs.[8] Following Sims and Zha (1999), we report horizon-by-horizon 68% and 90% posterior density regions as "error bands".

Results for the effects on loans and corporate securities are shown in Figure 3. The left column shows that an expansionary conventional monetary policy shock induces a progressive increase in total loans granted to non-financial corporations that reaches 0.5% after 18

[8]Results of baseline models are available in Appendix C.

months, and an immediate and persistent fall in total debt securities. By contrast, the right column shows that unconventional monetary policy easing has the opposite effect. Total loans distributed to non-financial corporations display a rapid fall of around 0.5% within 6 months, with a subsequent recovery and rebound from 12 months as the expansion begins. Debt securities experience a rapid expansion and reach a 0.25% increase after one year.

Conventional and unconventional monetary policy shocks drive loans and debt securities in opposite directions. However, in case of loans this difference is short lived, while for the debt securities it is long lasting. As a way to illustrate the differences in dynamics between the two policy shocks, we report in the last column of Figure 3 the differences in their impulse responses. For total loans, when looking at the 16% and 84% percentiles, the responses to conventional and unconventional monetary policy shocks are remarkably different. The error bands lie within the same (positive) region in the short-run, indicating that differences between regimes are robust. Note, however, that these differences disappear quickly over the next months that follow the initial shock. By contrast, the differences in impulse responses of debt securities are persistent, with the error bands lying within the same (negative) region throughout the months. Summarizing, there is strong evidence that conventional and unconventional monetary policy shocks affect the corporate debt structure in a different way.

We now repeat the same exercise for the components of total loans and total debt securities. Figure 4 displays the responses of bank loans, mortgages, and other loans to two types of monetary policy shocks. Our results indicate that the initial rise in the total loan variable after a conventional monetary easing reflects an increase in each type of loan. In particular, they all rise about 0.50% after 24 months with a high posterior probability. For each component, a zero response is almost at the boundary of the 90 percent error bands, making results robust. Regarding unconventional policy shocks, the initial decline in total loans is exclusively attributable to bank loans and mortgages, with a sudden drop of 1% after a couple of months. Both the initial decline and the subsequent recovery and rebound appear relatively robust as evidenced by the posterior probability mass. In contrast, other loans react positively and immediately, with a posterior probability mass lying only within the positive region.

Figure 5 shows the responses of corporate bonds, commercial papers, and municipal securities to both types of policy shocks. As can be seen from this figure, the slow and persistent decline in debt securities is explained by the corporate bonds developments, which exhibit a similar response pattern. Municipal securities also contribute to the decline in debt securities, but only in the short run. By contrast, the response of commercial papers remains relatively uncertain as suggested by its 68% and 90% error bands. Regarding unconventional policy shocks, the initial rise then persistent pattern in total debt securities primarily reflect an increase in corporate bonds and municipal securities, with a maximum rise of about 0.25% and 1%, respectively, attained 12 months after the shock. In contrast, commercial papers experience a large and immediate decline, reach their minimum, then begin to recover in a steady manner.

Looking at conventional monetary policy shocks, our results are in line with Kashyap, Stein, and Wilcox (1993) and Becker and Ivashina (2014); conventional monetary policy easing increases loans granted to non-financial corporations but reduces corporate bond issuance, thus supporting the existence of a "bank lending channel" of conventional monetary transmission. Unconventional monetary policy, characterized by asset purchases, appear to have a different transmission channel: unconventional policy easing decreases loans in the short run but stimulates corporate debt securities issuance. A possible explanation for this loans behavior could be that by relaxing conditions on corporate bond markets, unconventional monetary policy reduces the firms' need to draw on bank credit lines. This corroborates with the empirical micro literature that shows how policies that stimulate bond markets play a role in the substitution of bank loans toward bonds (e.g., Arce, Gimeno, and Mayordomo, 2017; Balloch, 2018; Grosse-Rueschkamp, Steffen, and Streitz, 2019). An increase in long-term corporate bonds is also in line with the "gap-filling" theory by Greenwood, Hanson, and Stein (2010). When the central bank purchases long-term government bonds, there is a lack of long-term assets in the market. Acting as macro liquidity providers, firms fill the gap by issuing more long-term bonds to meet the demand for long-term assets. Furthermore, the appetite for long-term bonds in the detriment of short-term ones provides an explanation of the decline in commercial papers, whose their maturities range up to 270 days, with an average about 30 days.

To better understand the differences in the transmission mechanisms, Figure 6 shows the impact of the two policy shocks on various corporate credit costs. Once again, we consider a sequence of VARs which adds an additional credit cost variable to the baseline specification.

We first measure the responses of corporate bond yields to conventional and unconventional monetary policy shocks. Regarding AAA- and BAA-corporate yields (Panels A, B, E, F), their responses appear to be particularly sensitive to unconventional monetary policy shocks, with the corresponding declines of around 15 basis points on impact for both types of yields. By contrast, the response of those two yields to conventional monetary policy is muted on impact, and the decline that arrives later is much smaller in magnitude (around 5 basis points). This different response of corporate yields to both types of shocks is particularly interesting. A potential explanation is the so-called "portfolio rebalancing" channel of monetary transmission, where investors respond to the central bank assets purchases by increasing their demand for higher-yield assets, such as corporate securities. Such a channel turns out to be more active following an unconventional policy shock, particularly in the low interest rate environment. By providing a large amount of liquidity, asset purchases give incentives to investors who sold their safe assets to the central bank to rebalance their portfolio with riskier assets which in turn would drive up the prices of these assets. Furthermore, there is a decline in intermediate- and long-term BAA-AAA spreads (Panels K, L, O, P) in intermediate- and long-term corporate spreads over the relevant Treasury bond yield (Panels I, J, M, N), which appear to be more persistent after an unconventional monetary policy shock, thus suggesting a more pronounced "search for yield channel", as compared to conventional monetary policy. More persistent responses of corporate-sovereign spreads are also in line with "default risk channel" of non-standard policies, where the economic boost they provide reduces firms' default risk and therefore the corporate bond spreads decline (e.g., Krishnamurthy and Vissing-Jorgensen, 2011; Wright, 2012; Gilchrist, López-Salido, and Zakrajšek, 2015; Rogers, Scotti, and Wright, 2018). The above-mentioned channels could be a possible source of the substantial difference in the estimated responses of corporate debt structure after both policy shocks.

Another potential explanation for different effects of conventional and unconventional monetary policy on corporate debt structure is their different impact on price of duration risk. Following unconventional monetary policy shock, the long-short corporate spread (Panels D and H), which is defined as the difference between the long-term corporate yield and the 3-month commercial paper interest rate, exhibits an immediate and persistent decline of several basis points. This decline is consistent with the "duration risk channel" of unconventional monetary policy; by purchasing long-term assets, the monetary authority is able to reduce the duration risk in the hands of investors and thereby alter the yield curve, particularly reducing long-term bond yields relative to short-term yields. This channel is clearly not in evidence following a conventional monetary policy surprise, given that the conventional shock reduces short-term rate relatively to long-term yield. Indeed, it appears that the spread increases roughly by 10 basis points after the conventional shock, then returns to its pre-level shock after one year. A decrease in the long-short corporate spread after unconventional monetary policy shock could favor long-term debt issuance, such as corporate bonds, with respect to shorter-term debt, such as commercial paper.

Finally, the decline in the 30-year mortgage spread (i.e. the difference between the 30-year mortgage rate and the 10-year government bond rate) after a conventional monetary easing, is consistent with the increase in mortgage loans that we observed previously (Panel B, Figure 4). By contrast, unconventional easing raises this spread in six months following the shock, thus explaining the fall in the volume of mortgage loans in the short-term (Panel

E, Figure 4).

VI Conclusion

We have examined the effects of conventional and unconventional monetary policy shocks on U.S. corporate debt structure using a class of VAR models identified with high-frequency external instruments. Our results consistently show that both types of shocks affect the composition of debt structure, though in a different way: conventional monetary easing increases the share of loans in corporate debt financing while unconventional monetary easing increases the share of debt securities.

Say it differently, we find evidence that conventional monetary policy operates via a traditional bank lending channel in the spirit of Kashyap, Stein, and Wilcox (1993), but this is not the case for unconventional policy. This latter appears to work via portfolio rebalancing channels, and more particularly, via the search-for-yield and duration risk channels.

Overall, our findings suggest that further empirical research on conventional and unconventional monetary policy and their effects on the structure of corporate debt is crucial in order to better understand the mechanism of monetary transmission to the real economy. Some recent works shows that the corporate debt structure can alter the monetary policy transmission across firms and across countries (e.g., Darmouni, Giesecke, and Rodnyansky, 2019; Holm-Hadulla and Thürwächter, 2020). From a theoretical perspective, modeling such patterns is also an interesting future research topic.

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A Data

All variables are monthly time series covering January 1990 through December 2015. Underlying data for debt variables are quarterly; in those cases, we interpolate using the procedure described in Chow and Lin (1971) with monthly data on industrial production, consumption and commercial and industrial loans. Calculations use natural logs of all variables, except interest rate variables and the unemployment rate.

Variable	**Description**	**Source**
Unemployment rate	Unemployment Rate, Percent, Monthly, Seasonally Adjusted (SA)	FRED Economic Data
Prices	Consumer Price Index for All Urban Consumers: All Items, SA	FRED Economic Data
One-year Treasury yields	Fitted Yield on a 1-Year Zero Coupon Bond	Kim and Wright (2005)
Ten-year Treasury yields	Fitted Yield on a 10-Year Zero Coupon Bond	Kim and Wright (2005)
EBP	Excess Bond Premium	Gilchrist and Zakrajšek (2012)
Total loans	non-financial Corporate Business sector (L.103), Quarterly	U.S. Financial Accounts (Z.1)
Loans	non-financial Corporate Business sector (L.103), Quarterly	U.S. Financial Accounts (Z.1)
Mortgages	non-financial Corporate Business sector (L.103), Quarterly	U.S. Financial Accounts (Z.1)
Other loans	non-financial Corporate Business sector (L.103), Quarterly	U.S. Financial Accounts (Z.1)
Debt securities	non-financial Corporate Business sector (L.103), Quarterly	U.S. Financial Accounts (Z.1)

Commercial Paper	non-financial Corporate Business sector (L.103), Quarterly	U.S. Financial Accounts (Z.1)
Municipal securities	non-financial Corporate Business sector (L.103), Quarterly	U.S. Financial Accounts (Z.1)
Corporate bonds	non-financial Corporate Business sector (L.103), Quarterly	U.S. Financial Accounts (Z.1)
AAA	Moody's Seasoned Aaa Corporate Bond Yield, Monthly, Not SA	FRED Economic Data
BAA	Moody's Seasoned Baa Corporate Bond Yield, Monthly, Not SA	FRED Economic Data
Mortgage rate	30-Year Fixed Rate Mortgage Average	FRED Economic Data
Long-term Corporate yield	Bloomberg Barclays Long U.S. Corporate Yield, USD	Datastream
Commercial paper interest rate	3 month non-financial corporate Commercial paper, Middle rate	Datastream
Long-term Sovereign yield	Bloomberg Barclays U.S. Treasury, Long USD	Datastream
Intermediate-term Sovereign yield	Bloomberg Barclays U.S. Treasury, Intermediate USD	Datastream
Long-term Corporate yield	Bloomberg Barclays Long Corporate USD	Datastream
Intermediate-term Corporate yield	Bloomberg Barclays Intermediate Corporate USD	Datastream
Long-term AAA	Aaa Long-term Corporate yield, Bloomberg Barclays	Datastream
Intermediate AAA	Aaa Intermediate-term Corporate, yield, Bloomberg Barclays	Datastream
Long-term BAA	Baa Long-term Corporate yield, Bloomberg Barclays	Datastream

Intermediate BAA	Baa Intermediate-term Corporate, yield, Bloomberg Barclays	Datastream
Industrial production	Indus. Production Index, Monthly, SA	FRED Economic Data
Consumption	Personal Consumption Expenditures, Monthly, SA	FRED Economic Data
Commercial and industrial loans	All Commercial Banks, Monthly, SA	FRED Economic Data

B Gibbs Sampler for Proxy-VARs

We employ a VAR model of the following form:

$$y_t = \sum_{i=1}^{\rho} B_i y_{t-i} + C_y + \upsilon_t, \qquad t = 1, \dots, T, \tag{3}$$

where y_t is an $n \times 1$ vector of endogenous variables; C_y contains the constant terms; ρ is the number of lags; and T is the sample size. We assume that $\upsilon_t = A\varepsilon_t$ where ε_t has the following distribution:

$$p(\varepsilon_t) = \text{normal}(\varepsilon_t | 0, I), \tag{4}$$

with I is an $n \times n$ identity matrix, and $\text{normal}(x|\mu, \Sigma)$ denotes the multivariate normal distribution of x with mean μ and variance Σ. This implies that υ_t has the following distribution $p(\upsilon_t) = \text{normal}(\upsilon_t | 0, AA')$. The variable ε_t represents all structural shocks hitting the economy.

We apply the following partition $y_t = \left[y_t^p, y_t^{\neq p}\right]$ where y_t^p represents the policy indicator, and $y_t^{\neq p}$ denotes the remaining endogenous variables; and $\varepsilon_t = \left[\varepsilon_t^p, \varepsilon_t^{\neq p}\right]$ where ε_t^p represents exogenous variations in the policy indicator, and $\varepsilon_t^{\neq p}$ denotes the remaining structural shocks of the model.

Our approach to identification of monetary policy shock, that is ε_t^p, is based on the use of one external instrument z_t, along the lines of Stock and Watson (2012) and Mertens and Ravn (2013). It may be worth mentioning that we make an explicit distinction between the policy indicator and the policy instrument. The latter helps us to isolate the movements of the policy indicator that are only due to monetary policy actions. It must satisfy several critical assumptions in order to identify movements in the policy indicator that are due to purely exogenous monetary policy disturbances. The instrument must be correlated with the unconventional monetary policy ε_t^p but uncorrelated with all other structural shocks $\varepsilon_t^{\neq p}$. This assumption can be summarized as follows:

$$\mathrm{E}\left[z_t \varepsilon_t^p\right] = \psi \tag{5}$$

$$\mathrm{E}\left[z_t \varepsilon_t^{\neq p}\right] = 0 \tag{6}$$

We use unexpected changes in different interest rates on FOMC dates as potential instruments z_t. We re-write the system in (3) in a more compact form. The model becomes as follows:

$$y_t = By_{t-1} + C_y + \upsilon_t, \tag{7}$$

where $B = [B_1 \dots B_\rho]$, and $y_{t-1} = [y_1 \dots y_\rho]'$. We introduce an observation equation, which relates our instrument to the structural shocks:

$$z_t = [\psi \quad \mathbf{0}]\varepsilon_t + C_z + \Omega^{-\frac{1}{2}} u_t, \tag{8}$$

where $\mathbf{0}$ is an $1 \times (n-1)$ row of zeros, and C_z contains the constant term. This equation is directly based on the assumptions in (5) and (6). The observation equation can also directly relate the instrument to the reduced-form shocks:

$$z_t = [\psi \quad \mathbf{0}]A^{-1}A\varepsilon_t + C_z + \Omega^{-\frac{1}{2}}u_t, \tag{9}$$

$$= [\psi \quad \mathbf{0}]A^{-1}\upsilon_t + C_z + \Omega^{-\frac{1}{2}}u_t, \tag{10}$$

$$= F\upsilon_t + C_z + \Omega^{-\frac{1}{2}}u_t, \tag{11}$$

with $F = [\psi \quad \mathbf{0}]A^{-1}$.

Using (7) and (11), we compact the overall system as:

$$\mathrm{E}\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \text{normal}\left(\begin{bmatrix} y_t \\ z_t \end{bmatrix} \middle\| \begin{bmatrix} C_y + By_{t-1} \\ C_z \end{bmatrix}, \begin{bmatrix} (AA')^{-1} & \Gamma' \\ \Gamma & \tilde{\Omega} \end{bmatrix}\right), \tag{12}$$

where Γ is the variance-covariance matrix between the instruments and the forecast errors are as follows:

$$\Gamma = \mathrm{Cov}[z_t, \upsilon_t], \tag{13}$$

$$= FAA', \tag{14}$$

$$= [\psi \quad \mathbf{0}]A^{-1}AA', \tag{15}$$

$$= [\psi \quad \mathbf{0}]A'. \tag{16}$$

Following Mertens and Ravn (2013), we can now identify the parameters of the contemporaneous matrix A. We assume that $A = [\alpha^{[1]}, \alpha^{[2]}] = \begin{bmatrix} \alpha_{1,1} & \alpha_{1,2} \\ \alpha_{2,1} & \alpha_{2,2} \end{bmatrix}$ with $\alpha^{[1]} = [\alpha_{1,1}, \alpha_{2,1}]'$

and $\alpha^{[2]} = [\alpha_{1,2}, \alpha_{2,2}]'$. Using the definitions of Γ and the forecast errors, it follows that:

$$\begin{aligned}
\Gamma &= \text{Cov}[z_t, \upsilon_t], \\
&= [\psi \quad \mathbf{0}]A', \\
&= \psi\alpha^{[1]}, \\
&= [\psi\alpha_{1,1}, \psi\alpha_{2,1}].
\end{aligned}$$

Partitioning $\Gamma = [\Gamma_1, \Gamma_2]$, we can identify the contemporaneous matrix, A, as follows:

$$\begin{aligned}
\alpha_{1,1} &= \frac{1}{\psi}\Gamma_1 \\
\alpha_{2,1} &= \frac{1}{\psi}\Gamma_2 = \alpha_{1,1}\left(\Gamma_1^{-1}\Gamma_2\right).
\end{aligned}$$

After identifying the structural parameters, we can directly compute the impulse responses of y_t to the unconventional monetary policy shock ε_t^p from the system (3).

To characterize the uncertainty of our results, we follow Drautzburg (2020) by employing modern Bayesian methods to estimate our VAR model. More specifically, we use a Gibbs-sampling procedure to alternately sample from conditional distributions, namely a normal posterior distribution and a wishart posterior distribution. Equation (12) corresponds to a SUR model, allowing us to employ a standard technique of inference reviewed in any Bayesian textbook. We vectorize the model (12) as:

$$Y_{\text{SUR}} = X_{\text{SUR}}\beta_{\text{SUR}} + \nu_{\text{SUR}}, \qquad \text{normal}(\nu_{\text{SUR}}|0, V \otimes I_T), \tag{17}$$

where

$$V = \begin{bmatrix} AA' & \Gamma' \\ \Gamma & \tilde{\Omega} \end{bmatrix}. \tag{18}$$

with $\tilde{\Omega} = \Omega + FAA'F'$ as the covariance-variance matrix of the external instrument. Under the flat prior $p(\beta) = \text{normal}(\beta|\bar{\beta}_0, N_0)$ and $p(V^{-1}) = \text{wishart}(V^{-1}|((\nu_0 S_0)^{-1}, \nu_0)$, where $\text{wishart}(x|S, n)$ is the wishart distribution with S as the scale matrix and n as the degree of freedom, we can employ the Gibbs sampler technique for simulations by alternately sampling from two conditional posterior distributions. For $i = 1, 2, \ldots, N_1 + N_2$,

1. Draw $\beta^{(i)}$ conditional on $V^{(i-1)}$:

$$\text{normal}\left(\beta^{(i)}|\bar{\beta}_T(V), (N_{XX}(V) + N_0)^{-1}\right), \tag{19}$$

   with $\bar{\beta}(V) = (N_{XX}(V) + N_0)^{-1}(N_{XY}(V) + N_0\bar{\beta}_0)$.[9]

2. Draw $V^{(i)}$ conditional on $\beta^{(i)}$:

$$\text{wishart}\left(V^{(i)}\middle|\frac{S_T(\beta)^{-1}}{\nu_0 + T}, \nu_0 + T\right), \tag{21}$$

   with $S_T(\beta) = \frac{1}{\nu_0+T}\begin{bmatrix}(Y - XB)' \\ (Z - 1_{T\mu_z'})'\end{bmatrix}\begin{bmatrix}(Y - XB) & (Z - 1_{T\mu_z'})\end{bmatrix} + \frac{\nu_0}{\nu_0+T}S_0$.
   Note that $S_T(\beta)^{-1}$, $N_{XX}(V)$ and $N_{XY}(V)$ are the posterior parameters.

3. Repeat (1) and (2) until the entire sequence ($N_1 + N_2$ draws) is simulated;

4. Keep the last N_2 draws in the sequence.

C Effects of monetary policy with the baseline model

Although the main focus in this paper is on the effects of monetary policy shocks on corporate debt structure, our methodology also gives estimates of the effects of monetary policy shocks

[9] The posterior parameters $N_{XX}(V)$ and $N_{XY}(V)$ are defined as follows:

$$N_{XX}(V) = \tilde{X}'\tilde{X}, \qquad N_{XX}(V) = \tilde{X}'\tilde{Y}, \tag{20}$$

where $\tilde{X} = \left((U^{-1})' \otimes I_T\right)\begin{bmatrix} I_n \otimes X_y & \underset{T(n\rho+1)\times T}{\mathbf{0}} \\ \underset{T\times Tn}{\mathbf{0}} & X_z \end{bmatrix}$, $\tilde{Y} = \left((U^{-1})' \otimes I_T\right)\begin{bmatrix} I_n \otimes Y & \underset{T(n\rho+1)\times T}{\mathbf{0}} \\ \underset{T\times Tn}{\mathbf{0}} & Z \end{bmatrix}$, $X_y = [Y_{-1} \quad \ldots \quad Y_{-\rho} \quad \mathbf{1}_T]$, and $X_z = [\mathbf{1}_T]$.

on macroeconomic and financial variables. We report the results from VARs omitting the variable d_t. Figure 7 shows the effects of a) conventional and b) unconventional monetary policy shocks on 1-year, 10-year zero coupon yields, the unemployment rate, prices and the excess bond premium.

Both easing shocks are persistently inflationary with high posterior probability. The result that only a small fraction of posterior draws lies within the negative region contrasts with many identification schemes used in the literature that finds a drop in prices, a phenomenon commonly referred to as the price puzzle (e.g., Sims, 1992). Importantly, both monetary policies lead to an immediate median decrease in unemployment. However, the response of unemployment is less precisely estimated following the conventional monetary policy shock, and there is a posterior probability mass on positive region (i.e., contractionary region). This corroborates with recent findings reported by monetary VAR literature (e.g., Arias, Caldara, and Rubio-Ramírez, 2019). Both shocks induce a 10 basis point decline in the excess bond premium, which then returns to its original level over the course of two years. A decline in the excess bond premium represents an increase in investors' risk appetite in the corporate bond market.

Overall, our findings indicate that both policies had powerful effects on economic activity. The behavior of the economy is consistent with a number of studies analyzing the macroeconomic effects of U.S. conventional monetary policy (e.g., Leeper, Sims, and Zha, 1996; Christiano, Eichenbaum, and Evans, 1999; Gertler and Karadi, 2015; Caldara and Herbst, 2019) and unconventional monetary policy (e.g., Chen, Cúrdia, and Ferrero, 2012; Baumeister and Benati, 2013; Gambacorta, Hofmann, and Peersman, 2014; Swanson and Williams, 2014; Weale and Wieladek, 2016; Del Negro, Eggertsson, Ferrero, and Kiyotaki, 2017; Liu, Theodoridis, Mumtaz, and Zanetti, 2019). For a comparison of macroeconomic effects of both types of shocks, see, for example, Lhuissier, Mojon, and Rubio-Ramírez (2020).

D Tables

Table 1: L.103 non-financial Corporate Business

Period	*2015.Q2*
Total liabilities	16622.7
Debt securities	5.388.9
Commercial Paper	179.3
Municipal securities	536.5
Corporate bonds	4673.0
Loans	2555.1
Depository institution loans n.e.c.	833.0
Other loans and advances	1141.5
Mortgages	580.6
Tradable payables	2058.7
Taxes payable	57.5
Foreign direct investment in U.S.	3014.7
Miscellaneous liabilities	79.9
Pension fund contributions payable	187.4
Claims of pension fund on sponsor	3280.5
Other	580.6

Note: Billions of dollars; amounts outstanding end of period, not seasonally adjusted.

E Figures

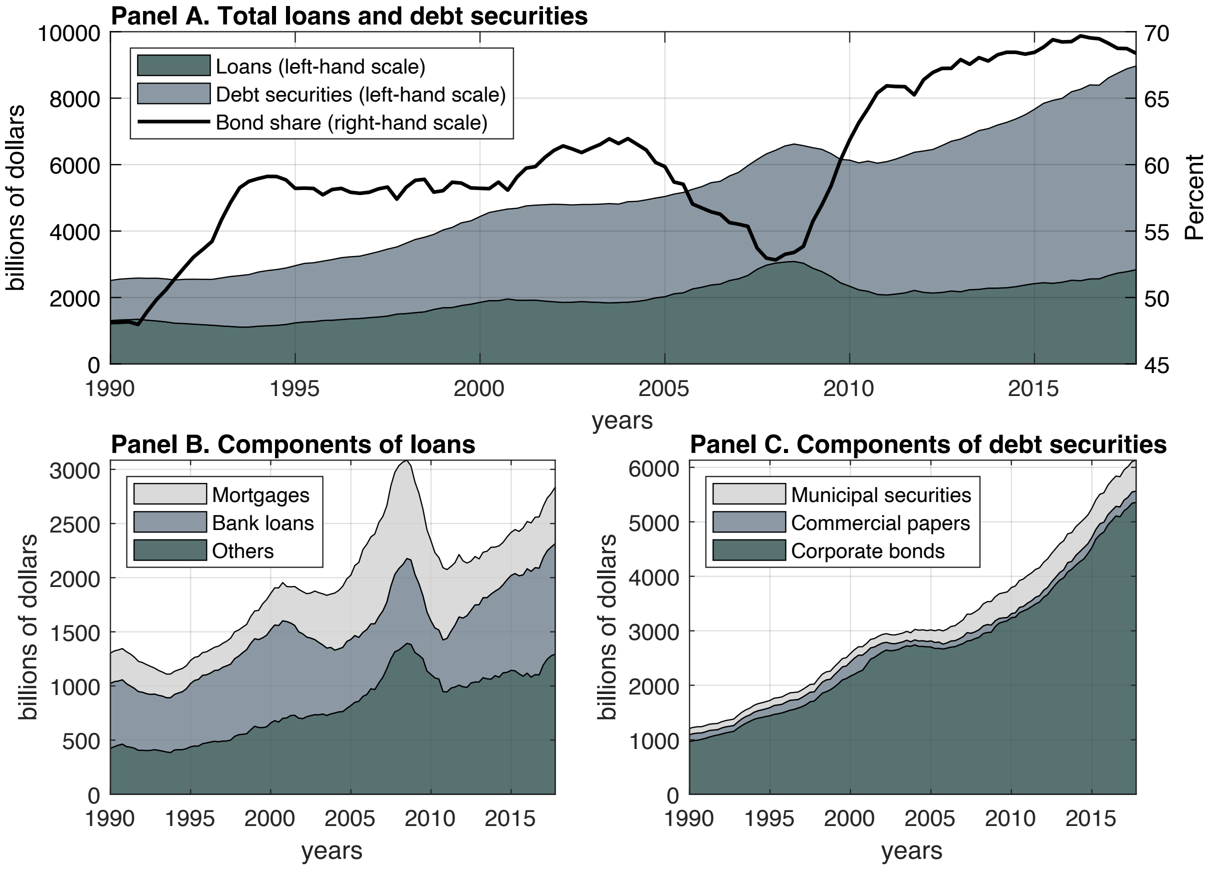


Figure 1: Sample period: 1990.Q1-2015.Q4. U.S. corporate debt structure.

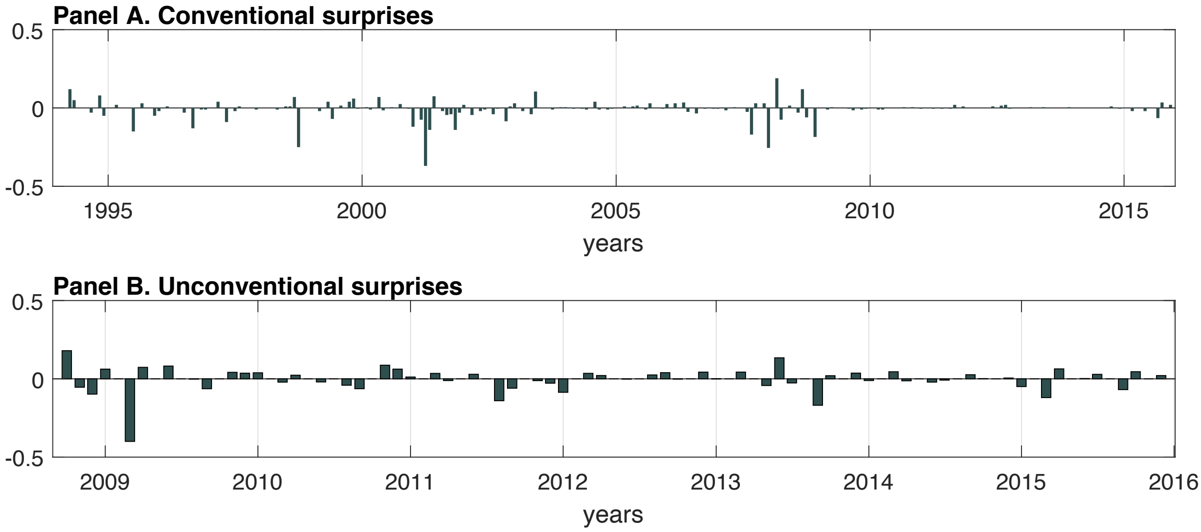


Figure 2: Time series of conventional and unconventional surprises.

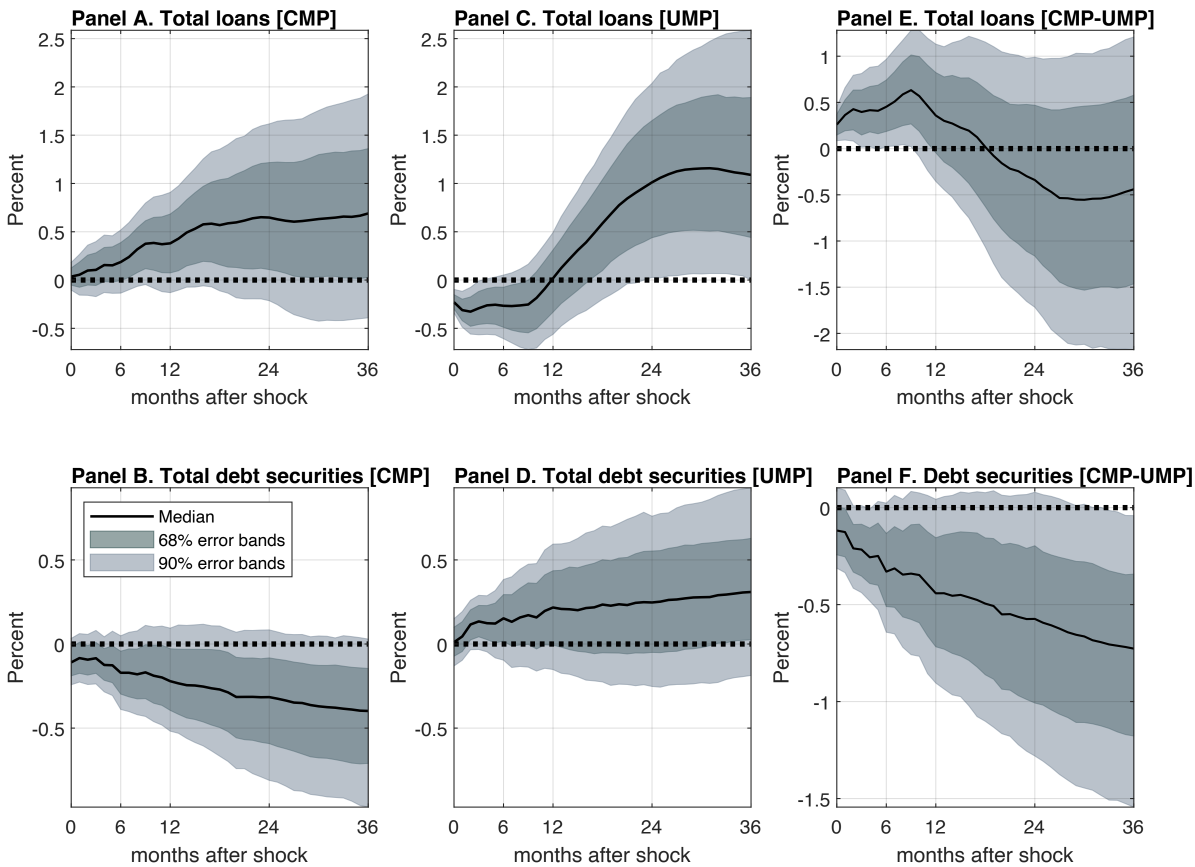


Figure 3: Responses of loans and securities to two types of monetary policy shocks; "CMP" for conventional monetary policy and "UMP" for unconventional monetary policy. Median, 68% and 90% error bands are reported.

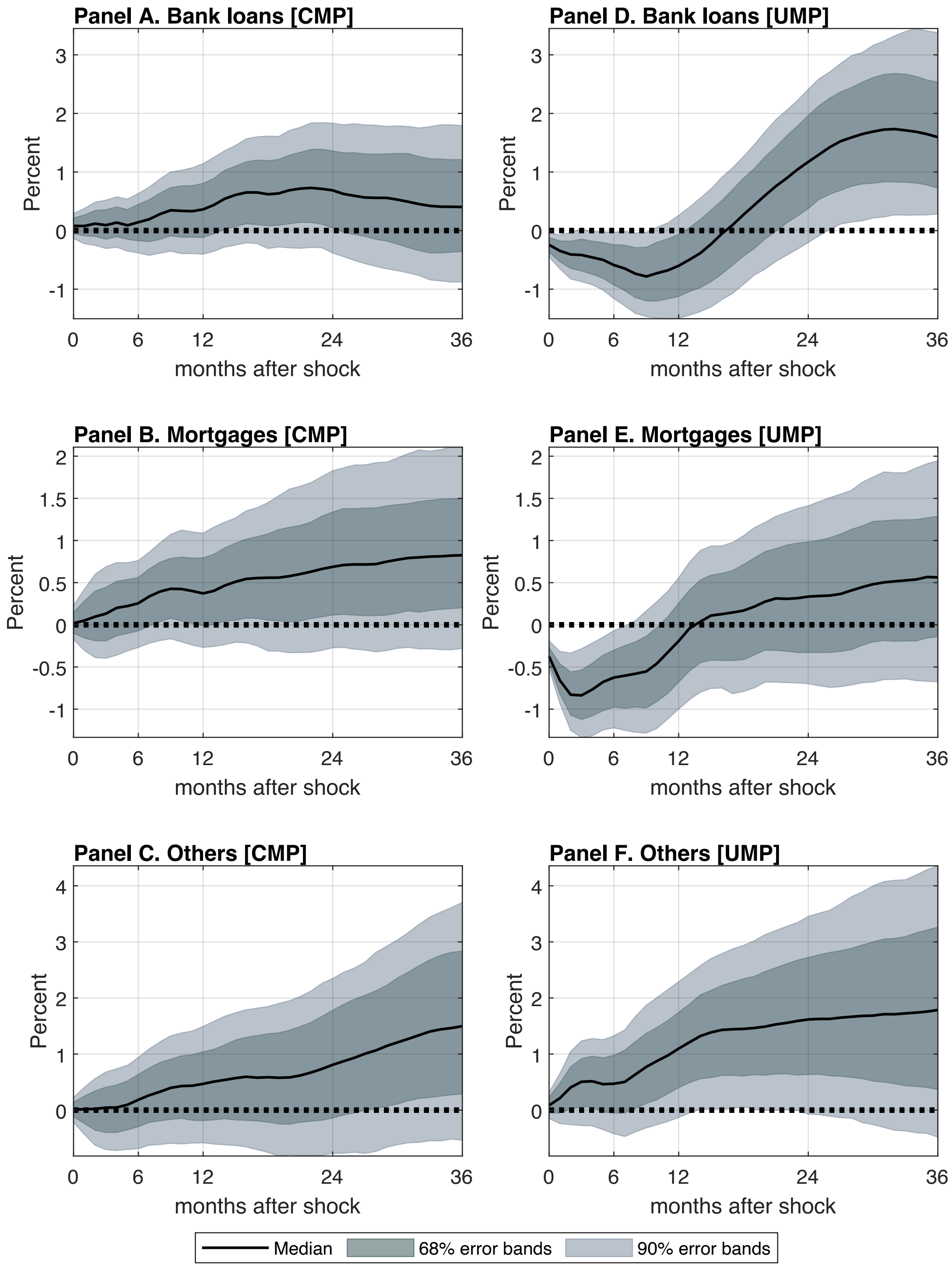


Figure 4: Responses of the components of total loans to two types of monetary policy shocks; "CMP" for conventional monetary policy and "UMP" for unconventional monetary policy. Median, 68% and 90% error bands are reported.

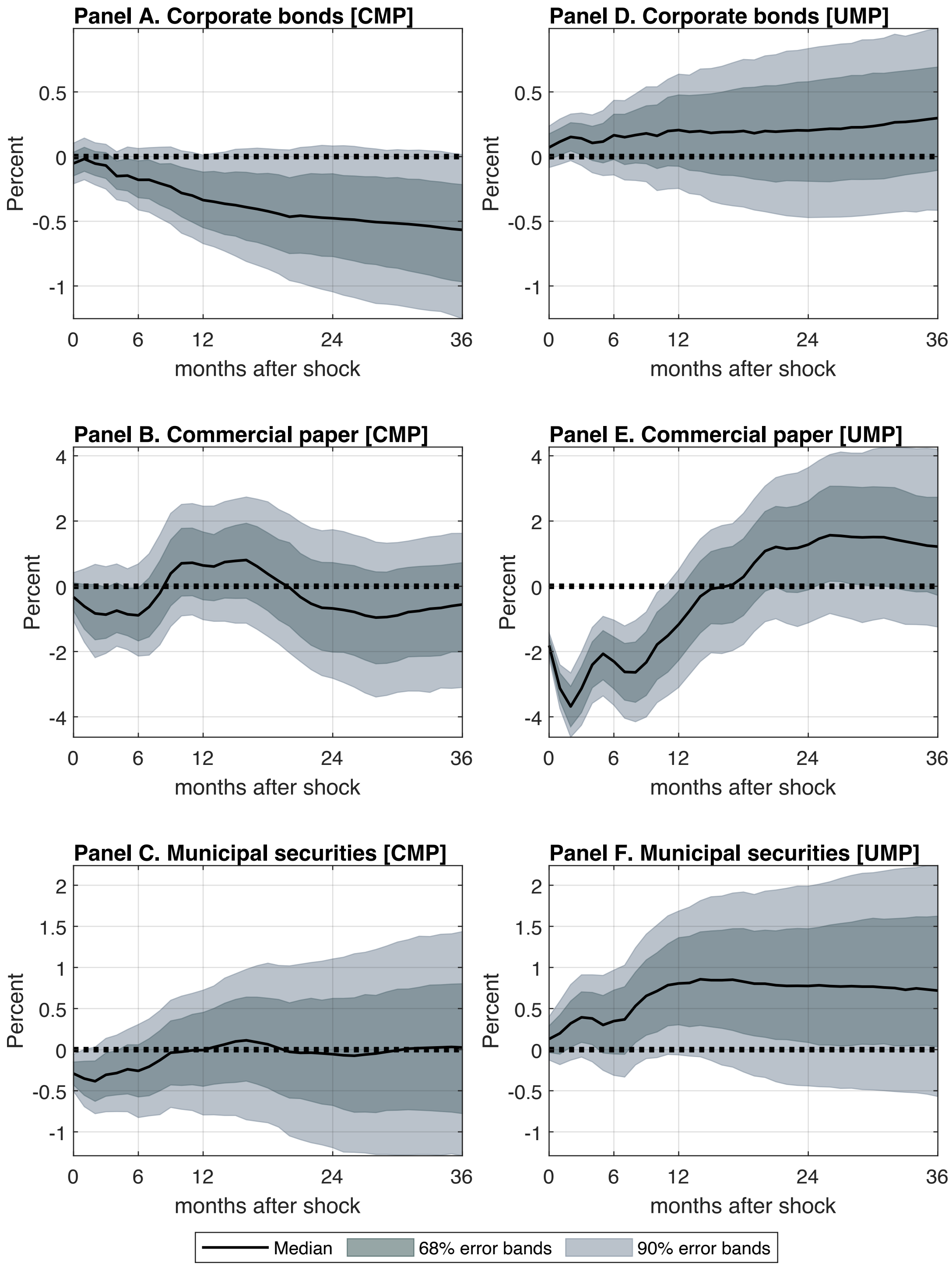


Figure 5: Responses of the components of debt securities to two types of monetary policy shocks; "CMP" for conventional monetary policy and "UMP" for unconventional monetary policy. Median, 68% and 90% error bands are reported.

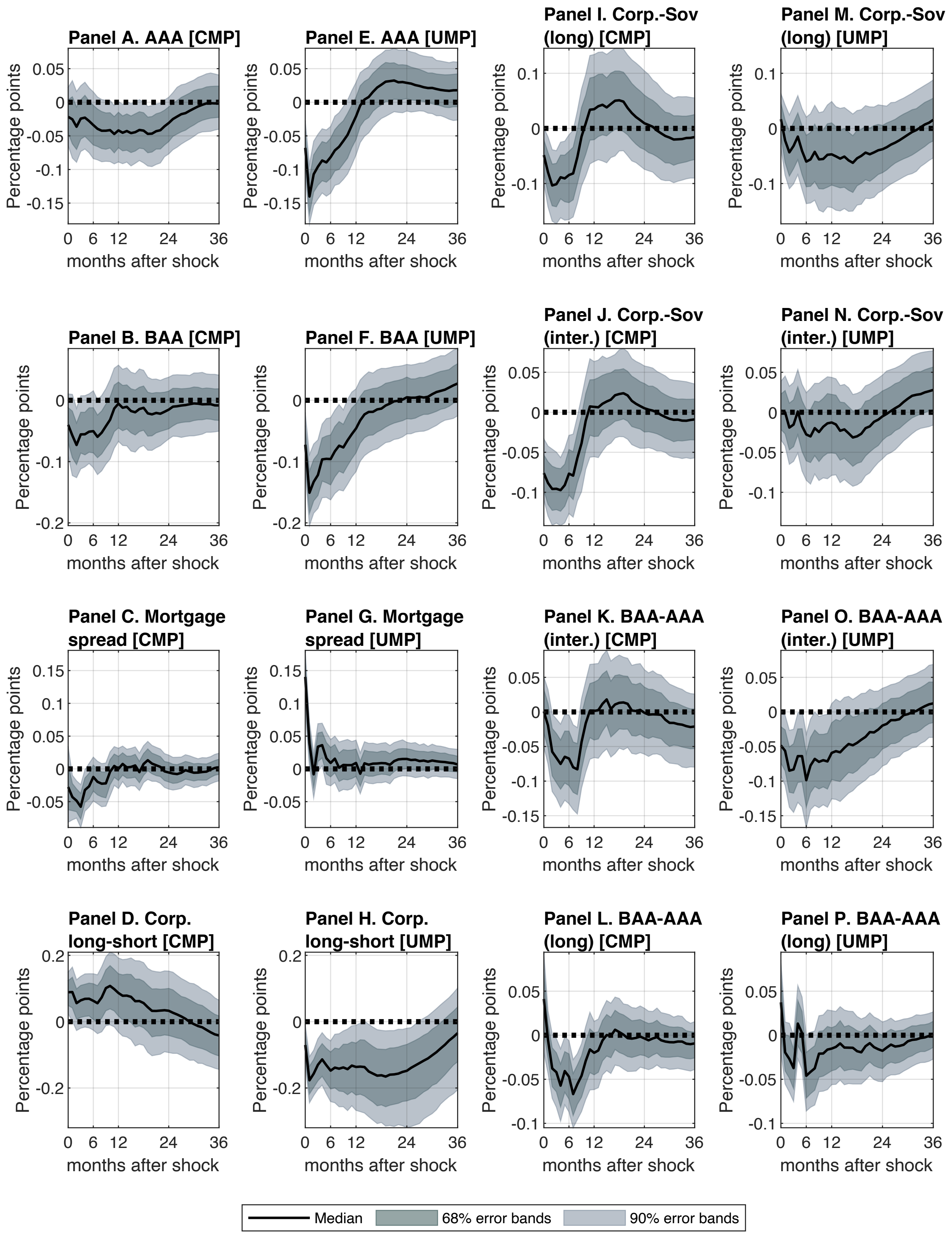
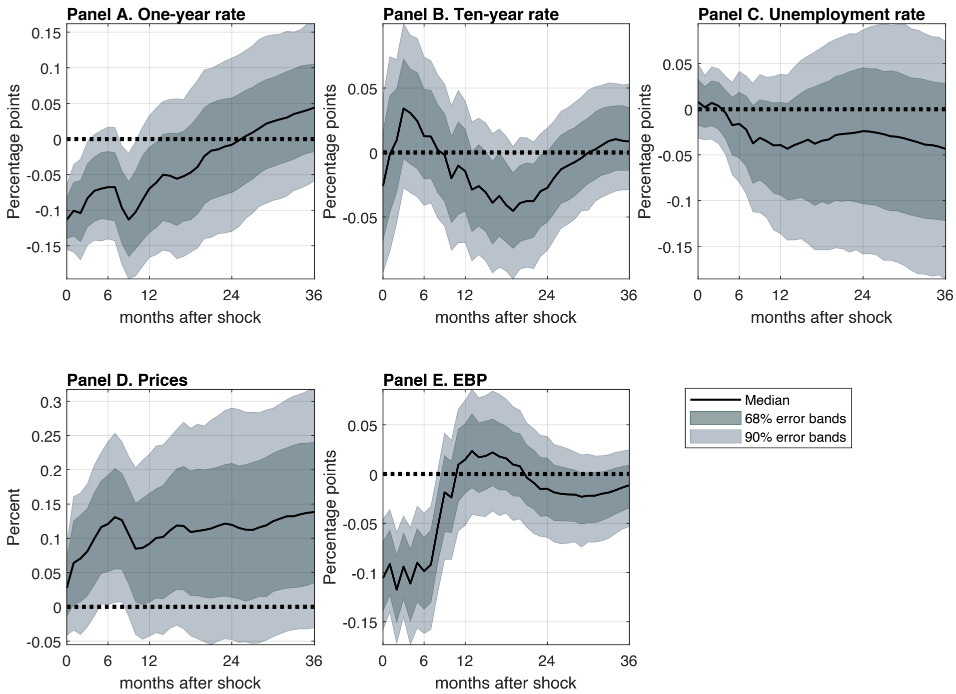
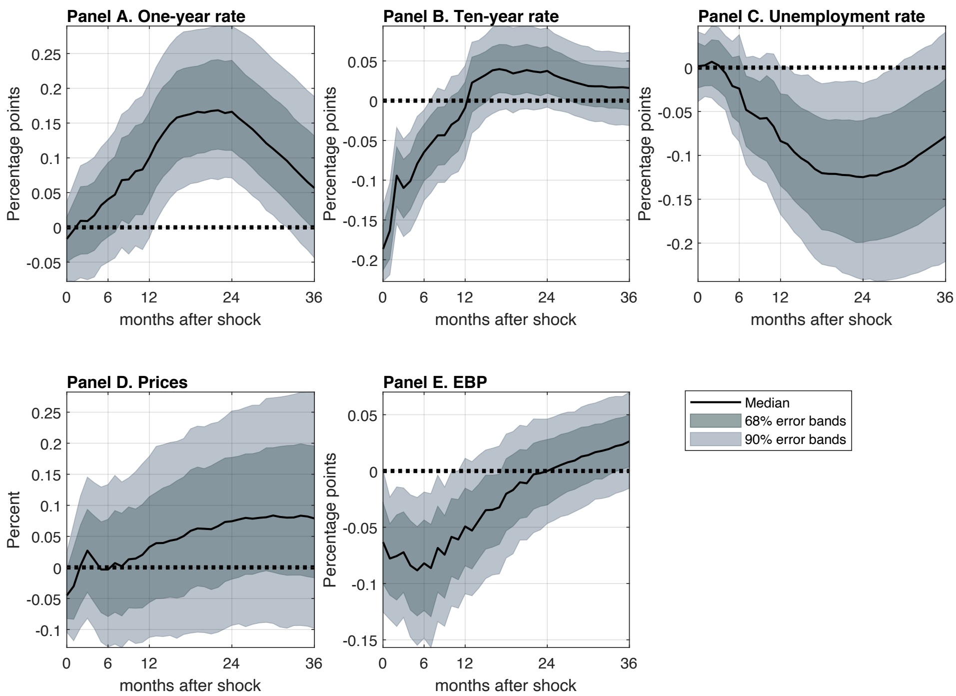


Figure 6: Responses of various yields and spreads to two types of monetary policy shocks; "CMP" for conventional monetary policy and "UMP" for unconventional monetary policy. Median, 68% and 90% error bands are reported.



(a) CMP



(b) UMP

Figure 7: Impulse responses to two types of monetary policy shocks; a) "CMP" for conventional monetary policy and b) "UMP" for unconventional monetary policy. Median, 68% and 90% error bands are reported.