RISK-TAKING AND MONETARY POLICY

ZHEYU YANG
Department of Economics,George Washington University

"Low for long" interest rate and other accommodative monetary policies increase risk-taking and medium- and long term macro-financial vulnerabilities. This paper aims to contribute to understanding how accommodative monetary policy have reshaped the risk perspective among the fixed-income market investors. I study the effects of People's Bank of China's monetary announcements on domestic corporate bond prices. Exploiting information embedded in high-frequency co-movement of financial assets prices and using a Bayesian structural vector autoregression, I deconstructed market surprises around the central bank's announcements on Reserve Requirement Ratios into shocks to investors' beliefs about monetary policy and shocks to the beliefs about non-monetary fundamentals. Using a sample of 16,738 corporate bonds issued by 2,711 non-financial firms between 2010 and 2020, I find the monetary shocks have strong effects on bond pricing and can explain about one-fourth of the price movement around the releases. I further test the hypothesis of risk-taking, i.e., whether the effects differentiate across various credit risk groups. The result shows risky bonds outperform safer bonds following a monetary easing shock, i.e., a significant increase in appetite for risk after monetary policy becomes accommodative. More importantly, the asymmetry between the effects of monetary easing and tightening further confirms the role of accommodative monetary policy as a key driver in risk-taking. The findings raise implications for financial stability and macroprudential policy.

KEYWORDS: risk-taking, monetary policy, asset prices, China economy.

1. INTRODUCTION

A central question in macroeconomics is how monetary policy affects the economy. The transmission of monetary policy to the broader economy takes place through several channels including interest rates, exchange rates and balance-sheet channels. The recent financial crisis has spurred a debate on whether an additional mechanism in the transmission of monetary policy—the risk-taking channel—affects the supply of credit.

The key empirical challenge in answering this question, however, is that risk-taking is supply-driven and generated by an increased appetite for risk by investors when monetary policy becomes accommodative. But accommodative monetary policy also affects demand for investment and credit. Therefore, to identify this channel, the effect of demand (borrowing) must be disentangled from the effect of supply (lending). The most common approach to overcome this simultaneous shifts in demand and supply is attempting to quantify the movements from both sides. Researches have used loan-level data combined with lenders (banks) and borrowers (firms) information to exam whether monetary policy led to the origination of riskier individual bank loans while trying to control for the demand for such loans (Dell'Ariccia et al., 2017, Delis et al., 2017, Calomiris et al., 2019, Krussl et al., 2017). But firm's decision on whether to engage in speculative investment induced by accommodative monetary policy and cheap borrowing is unobservable in the data and hard to detect. Therefore the concerns for the problem remains.

An alternative approach to tackle this identification challenge—the one I pursue in this paper—is to focus on movements in bond prices in a narrow window around policy changes. This approach exploits the fact that the demand for credit—firms' borrowing from the bond

Zheyu Yang: zhyyang@gwu.edu

markets—does not change instantaneously when policy changes. The outstanding amount of bonds is considered relative steady within such short period of time. But the supply of the credit—the demand for bonds by investors—reacts contemporarily to the monetary news. This is because the financial market participants are forward looking and any new information arrives the markets will be incorporated. This unique setting allows me to cleanly separate the influence of supply of credit from demand for credit on prices.

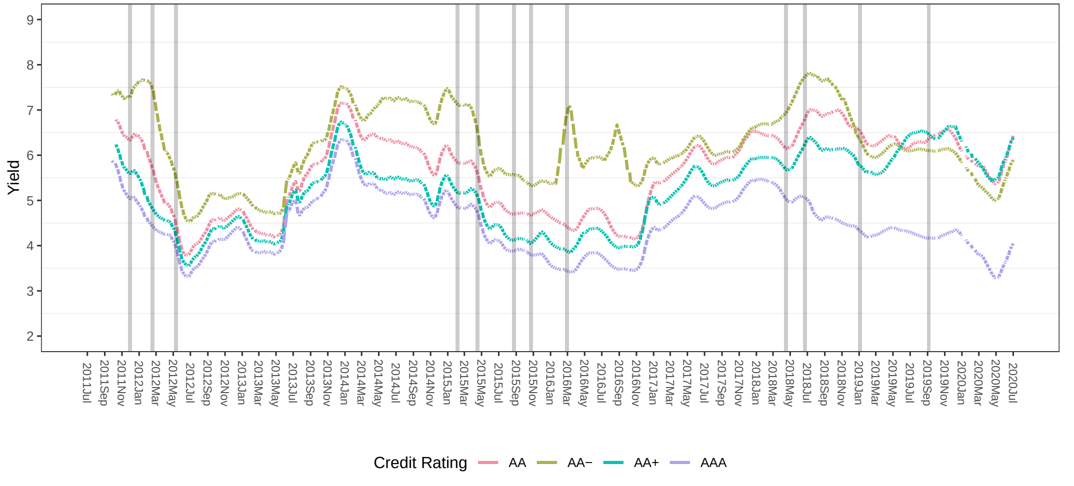

FIGURE 1.—China Corporate Bond Yield by Credit Ratings: 2011-2020. The shaded vertical lines represent the time of PBoC's announcements on the Reserve Requirement Ratio. Sources: CCER database. Yields are based on author's own calculations.

I use price changes of 16,738 corporate bonds over a 24-hour window surrounding 12 People's Bank of China's announcements on Reserve Requirement Ratios between 2010 and 2020 to investigate the risk-taking effect on corporate bond market (Fig. 1). The data set includes bonds from interbank market and exchange markets, which accounts for over 90% of issuance in China. I estimate the price return differentials between risky bonds and safe bonds facing changes in monetary policy stance within narrow windows of central bank announcements, in which the outstanding amount of corporate bonds—the demand for investment and credit in the bond market—can be treated as constant. Therefore, any changes in the return differentials during that periods of time can be reasonably attributed to the changes in the supply of the credit.

A major strength of this identification approach is how cleanly it is able to isolate the movement of supply from the demand side and to address the simultaneous problem. As is often the case, this comes at the cost of reduced statistical power. The price returns I estimate around announcement events are quite small (they have a standard deviation of only about 10 basis points). The reduced statistical power precludes me from estimating the long-term effect of risk-taking on bond markets. Intuitively, price changes several days or months in the future are influenced by other shocks, reducing the signal-to-noise ratio too small to generate reliable results. I can, instead, measure the contemporary responses of bond prices to changes in monetary policy, which is important since the link between short-end policy rates and longer-end rates which firms are effectively borrowing at is the key in monetary policy transmission. By focusing on the contemporary effects of monetary policy shocks on corporate bond rates, this paper is shedding light on the core empirical issue in monetary economics.

Another challenge is, of course, how to identify the monetary policy shocks from the central bank policy actions. In general, there are two schools of identification strategies: one relies on correctly specifying the underlying policy function of the central bank and fitting it with actual data; the other one relaxes the assumption on the underlying policy function and instead capturing the policy shocks using measurement on market reactions to the policy changes. Researchers have attempted to estimate the underlying policy function of the People's Bank of China. The difficulty in estimating China monetary policy using this strategy is that the country's monetary policy framework is constantly evolving over time, as pointed out by Yi (2018), the chairman of the People's Bank of China. Over the years, China's monetary policy framework is gradually shifting from quantity control to price control, which implies that the underlying policy function may not be unchanged. For example, Chen et al. (2018) estimates People's Bank of China's policy function based on a Taylor-rule-alike function and the central bank's M2 supply, for which they argue the central bank uses as its intermediate target. But they limit the sample period only between 2009 and 2015 due to the fact that the central bank later changed its intermediate target and the implementation framework.

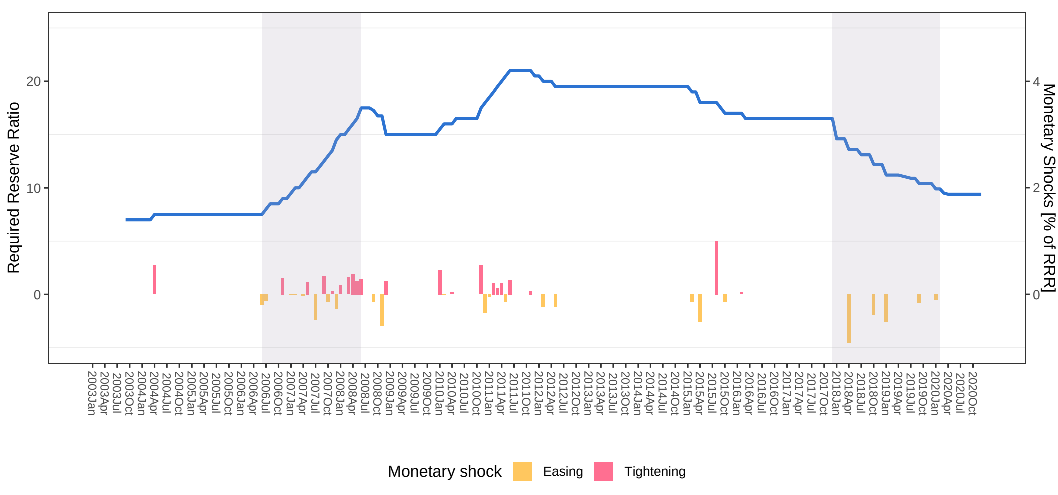

FIGURE 2.—Required Reserve Ratio and Monetary Policy Shocks. The Blue line represents China's RRR. The colored bars represent the identified monetary policy shocks from each PBoC's announcements. The shocks are scaled in term of a 100 bps change in the RRR. The two shaded area represent the consecutively raising /cutting RRR periods.

I therefore turn to the second identification strategy, the so called High-Frequency Identification (HFI), which was first pioneered by Cook and Hahn (1989) then developed by Nakamura and Steinsson (2018) and many others. It is based on the fact that central bank announcement reveals a disproportionate amount of monetary news. The lumpy way in which monetary news is revealed at announcements allows for a discontinuity-based identification scheme. However, central bank communication conveys not only monetary news but also non-monetary news about economic growth (Cieslak and Schrimpf, 2018). The non-monetary news in central bank communication poses a challenge to the quantification of effects of monetary policy identified by the HFI as the shock can be confronted by other information. To dissect the news content of central bank announcement, I exploit the information embedded in the joint dynamic of equity returns and interest rates around the policy releases. While a conventional monetary policy shock affects the real rate and induces a *negative* comovement of stocks and yields through higher discount rate, growth shocks induce a *positive* comovement of stocks and yields via raised expectation on future revenue. The monetary policy shocks in this paper are identified through the high-frequency comovement between 1-year treasury yield and stock index returns captured from the financial markets around policy announcements using a Bayesian Structural Vector-autoregression (BSVAR) with sign restrictions (Jarociski and Karadi, 2020, Kerssenfischer, 2019, Andrade and Ferroni, 2021, Miranda-Agrippino, 2016, Miranda-Agrippino and Ricco, 2021, Nakamura and Steinsson, 2018). I derive restrictions on the joint dynamics of macroeconomic factors, monetary policy and asset prices necessary to support the stylized facts, and rely on high-frequency data to construct the covariates at the level of a single event. The sign of those covariates allows one to determine the dominant piece of economic news revealed by central banks beyond just monetary policy decision statements. Figure 2 plots the identified monetary shocks along with announced changes on Reserve Requirement Ratios.

I use bonds' credit ratings to proxy their credit risks. The credit ratings reflect the creditworthiness of the issuers, such as their financial ability to make interest payments and repay the debt in full at maturity. Bonds with better ratings are perceived as lower credit risk, and vice versa. The advantage of using bonds is that their ratings explicitly differentiate their riskiness. The disadvantage goes to concerns with the country's domestic rating quality. Credit ratings in the domestic bond market are highly up-skewed: the vast majority of Chinese bonds fall into only three categories: AAA, AA+, and AA, which means the domestic ratings are inflated rating and the rating scales are broadened. A one-notch difference in credit ratings in China's bond market is likely equivalent to a one-letter (or three-notch) difference in international ratingsLivingston et al. (2018). For example, a notch difference in Chinese credit ratings is associated with 58 basis points difference in yield, while the difference is associated with 9-18 basis points in investment grading in the US and Europe bond markets. Inflated and broadened ratings potentially distort the distribution of credit risk in the sample. To address this issue, I also include firms' annual financial balance sheet and income statements into the analysis to control for any potential differentials within each credit rating groups.

With the granularity of the data, I can isolate specifically how a bond's riskiness, as measured by its credit rating, affect its returns on central bank announcement days, while flexibly control for a group of bond's and issuer's characteristics. In particular, my baseline regressions include fixed effects that ensure that I compare the price reactions of bonds that have the same year-to-maturity but different levels of credit risk, while also controlling for industry effect and duration effect. I find strong evidence of risk-taking: following a monetary easing shock, the price returns *increase* as the bonds become *riskier*. The effects are asymmetric: the price responses to monetary easing shocks significantly differentiate across various credit risk groups, while responses to monetary tightening shocks do not. Chen et al. (2017) has a similar finding in their paper using data from the stock market. The asymmetric effect of monetary policy shows the role of accommodative monetary policy as a key driver in risk-taking. The finding is robust across corporate bonds with different characteristics, such as years-to-maturity, industry, and coupon rate, and across firms with different attributes, such as leverage ratios, profitability, liquidity, and size.

This paper also documents an information channel in the PBoC's monetary policy implementation, i.e. the notion that central bank announcements reveal relevant information about the economy that is not in the information set of the public. The estimated information channel has real impact on economic activities and asset prices. First, a positive informational shock (good news about economic growth) is inflationary. A one-standard-deviation informational shock will raise both output and inflation in 9-12 month. The shock also mildly reduce excess bond premium (Fig. 6). Second, the informational shocks have strong contemporary impacts on the corporate bond prices. A natural interpretation to this result is that, given the credit spreads of risky bonds and safe bonds has considerable predictive informational content for economic activities(Gilchrist and Zakrajšek, 2012), it is not surprising that the revealed information about future economic activities at central bank releases moves corporate bond prices. If the economic system is governed by (a) latent factor(s), shocks to the current state variable will affect both future economic activities and current asset prices, as the asset prices are forward-looking. The central bank information effect on asset pricing calls for more sophisticated modeling.

The rest of the paper is organized as follows. Section 2 introduces the related literature. Section 3 introduces the corporate bond data used in the analysis. Section 4 briefly presents the institutional background of China's corporate bond market and monetary policy framework. Section 5 discusses the identification of monetary policy and the econometric methodology. Section 6 presents the empirical strategy of monetary policy on risk-taking and the main results. Section 7 concludes the paper.

2. LITERATURE REVIEW

My paper is closely related to the strands of literature on monetary policy and risk-taking. Borio and Zhu (2012) relate monetary policy transmission mechanism to the perception and pricing of risk by economic agents and point out the importance of the "risk-taking channel" of monetary policy in the evolving financial system. Bruno and Shin (2015) further study the operation of the risk-taking channel through the banking sector and find that the financing costs of banks, which are closely tied to the short-term interest rate chosen by the central bank, affects their decisions on how much exposure to take on. Dell'Ariccia et al. (2017) study the relationship between interest rates and bank risk-taking by using loan-level data in the US. They provide evidence that a low short-term interest rate environment increases bank risk-taking. Weale and Wieladek (2016) study the effect of unconventional monetary policy in UK during the GFC. They find announcements of large-scale purchase of government bonds program raises the appetite for risk. Calomiris et al. (2019) study the effect of eligibility for inclusion in important international market indexes and find that low interest rate environment created by developed countries' monetary policies after GFC increases the demand for emerging market corporate bonds. Ammer et al. (2018) test for search for yield by examine whether changes in interest rates in domestic markets drove investors to shift into riskier assets in the US and they find that the more interest rates at home decline, the more investors shift their international bond portfolios towards riskier US corporate bonds.

My paper also contributes to a long line of research that assesses the effect of monetary policy on asset prices. Mishkin (2001) summarizes the channels provided by asset prices through which monetary policy affects the economy. First is through investment. Tobin's q, which is defined as the market value of firms divided by the replacement cost of capital, establishes a link between stock prices and investment spending. Second is the credit channel (Bernanke and Blinder, 1992). A change in monetary policy is likely to change the firms' external finance premium, which is the difference in cost between funds generated internally (by retaining earnings) and funds raised externally (by issuing equity or debt instruments) caused by the asymmetric information in the credit market. Third is through wealth effects. Expansionary monetary policy which raise asset prices, raise the value of household financial wealth, thereby increasing household consumption. Empirically, many researches find evidences of the relationship between monetary policy and asset prices. Assenmacher and Gerlach (2008) using data on 17 OECD countries between 1986 to 2006 finds that monetary easing shocks significantly raise the asset prices. Rigobon and Sack (2004) estimates the response of asset prices to changes in monetary policy shock identified based on FOMC meetings and Chairman's monetary policy testimony to congress and the increase in the variance of policy shocks. Their results show that an increase in short-term interest rates results a decline in stock prices and an increase in bond yields. Grkaynak et al. (2004) studies the effect of changes in the federal funds rate and FOMC statements on asset prices and find that although they both have important effects the statements will have a much greater impact on longer-term treasury yields.

My paper also relates to the numerous research work on how to identify monetary policy shocks in China and to assess the country's monetary policy (Chen et al., 2018, Li et al., 2014, Li and Wang, 2020, Sun, 2015, 2018, Chen et al., 2017, Fu and Ho, 2022). Related literature also discusses the causes and impacts of risk-taking in the country's financial system, especially from the perspective of expansion of shadow banking sector and off-balance-sheet entrusted lending activities. With growing debt levels and slowdown in economic growth, risk-taking has become a growing concern in China's bank-based financial system and affecting the country's transmission mechanism of monetary policy (Sun, 2019, Li et al., 2014, Zhou and Tewari, 2019, Dong et al., 2014, Fang et al., 2019). The growing risk-taking also intertwine the efforts to circumvent regulatory restrictions on banking system (Wu and Shen, 2019, Wang et al., 2021), which raises serious implications for macroprudential policy.

3. DATA

I construct a security-level corporate bond price return dataset that links the secondary-market prices with issuers' information and their annual financial reports. The secondary-market prices are reported by the Shanghai Clearing House. Shanghai Clearing House is the only central clearing institute in the interbank market who acts as a counterparty to both sellers and buyers and performing clearing and settlement in transactions. The data is first available in September 2011. The total coverage of the data is 201,707 debt instruments, which includes government treasury bonds, local government bonds, central bank bills, policy banks' bonds, commercial papers, medium-term notes, negotiable certificates of deposit, private-placed notes, corporate bonds, enterprise bonds, etc. The prices used in the analysis are clean prices of the bonds, which is the price not including accrued interest payments.

Issuers' information which includes issuer's name, issuance size, issuance date, maturity date, the issuer's credit rating and issuer's industry, is from WIND, a major data vendor in China. The secondary-market prices are linked with the issuers' information based on bonds and issuers' names. I select only the corporate bonds, enterprise bonds, medium-term notes, and commercial papers, excluding the private-placed notes and convertible bonds in the data. The final data set contains 16,740 bonds issued by 2,711 non-financial issuers. The time span is from September 2011 to August 2020. Table I shows the distributions of issuers and bonds across industries and various credit rating groups. Two things worth noting: the issuers' distribution across industries roughly match the bonds' distribution, but the distributions of these two across credit ratings do not. For example, only 10% of issuers are rated AAA, but they issue over 33% of the total bonds. On the contrary, the AA and AA- rated issuers account for 74% of the total issuers, but they only issuing 43% of the total issuance. The statistics of the data confirm the fact that corporate bonds in China are likely to be issued by large firms with highly up-skewed credit ratings, and the vast majority of Chinese bonds fall into only three categories: AAA, AA+, and AA, which were found in Livingston et al. (2018).

TABLE I

ISSUERS AND BONDS BY INDUSTRIES AND CREDIT RATINGS

	Issuer		Bond	
	#	%	#	%
Industry				
Consumer Discretionary	258	9.5	1,312	7.8
Consumer Staples	106	3.9	481	2.8
Energy	114	4.2	988	5.9
Healthcare	80	2.9	346	2.0
Industrial	1,359	50.1	8,643	51.6
Information Technology	112	4.1	497	2.9
Materials	316	11.6	1,973	11.7
Real Estate	169	6.2	865	5.1
Telecommunication Services	6	0.2	32	0.1
Utilities	191	7.0	1,603	9.5
Credit Ratings				
AAA	269	9.9	5,591	33.3
AA+	436	16.0	3,854	23.0
AA	1,322	48.7	5,887	35.1
AA-	684	25.2	1,408	8.4
Total	2,711	100	16,740	100

The issuers' annual financial reports are obtained through the China Center for Economic Research (CCER) database. Mandated by PBoC, the National Development and Reform Commission (NDRC), and China Securities Regulatory Commission (CSRC), debt instruments issuers must disclose their annual financial reports. Given the mandatory reporting by the issuers, the data is comprehensive, i.e., it captures most of debt securities issuers on the market. The annual financial reports data consists of 8,918 non-financial firms' annual financial reports from 2010 to 2021, including firms' total asset, returns on total asset, returns on equity, current ratio, quick ratio, debt ratio, short-term to total debt ratio, cash ratio, and cash to debt ratio. The current, quick and cash ratios are liquidity measurements that measures a company's ability to pay short-term debt that due within one year. Cash to debt ratio is the ratio of a company's cash flow from operations to its total debt which measures how long it would take a company to repay its debt. Debt ratio is the ratio of total debt to total asset which measures the extent of a company's leverage. The price data is linked with the previous fiscal year's financial variables based on issuers' names, i.e., if the price data is in 2018, then the financial report used for the issuer is 2017. Given the reports are annual, the 2017 report is the latest financial report for the investors in 2018. The analysis is then done based on the investors' *ex ante* perspective.

4. CHINA'S CORPORATE BOND MARKET AND MONETARY POLICY

In this section, I discuss the unique features of China's corporate bond market and its monetary policy framework, which are pertinent to the subsequent empirical analysis. The discussion focuses on two issues: (1) institutional facts about China's domestic bond market and the credit ratings, (2) the background and evolution of China's monetary policy framework.

4.1. *China Corporate Bond Market*

China's corporate contribute almost a third (31%[1]) of global corporate debt, while the country only contributes a fifth (19%) of global GDP. Despite the fact that the first Chinese bond was issued as early as 1861 in the Qing Dynasty, the current bond market is young relative to those of advanced economies. The country initially only had a primary market where only new issuances were allowed. It was not until 1990 when a secondary market was established nationwide could government bonds to be traded in the markets. The secondary bond market includes three submarkets: the exchange market, the interbank market, and the over-the counter (OTC) market. The exchange market was the most active market where individual investors and commercial banks were the most active participants. However, banks were pulled out of the exchange market in 1997 and started to trade with each other exclusively in the interbank market. Since then, the interbank market has grown rapidly and has become dominant in bond markets. Today the interbank market accounts for about 90% of the debt securities issued in China. The OTC market has consistently accounted for only a small share of market activities.

The corporate bond market in China is different from the US bond market in several ways. First, bonds in China are likely to be issued by large firms with highly up-skewed credit ratings: the vast majority of Chinese bonds fall into only three categories: AAA, AA+, and AA. The Chinese rating industry inflates rating and broad rating scales. As a result, a notch difference in Chinese credit ratings is associated with 58 basis points difference in yield, while the difference is associated with 9-18 basis points in investment grading in the US and Europe bond markets (Livingston et al., 2018). A one-notch difference in credit ratings in China's bond market is likely equivalent to a one-letter (or three-notch) difference in international ratings. Second, the default rates in China is artificially low: in 2021, this number is 0.76%[2] compared to the 1.2%[3] in the US market. Third, the average maturity of bonds in China is 1.74 years, which is much shorter than the average maturity in the US (Amstad and He, 2020). These differences partly reflect the different model used by the Chinese government to manage its financial system, that is, government's tight control on issuances and implicit government guarantees to avoid public defaults (Ding et al., 2020, Brunnermeier et al., 2020).

Many of the issuers are implicit government guaranteed and soft budget-constrained, which distorts the market. A soft budget-constraint arises whenever a funding source finds it impossible to keep an enterprise to a fixed budget, i.e., whenever the enterprise can extract ex post a bigger subsidy or loan than would have been considered efficient ex ante (Maskin, 1996). Issuers with strong implicit government guarantee, usually state-owned enterprises (SOEs), are insensitive to the level of interest rates at borrowing, pushing up the market demand for investment. Being crowded out, firms with no such guarantee from the government, who are usually privately-owned, have to borrow at higher rates. Furthermore, issuers with implicit government guarantee usually receive better credit ratings than those who do not. For example, there are only about 6% of AAA bonds that are issued by privately-owned enterprises, while the private firms' issuances account for about 58% in the AA bonds. The highly imbalanced distribution of credit ratings reflects the fact that political connection heavily affects the market. The investors

---

[1]Ip, Christine et.al.. 2021. "Can China Escape Its Corporate Debt Trap?" S&P Global, October 19, 2021. https://www.spglobal.com/_assets/documents/ratings/research/100620188.pdf

[2]Wang, Ying et.al.. 2022. "China Corporate Bond Default Rate Set to Rise in 2022" Fitch Ratings, January 27, 2022. https://www.fitchratings.com/research/corporate-finance/china-corporate-bond-default-rate-set-to-rise-in-2022-27-01-2022

[3]Fagan, Kevin. 2022. "Corporate Defaults Signals Cautions Optimism for the Office Sector" Moody's Analytics, February 7, 2022. https://cre.moodysanalytics.com/insights/cre-news/corporate-defaults-signal-cautious-optimism-for-the-office-sector/

tend to believe issuers will receive timely and sufficient extraordinary support from regional and central governments in time of financial distress to avoid systematic financial risk. The low default rate and implicit government guarantee are likely to affect bond pricing, especially in the context of monetary policy changes.

The China's corporate bond market directly grew out of its banking sector and features banks as the major investors (Amstad and He, 2020). Consequently, the demand for corporate bonds is significantly affected by the banking sector's liquidity condition and risk preference, which, in turn, depends on the monetary policy stance and regulations on the banking sector. Most of the participants in secondary market in the interbank market are commercial banks with high degree of homogeneity in trading strategies and funding source, which amplifies the perceived risks and the comovement in bond prices. The fact that the business model of commercial banks relies on balancing the yield earned from assets with the financing cost on liabilities provides a unique channel for monetary policy to affect the bond market. One of financial cost the commercial banks have to bear is the lost on the reserve requirement[4] imposed by the central bank, which can be as high as about 20% in China. The reason for the reserve requirement to be a significant financial burden for the banks is that they have to pay a relatively higher interest for the reserves than the interest it generates. For example, the average deposit rate the commercial banks have to pay to their customers is roughly between 2%-3% for the last two decades, but the interest rate the commercial banks received on their reserve balances is 1.6%[5]. Deposit is just one of the commercial banks' fund sources. The seven-day interbank bond collateral repo (DR007) rate and the one-year medium-term lending facility (MLF) rate, which are two benchmark rates that a commercial bank can borrow at from the interbank market, are 2.20% and 2.95%, respectively, which are also significantly higher than the interest rate on the reserve balances. The reserve requirement is essentially equivalent to a taxation on the banks (Zhang, 2021). As the return on investment declines and the pressure on revenue generation rises, the reserve requirement has become a burden to the banks and significantly affects the banking sector's liquidity condition. When PBoC cuts the RRR, it will increase the excess reserves of banks, lower banks' liability-side financing cost, and improve liquidity condition in the interbank market, which benefits the bond market. Cutting RRRs also signals a potential pivot of the macroeconomic policy to the direction of credit expansion and growth-support, which can alter the market expectation and benefit corporate bond market.

4.2. *China Monetary Policy Framework*

The objectives of China's monetary policy framework, according to the *Law of the People's Republic of China on the People's Bank of China* article 3, are "to maintain the stability of the value of the currency and thereby promote economic growth". The PBoC may use the following tools to conduct monetary policy: 1) requiring banks and financial institutions to place deposit reserves at a prescribed ratio; 2) deciding the benchmark interest rates; 3) providing discount service to banks and financial institutions; 4) providing loans to commercial banks; 5) purchasing and selling central government bonds and other government securities, financial bonds, and foreign exchange on the open market.

The central bank uses several instruments to manage liquidity in the banking system, including *Open Market Operation* (OMO), *Required Reserve Ratio* (RRR), *Medium-term Lending*

[4]The reserve requirement refers to the amount of money that banks must hold in their coffers as a proportion of their total deposits.

[5]The People's Bank of China is one of a few central banks that pay interest on the reserve balance, largely due to the high reserve requirement ratio it imposes on the banking sector.

Facility (MLF), and *Standing Lending Facility* (SLF). With the recent reform on the RRR implementation, PBoC further distinguishes financial institutions based on their systematic importance and provides differential treatments accordingly. Financial institutions are categorized into three "tranches" based on size and the service positioning. The first tranche applies to large banks. The second tranche applies to medium-size banks, including joint-stock commercial banks and city commercial banks. The third tranche applies to small banks, which consists of rural credit union, rural cooperative banks, and village banks. As one of the preferential treatments, the banks in second and third tranches have slightly lower required reserve requirements compared to those in the first tranche. In time of RRR adjustment, banks who have met certain evaluation criteria will be eligible for further RRR cuts. These criteria usually includes a certain proportion of the bank's lending to the local counties, Micro and Small Businesses (MSBs) and etc.

PBoC has established a preliminary policy rates corridor system. The short-term policy rate is the DR007 rate, namely the seven-day repo rate in the interbank market. A repo is a loan secured against collateral. The medium-term policy rate is the MLF rate. The ceiling of the corridor is the SLF rate and the bottom of the corridor is the excessive reserve rate. China's monetary policy is gradually shifting from quantity control to price control. At present, the monetary policy framework is in a transition phase and both set of tools are employed during the process. Price control has been more important than it used to be, but at the same time, with the impact of the basis and systems as well as people's thinking pattern, quantity control is not yet discarded and remains very important (Yi, 2018). Fig. 3 plots the RRR and key interest rates. PBoC also reforms the *Loan Prime rate* (LPR) formation mechanism. LPR has played a guiding role in the formation of interest rates. The quote is formed by adding a few basis points to the rate of MLF with a maturity of one year. The LPR is then served as a pricing reference for bank's long-term loans such as housing mortgage.

PBoC has also improved its communication with market and public through a variety of channels such as press conferences, monetary policy reports, statements on its website, newspaper and official account of some popular social media. PBoC regularly holds press conferences after the announcements on adjusting the RRR. It also jointly hosts press conference with other departments in the state council to explain its current policy stance. PBoC also post a Q&As session on its website for some of the important monetary policy decisions it makes. The monetary policy reports are published quarterly since 2000s. It is a detailed report with summaries of current financial conditions and policy stance as well as economic forecasts and policy forward guidance. PBoC also makes effort in engaging communication with the young generations through popular social media platforms.

5. IDENTIFICATION OF CHINA'S MONETARY POLICY SHOCKS

An important issue that arises when measuring the effect of monetary policy is the correct *identification of monetary policy shocks*. In the early literature, researches use changes in markets interest rates or policy rates directly as the measures of monetary policy. The problem with these measures is, however, that the changes in policy rates coincide with business cycle conditions. This is because the central bank endogenously reacts to the development in markets and macroeconomic conditions. Failing to recognize such endogeneity issue raises the so-called "price puzzle" (Bernanke and Blinder, 1992, Christiano et al., 1994), i.e. an increase in domestic inflation in response to a contractionary interest rate shock. Moreover, the current monetary policy framework of PBoC can be described as "multiple-instrument and multiple-objective" (Yi, 2018, Sun, 2018). The fact that PBoC does not adopt the *one-instrument short-term interest rate* operating framework which is used by modern central banks in advanced

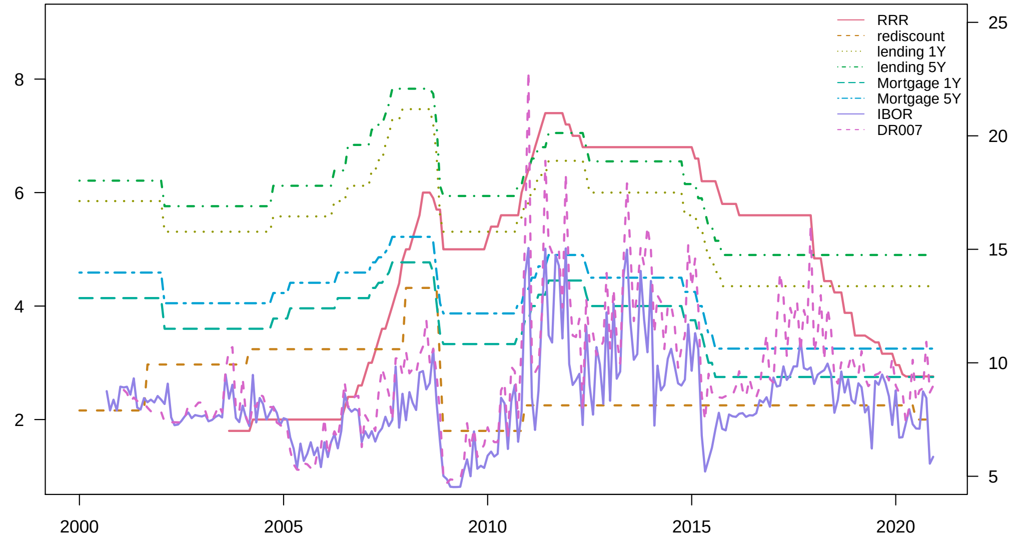

FIGURE 3.—RRR and the Key Interest Rates in China. The Rediscount rate, 1 Year/5 Year Lending rates, 1 Year/5 Year Mortgage rates, Interbank Overnight rate, and the DR007 use the left axis; the required reserve ratio uses the right axis. Sources: CEIC China Database

economies[6] further creates difficulty in identification of monetary policy stance for researchers and policy observers.

The use of policy announcements can help overcome these identification challenges. The announcement event provides an opportunity to isolate the exogenous and unexpected part of variation in policy. Within a short time window, the movements in financial asset prices are likely to be solely caused by the central bank's policy decisions and not by other factors. In other word, the financial asset price changes around announcements are assumed to change to the extent the announcement surprises the markets—if prices reflect expectations. Popular choices among the proxy financial variables include overnight rates, short- and medium-term treasury rates, and futures on the policy rates. The approach does not require any assumptions on the central bank's reaction function. The identification of monetary policy shocks based on high-frequency market surprises (HFI) in financial variables has been widely adopted in recent literature (Kuttner, 2001, Grkaynak et al., 2005, Bernanke and Kuttner, 2005, Gertler and Karadi, 2015).

However, these announcements reveal news not just about policy but also about the central bank's assessment of the economic outlook. A growing body of research has argued that central banks have an informational advantage in assessing the economic outlook which causes the asymmetry of information between the central bank and the public (Romer and Romer, 2000, Nakamura and Steinsson, 2018, Lunsford, 2020, Jarociski and Karadi, 2020). In that respect, policy announcement by the central bank may influence private-sector beliefs about the state

[6]For example, the Fed Fund rate for the Federal Reserve; Deposit Facility rate for the European Central Bank

of economy. The market reacts not only to the policy changes, but also to the revealed central banks' views on the economic forecast at the announcements. The market movements are caused by not only the interest or credit channel but also the informational channel of monetary policy.

5.1. *The Informational Content of Central Bank's Policy Announcements*

Figure 4 attempts to demonstrate the idea behind the informational content of monetary policy announcements, i.e., the market surprises captured by high-frequency identification may not solely be a reflect of the monetary policy shocks, by plotting the relationship between the interest rates and stock price surprises around monetary policy announcement dates for China (left) and US (right). With the surprises in stock prices on the y-axis and the surprises in interest rates on the x-axis, it shows that many monetary tightening announcements are accompanied by stock price increases and many monetary easing announcements are accompanied by stock price declines, which is at odds with the standard economic theories. This phenomenon is known as the *wrong-signed responses of stock prices*. The left panel shows that about half of PBoC's RRR announcements since 2003 are accompanied by a positive comovement of interest rate and stock price. The right panel shows that around one third of FOMC announcements between 1990 to 2020 are accompanied by such positive comovements, which reflects the fact that the *wrong-signed responses of stock prices* is very common across countries.

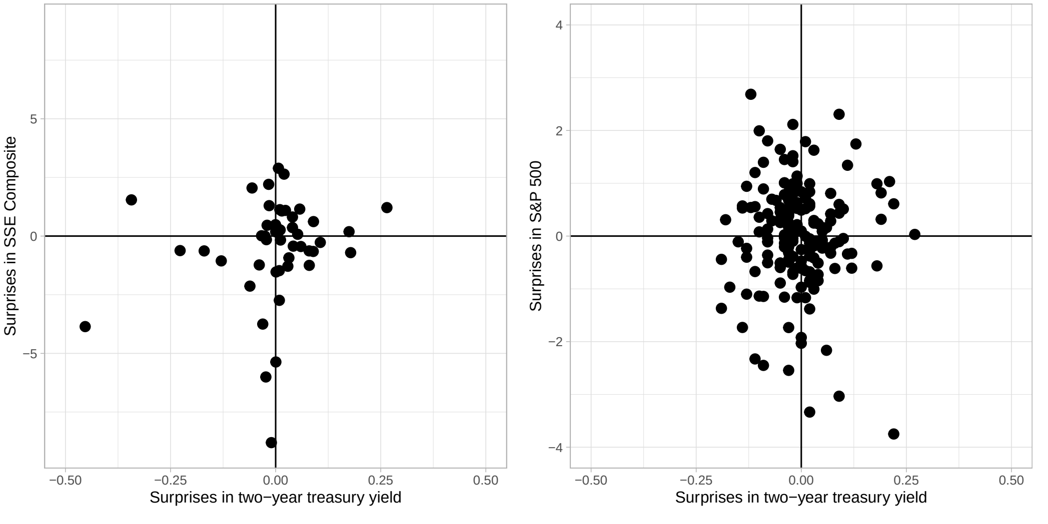

FIGURE 4.—Scatterplot of Interest Rate and Stock Price Surprises. For China the stock price is the SSE Composite index and the interest rate is the twelve-month future on the seven-day repo rate. For the US, it is the S&P 500 index and the two-year treasury.

Pure monetary policy shocks can be disentangled from informational content by analyzing the high-frequency co-movement between interest rates and stock prices around central bank's announcements. The comovement is informative because standard theory unambiguously predicts that a pure monetary policy tightening leads to lower stock market valuation. A monetary shock can be identified through a negative co-movement between interest rate and stock price changes, while an information shock contributes to a positive co-movement between the two surprises. The identification problem suits for a Bayesian structural VAR (SVAR) model with prior belief about the signs of the impact of certain shocks (Faust, 1998, Canova and De Nicolo, 2002, Uhlig, 2005). Uhlig (2005) tackles the "price puzzle" by restricting a positive monetary policy shock to both not decrease the fed fund rate and not increase the GDP deflator and the commodity price index. Kerssenfischer (2019) identifies the monetary policy shocks of the European central bank by sign-restricting on high-frequency co-movement between government bond yield and stock market changes. I exploit the high-frequency comovement around PBoC's RRR announcements to disentangle monetary policy shocks from the announcements' informational content. Specifically, I identify the monetary policy shocks by combining the high-frequency market surprise comovement between interest rates and stock prices around the RRR announcements with low-frequency macroeconomic series in a Bayesian Vector-Autoregression (BVAR) model. The macroeconomic series include monthly interest rates, price level, economic activity, and financial indicator. The BVAR model allows one to disentangle the pure monetary policy shocks from the possible information effect of central bank through *sign restrictions*. It also allows one to estimate the monetary policy shocks and the information shocks and their dynamic impact on the macroeconomic variables. The key identification strategy builds on high-frequency market variables' comovement around PBoC's monetary policy announcements. Differently to Jarociski and Karadi (2020), I restrict the impulse responses of the monetary policy shocks by both high- and low frequency impacts. A monetary policy tightening shock should cause a negative high-frequency comovement between interest rate and stock price around the announcement, and also having negative impacts on the low-frequency economic activity, price level and financial indicator as well.

5.2. *Deconstruction of Monetary Policy Surprises: A Bayesian Approach*

In this section, I demonstrate how to estimate a Bayesian VAR model with sign restrictions and identify structural shocks. The policy shock is identified through combining HFI with sign restrictions. Following Uhlig (2005), I use a uninformative Haar prior in the baseline specification, which does not introduce the model with any informative priors other than the sign restrictions imposed on the impulse responses. An informative prior will influence the posterior inference even if the sample size is infinite (Baumeister and Hamilton, 2015). Different to Jarociski and Karadi (2020), who use the Litterman priors (Litterman and et al., 1979) to deal with the nonstationary inputs, all variables in my model are pretransformed to be in the stationary form before enter the model.

Suppose a VAR that takes the general form:

$$Y_t = B_1 Y_{t-1} + B_2 Y_{t-2} + \cdots + B_l Y_{t-l} + u_t, \quad t = 1, \cdots, T, \tag{1}$$

where Y_t is an $m \times 1$ vector of variables at time $t = 1 - l, \cdots, T$, B_i are coefficient matrices of size $m \times m$ and u_t is the one-step ahead prediction error with variance-covariance matrix Σ.

There is not much disagreement about estimation of the model. But the disagreement starts on how to decompose the prediction error u_t into economically meaningful innovations, for example, a monetary policy innovation. Suppose that there are m fundamental innovations, denote ϵ_i for innovation i, which are assumed mutually independent and normalized to be of variance 1. The object is then to find a matrix A such that:

$$A\epsilon_t = u_t \tag{2}$$

The jth column of A then represents the immediate impact on all variables of one standard deviation shock of the jth fundamental innovation. To identity A, start with the relationship between A and the variance-covariance matrix:

$$\Sigma = E[u_t u_t'] = AE[\epsilon_t \epsilon_t']A' = AA' \tag{3}$$

The identification of A requires at least $m(m-1)/2$ restrictions. The standard approach to this identification problem is either using a Cholesky decomposition and implying a recursive ordering of the variables, or applying short-run or long-run restriction of separating transitory from permanent components (Blanchard and Quah, 1988).

Different to these conventional identification procedures, Uhlig (2005) proposes to only identify the shock of interest using some inequality sets of prioris. This is equivalent to identifying a single column a of the matrix A, where the vector a is called an impulse vector. To calculate the corresponding impulse response functions, let $\tilde{A}\tilde{A}' = \Sigma$ be a Chelsky decomposition of Σ. It can be showed that

$$a = \tilde{A}\alpha \tag{4}$$

where α is an m-dimension unit vector. Let $r_i(k)$ be the vector response at horizon k to the ith shock in the Cholesky decomposition. The impulse response for impulse vector a is then

$$r_a(k) = \sum_{i=1}^{m} \alpha_i r_i(k) \tag{5}$$

where α_i is the ith entry of unit vector α. Further, find a vector $\tilde{b} \neq 0$ with

$$(\Sigma - aa')b = 0 \tag{6}$$

with b normalized so that $b'a = 1$. Then

$$v_t^{(a)} = b'u_t \tag{7}$$

is the shock at time t in the direction of the impulse vector a. Essentially, b is the appropriate row of A^{-1}.

Numerically, this procedure can be accomplished by a Bayesian VAR with sign restrictions, which essentially explores the space of orthogonal decomposition of the shocks to see whether the responses conform with the imposed restrictions (Canova and De Nicolo, 2002). Let $\mathcal{S}(B, \Sigma, K)$ be the set of all the desired impulse vectors a. The posterior distribution is then given by the Normal-Wishart posterior for (B, Σ), times the indicator function on $\tilde{A}\alpha \in \mathcal{S}(B, \Sigma, K)$. Specifically, to draw from the posterior, jointly draw from both the unrestricted Normal-Wishart posterior for the VAR parameters (B, Σ), and a uniform distribution over the unit sphere of α space. Construct the impulse vector a according to Eq. (3), and calculate the impulse responses $r_{k,j}$ at horizon $k = 0, \cdots, K$ for variable j. If all the impulse responses satisfy the sign restrictions, keep the draw, otherwise discard it. Repeat the procedure to get sufficient draws.

Sign restricted models are set-identified (or partially identified). In the procedures proposed by Uhlig (2005), only one shock can be fully identified. Although it is possible in theory to handle multiple shocks (Rubio-Ramirez et al., 2010, Fry and Pagan, 2011), it is difficult to identify all shocks in the model by sign restrictions. One reason for this is that different sets of shocks might be characterized by the same set of restrictions, especially when there is not "enough" restrictions being imposed. Unlike imposing hard restrictions to just- or over- identify the models, the idea behind sign-restricted model is to weakly restrict the model and let the data speak for itself. A way to improve the model identification is to use additional constraints. In general, the more restrictions one imposes, the "better" identified the model is (Paustian, 2007). There are two approaches in adding additional constraints. One is to impose additional sign restrictions to the unrestricted responses of variables. Simulation results shows that increasing in number of constraints imposed on the model reduces error band of impulse response function (Danne, 2015). Another is to impose additional zero restrictions on selected impact responses (Jarociski and Karadi, 2020). In this paper, in addition to the high-frequency variables, restrictions are also imposed on the long term impact for monetary shocks, which are similar to the restrictions used in Uhlig (2005).

5.3. *The Model*

Let y_t be a vector of N_y macroeconomic and financial variables observed in month t. Let x_t be a vector of surprises in N_x financial instruments observed in month t. To construct x_t, I add up the intraday surprises occurring in month t on the days with announcements (if any). Note that x_t is zero in the months with no announcements. Our baseline model is VAR of Equation 1 with $Y_t = \binom{x_t}{y_t}$. Specifically, x_t contains high-frequency market surprises. y_t contains the low-frequency monthly macroeconomic variables. Table II summarizes the identification restrictions. The model can be written as follows:

$$\begin{pmatrix} x_t \\ y_t \end{pmatrix} = \sum_{p=1}^{P} \begin{pmatrix} \beta_{mm} & \beta_{my} \\ \beta_{ym} & \beta_{yy} \end{pmatrix} \begin{pmatrix} x_{t-p} \\ y_{t-p} \end{pmatrix} + \begin{pmatrix} u_t^m \\ u_t^y \end{pmatrix}, \quad \begin{pmatrix} u_t^m \\ u_t^y \end{pmatrix} \sim \mathcal{N}(0, \Sigma) \tag{8}$$

where $\mathcal{N}$ denotes the normal distribution. Here I did not put any predetermined hard constraints on the coefficients like the conventional methods. Instead, I let the data speaks out for itself.

TABLE II
IDENTIFICATION RESTRICTIONS

	Shock		
Variable	Monetary policy	Information channel	Other
high frequency			
Interest rate	+	+	·
stock index	−	+	·
low frequency			
Interest rate	+	·	·
stock index	−	·	·
Industrial output	−	·	·
Inflation	−	·	·
Excess bond premium	+	·	·

Note: + positive sign restrictions. − negative sign restrictions. · no restrictions.

I use the immediate change in the Chinese *2-year treasury bond* yields and the *SSE Composite index* around 48 PBoC's RRR announcements between 2003 and 2020 as proxies for the high-frequency comovement. The former measures the changes in expectations about short-term interest rates and the latter measures the changes in stock market valuation. The announcements are made on PBoC's website[7]. I choose the 24-hour window for the measurement because almost all of the statement were released in after-market hours[8]. For the monthly

[7] After 2015, such announcements are usually followed by a detail press release.
[8] Except for April 29, 2007

macroeconomic variables, I use the monthly average of the 1-year constant maturity treasury yield as the low-frequency monetary policy indicator. The advantage of using 1-year rate is that it incorporates the impact of potential (if any) forward guidance and is much less volatile than the overnight rates and the DR007. I use the monthly year-to-year growth rate of value-added industrial output as the measure of real activity and the monthly year-to-year growth in consumer price index (CPI) as the measure of inflation. I choose the industrial output and CPI over the GDP and GDP deflator because they do not requires the interpolation of quarterly data into monthly frequency. Another advantage of using of industrial output over the overall GDP, in China's case, is that the latter is highly correlated with its announced annual target by the government which make the data more vulnerable to factors other than economic activities. As for the monthly stock price index, I use the monthly average of SSE Composite index in log level. For the indicator of financial condition I include the monthly average of 10-year treasury constant maturity yield minus 2-year treasury constant maturity yield as a measure for excess bond premium. All the monthly macroeconomic series are from CEIC China database. The VAR has 12 lags. The sample is monthly from January 2002 to July 2020. I report the results based on 3,000 draws from a flat Normal inverted-Wishart posterior. Fig. 5 shows the decomposition results from the model. I employ the same practice on US data with the corresponding series and report the results as a benchmark. The results from US data are similar to those in Jarociski and Karadi (2020).

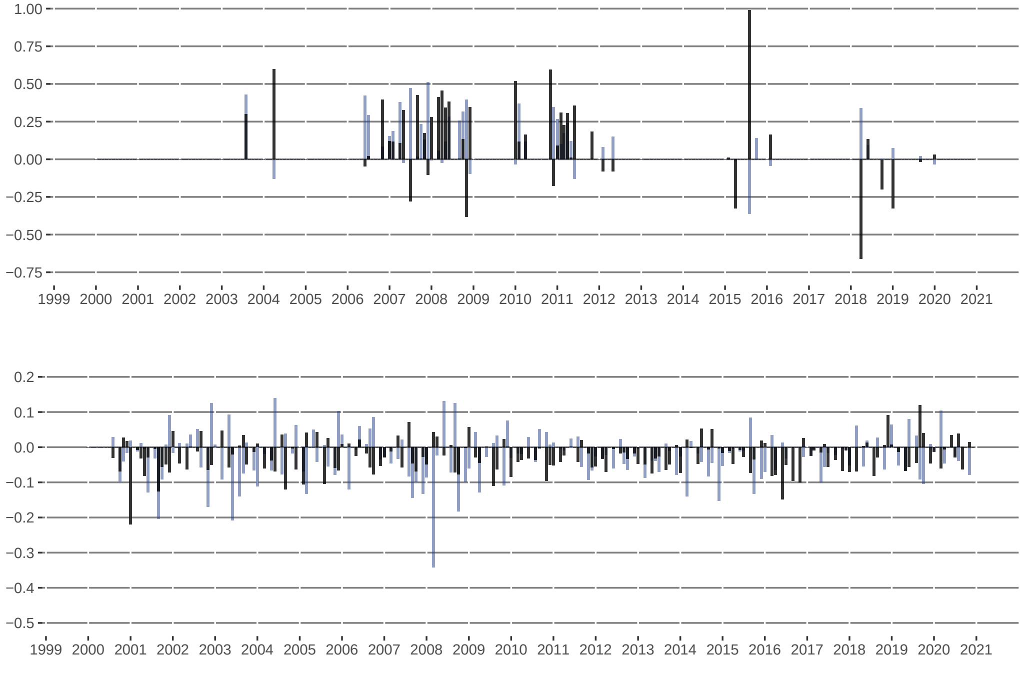

FIGURE 5.—The top panel depicts the decomposition of PBoC's RRR releases in China. The bottom panel is the same estimation for Fed's FOMC releases in US. The dark and light bars represent estimated monetary shocks and informational shocks from each central bank policy releases

5.4. *The Impulse Responses*

Figure 6 presents the impulse responses the identified shocks. A monetary policy shock is defined as a structural shock that causes the negative comovement of interest rate and stock valuation as well as the movements of macroeconomic variables as predicted by most of standard economic theories. An information shock which is characterized as a structural shock that causes the positive comovement of interest rate and stock valuation, is defined as the driver of the market surprises that cannot be explained by the monetary policy shocks. The result shows that the central bank's announcements not only contain monetary policy but also meaningful information content. The left panel shows impulse responses of the macroeconomic variables to a monetary policy shock. The shock does not produce the prize-puzzle and the rest of the results are in line with the standard economic theories. The right panel shows the impulse responses to an information shock, i.e., a shock of positive co-movement of interest rates and stock prices around the announcements. The information shock is informative about the macroeconomic variables too. For example, the information shock predicts a persistent increase in inflation and a sharp decline in the excess bond premium. The difference in the responses of inflation and the excess bond premium across the two panel shows that the positive co-movement shock reveals the part of information at the announcement that is not consistent with monetary policy shock. This is notable given there is no restrictions on the responses of any low-frequency variables y_t in the positive co-movement shock. If the high-frequency stock market response around the policy announcement were uninformative about the effect of the announcement on the economy, the impulse responses would have been similar in the two columns, which is clearly not the case.

By estimation, a one-standard-deviation monetary policy shock is associate with 0.3 to 2 basis points increase of the 2-year treasury yield and a 4 to 53 basis points drop in the SSE composite index in the 24-hour window. The one-year treasury yield increases by around 10 basis points and reverts to zero in 12 months. Industrial output decreases about 0.1% and reverts to zero in 18 months. Consumer price index growth drops about 16 basis points in 9 to 20 months. Excess bond premium immediately increases about 4 basis points after the announcement. A one-standard-deviation information shock is associated with a 1 to 2 basis points increase in the 2-year treasury yield and a 41 to 59 basis points increase in the SSE composite index at announcement. The shock has a mild positive impact on the 1-year government bond yield, and significantly reduces the excess bond premium by 2 basis points. The impacts on industrial output and inflation are quite different from the ones after a monetary policy shock: output increases about 10 to 14 basis points in about 9 to 12 months rather than declining as after a monetary tightening shock, and inflation rises about 12 basis points in about a year. These responses support the hypothesis that central bank tightens monetary supply to prevent overheating of the economy and communicates good news about the economic forecast at the announcements. The significant immediate impact on the 1-year government bond yield and excess bond premium show that the policy did not completely offset the initial effect of the news. But it offsets the effect of news in the long run. The result is very much in line with the finding of Jarociski and Karadi (2020) whose research is based on the US and Euro data.

6. EMPIRICAL RESULTS

In this section, I analyze the effect of the identified monetary policy shocks on corporate bond prices. The corporate bond data is available after September, 2011. Therefore, the time span of this analysis covers the PBoC's announcements occurred between 2011 to 2020, during which there are in total 12 announcements on adjusting the RRR. All the policy actions are RRR cuts, which suits the purpose of this analysis. Table III presents the summary statistics of

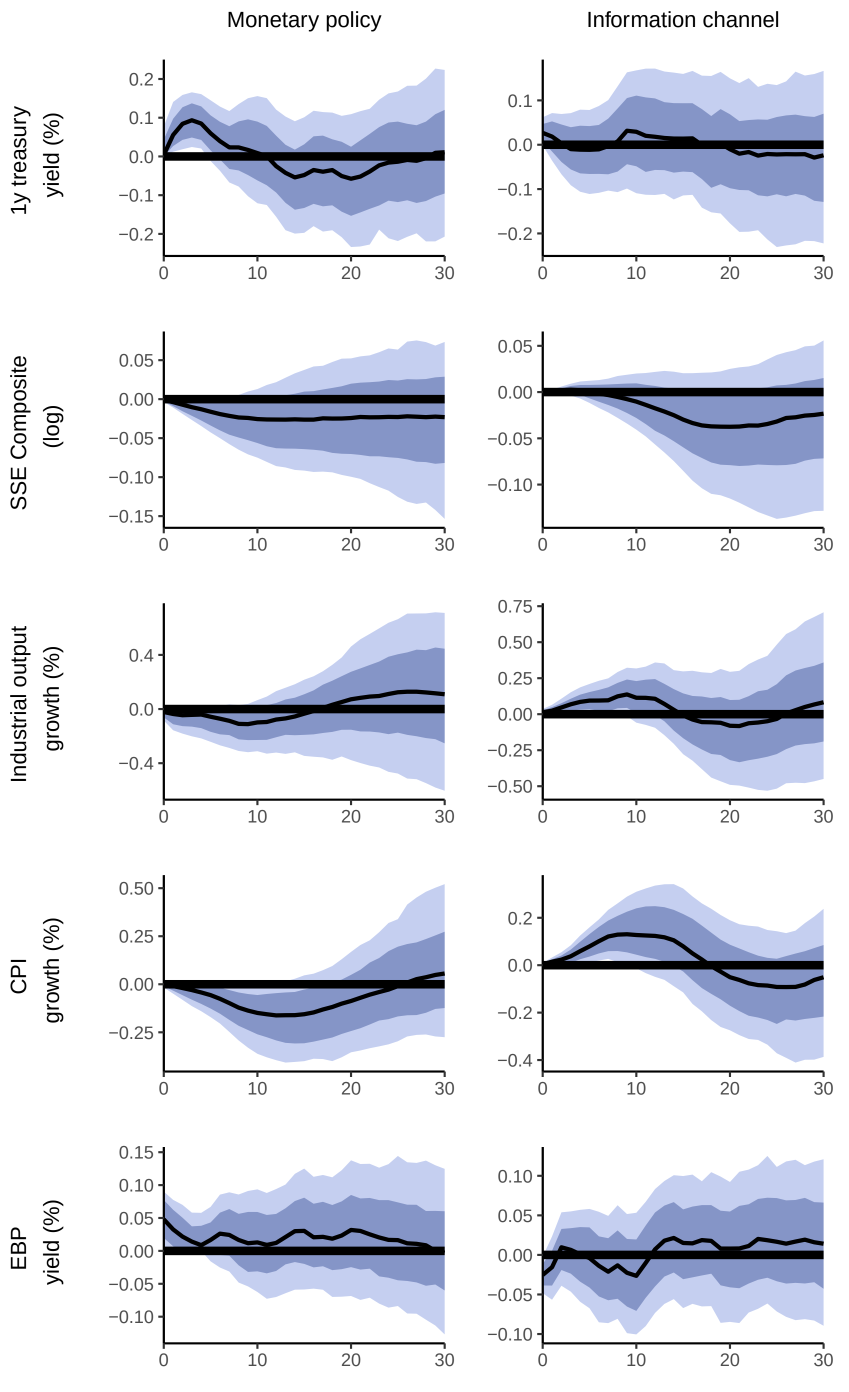

FIGURE 6.—Impulse Responses to One-Standard-Deviation Shocks. Median(line), percentiles 16-84 (darker band), percentile 5-95 (lighter band).

corporate bond returns around the policy announcements. Zeros are within the range of a one-standard-deviation of the means for all of the observations, indicating that overall the market mean returns does not move significantly on these dates.

TABLE III
SUMMARY STATISTICS OF BONDS' RETURN AROUND EACH ANNOUNCEMENTS

Announcement Date	RRR	Mean	S.d	Min	Max
2011-11-30	-0.50	0.03	0.07	-0.13	0.14
2012-02-18	-0.50	0.01	0.07	-0.13	0.32
2012-05-12	-0.50	0.06	0.06	-0.11	0.35
2015-02-04	-0.50	0.06	0.09	-0.50	0.49
2015-04-19	-1.00	0.13	0.12	-0.02	0.98
2015-08-25	-0.50	0.01	0.13	-5.56	1.35
2015-10-23	-0.50	0.08	0.12	-5.76	1.23
2016-02-29	-0.50	0.01	0.05	-0.98	0.85
2018-04-17	-1.00	0.34	0.38	-3.61	1.37
2018-06-24	-0.50	-0.00	0.11	-7.20	0.80
2019-01-04	-1.00	0.06	0.28	-10.31	0.98
2019-09-06	-0.50	0.03	0.20	-10.22	1.35

6.1. *The Overall Effect of Monetary Policy on Corporate Bonds*

In this section I estimate the overall effect of monetary policy shocks in corporate bond pricing:

$$r_{i,t} = \alpha_i + \beta shock_t + \alpha_{m,t} + \alpha_{j,t} + \epsilon_{i,t} \tag{9}$$

where $r_{i,t}$ denotes the price return of bond i from day $t-1$ to day $t+1$ around announcement day t. $shock_t$ are the identified monetary policy or information shocks at each announcement day t. $\alpha_{m,t}$, $\alpha_{j,t}$ are fixed effects interacting each year with, respectively, a bond's years to maturity and a bond issuer's industry. The year-by-years-to-maturity fixed effect flexibly control for changes in the term structure of interest rates. The year-by-industry fixed effect control for potential differential industry-level responses from year to year. With these fixed effects included, the regression always compare the price reactions of bonds from same industry that have the same time-to-maturity. ϵ_{it} is the idiosyncratic error term. Standard errors are two-way clustered by announcement date and by issuer. The coefficient β estimates the average effect of the shocks in the bond returns across the corporate bond markets.

Table IV reports the results. The average effect of a one-standard-deviation monetary policy tightening on corporate bond returns is -7.36 basis points (-6.3 without fixed effect, -7.16 with bond fixed effects). The estimated coefficients are significant. From column 1, the monetary shock alone can explain 17% variance in the price movements on announcement days, and the explanation power increasing to 27% after including the fixed effects. The average effect of one-standard-deviation information shock on bond returns is 15.1 basis points (10.5 without fixed effects, 12.8 with bond fixed effect). The significance of coefficient on the information shock shows the central bank's informational content is important. The opposite signs of the coefficients on monetary policy shocks and information shocks reflect the fact that these two channels affect the asset prices very differently. The estimations are comparable to the official estimation of the long term effect of adjusting RRR. According to an estimation of PBoC[9],

[9]based on an estimation of a 25 bps cut on April 25th, 2022

a 25 bps cut will provides 530 billion RMB long-term funds to the financial system. China's financial market has seen with a record high growth rate of money supply in the last decade. According to the World Bank Data, the average M2/GDP ratio of China for the last ten years is 193%, which is above twice of that of the US (91%) and far bigger than the 2020's global average (85%)[10]. The abundant fund in the financial system induces the rapid expansion of shadow banking in the last ten years, which reflects the growing risk-taking and the efforts to circumvent regulatory restrictions on banking system.

TABLE IV
THE EFFECT OF MONETARY POLICY SHOCK ON CORPORATE BOND RETURNS

Variable	(1) r	(2) r	(3) r
Monetary Shock	-0.0630^{***}	-0.0736^{***}	-0.0716^{***}
	(0.0017)	(0.0015)	(0.0011)
Bond FE			✓
Year × Years-to-maturity FE		✓	
Year × Industry FE		✓	
Observations	38,615	38,615	38,615
Adjusted R^2	0.1751	0.2736	0.2261
	(4) r	(5) r	(6) r
Information Shock	0.1058^{***}	0.1517^{***}	0.1284^{***}
	(0.0036)	(0.0037)	(0.0023)
Bond FE			✓
Year × Years-to-maturity FE		✓	
Year × Industry FE		✓	
Observations	38,615	38,615	38,615
Adjusted R^2	0.1256	0.2261	0.1680

6.2. *The Heterogeneous Responses From the Issuers*

The significant responses of corporate bond prices to monetary policy shocks on announcement dates raise the question of whether the response is driven by a wide market consensus or by a group of impacted firms. In other word, whether the effect of monetary policy is uniform or heterogeneous across the market, or the shocks impact the market heterogeneously. In order to answer this question, I regress each corporate bond returns on the shocks individually using the empirical model of Equation 9 (without fixed effects) and plot the coefficients distribution in Figure 7. The results show large heterogeneity in the response across firms. For the monetary policy shocks, the responses of firms range from -40.2 basis points to 0.6 basis points. The 0.5% to 99.5% percentile effects, after dropping the 1% extreme values, ranges from -26.5 basis points to 0.1 basis points, with a mean of -7.1 and a median of -5.9 basis points. For the information policy shocks, the responses are more dispersed. The responses range from -104.5 basis points to 111 basis points. The 0.5% to 99.5% percentile ranges from -63.7 basis points to 64.1 basis points, with a mean of 7.4 and a median of 6.1 basis points. Two

[10]The large difference is partly due to the important difference between the financial market structures.

observations are made from the result: first, the impact of shocks is not uniformly distributed across the market. Second, the effect of the central bank information channel is more disperse than the conventional channels. The impact of information shocks significantly varies across firms. A non-neglectable fraction of bond prices even fall after a upward revision in the economic outlook projection shock. In conclude, the results show that some firms are particularly strongly affected by the monetary policy while other firms are not so much. The next question would be: who are particularly affected?

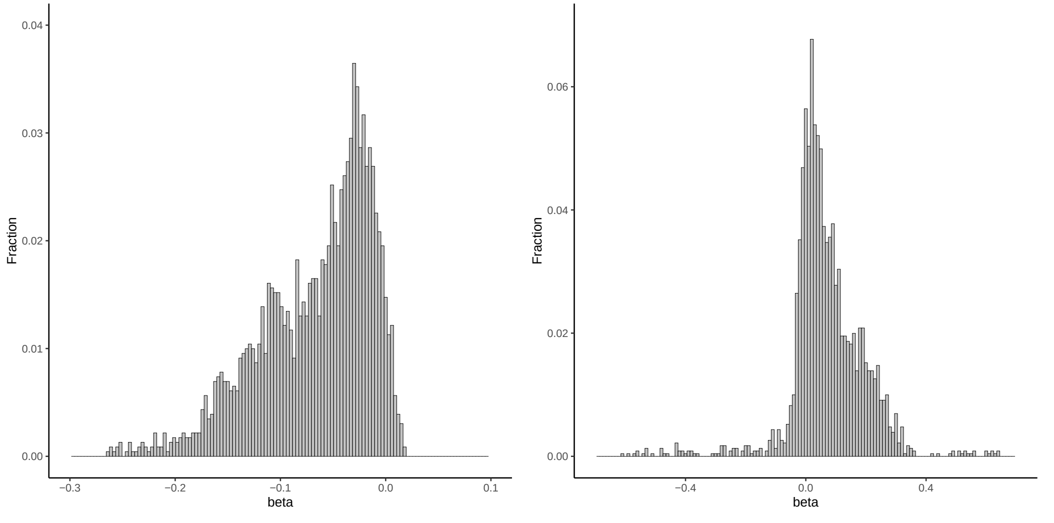

FIGURE 7.—Distribution of Policy Effect Across Bond Market

6.3. *Monetary Policy and Risk-taking*

A widely held view among many observers—including academics, policy makers, and the popular press alike—is that more accommodative monetary policy drives up risky asset prices. The granularity of this database allows me to flexibly control for a set of bond and issuer characteristics, and thus test the hypothesis. Following Smolyansky and Suarez (2021), I use the following regression equation:

$$r_{i,t} = \beta shock_t \times Credit\_risk_{i,t} + \phi Credit\_risk_i + \Gamma X_{i,t} + \alpha_{m,t} + \alpha_{j,t} + \alpha_{c,t} + \epsilon_{it} \quad (10)$$

where $Credit\_risk_{i,t}$ is the bond's credit rating at the time of the announcement, with higher values indicating riskier bonds (a unit increase means a one notch worse in credit rating, e.g., AAA to AA+). A set of control issuers' financial variables, $X_{i,t}$, includes issuer's total asset (in log), return on total asset, return on equity, current ratio, quick ratio, debt to total asset ratio, short debt to total debt ratio, cash to total asset ratio, cash to total debt ratio. Table V summarizes the financial variables. To control for potential cyclical effects for each issuance, $\alpha_{m,t}$, $\alpha_{j,t}$, as discussed before, are fixed effects interacting each year with, respectively, a bond's years to maturity and a bond issuer's industry. $\alpha_{c,t}$ is a fixed effect interacting year-by-years-to-maturity fixed effects with the corporate bond's coupon rates. The fixed effects that ensure that the comparison among the price reactions of bonds have the same time-to-maturity but different levels of credit risk, while also controlling for industry effects and other bond features. ϵ_{it} is the idiosyncratic error term. Standard errors are two-way clustered by announcement date and by issuer.

TABLE V

SUMMARY STATISTICS OF FIRMS' FINANCIAL VARIABLES

	Min	25%	Med	Mean	75%	Max	S.d
Total Asset (in log)	1.9	4.5	5.1	5.3	5.9	11.4	1.1
Return on Total Asset	0.0	2.0	3.8	4.6	6.1	145.8	4.5
Return on Equity	0.0	2.2	5.0	7.1	9.8	453.2	10.9
Current Ratio	0.1	1.0	1.4	2.4	2.4	151.3	4.2
Quick Ratio	0.1	0.6	0.9	1.3	1.5	41.7	1.4
Debt to Total Asset Ratio	10.7	47.5	58.9	57.4	68.3	94.6	15.2
Short Debt to Total Debt Ratio	4.7	42.8	63.1	60.5	78.5	100.0	22.3
Cash to Total Asset Ratio	0.0	0.2	0.3	0.4	0.5	9.0	0.5
Cash to total Debt Ratio	0.0	0.1	0.1	0.2	0.2	4.1	0.2

The sign on coefficient of interaction of monetary shocks and credit risk in Equation 10, β, tests for hypothesis of search for yield. If $\beta < 0$, monetary policy easing induces bonds with higher credit risk to outperform, while monetary tightening induces bond with higher credit risk to underperform, which is consistent with the "search for yield". If $\beta > 0$, then monetary policy tightening induces bonds with higher credit risk to outperform, while monetary easing induces bonds with higher credit risk to underperform. Similarly, the sign on coefficient of interaction of information shocks and credit risk reveals the effect of information channel of central bank on risky bond prices. If $\beta > 0$, good news about economic outlook induces bonds with higher credit risk to outperform, while bad news induces bond with higher credit risk to underperform.

The fixed effects play an essential role in the regression specification. A separate set of fixed effects for each year, which are in turn interacted with bond and issuer characteristics, allows one to isolate the price reaction specifically attributable to credit risk, and thus cleanly test the hypothesis. In particular, the year-by-years-to-maturity fixed effect α_{tm}, flexibly control for changes in the term structure of interest rates. The year-by-industry fixed effect α_{tj} control for potential differential industry-level responses from year to year. In essence, after adjusting for industry effect, the regression always compare the price reactions of bonds that have the same time-to-maturity but different level of credit risk. To address the concern that there may be difference in duration between higher and lower credit risk bonds, even after including fixed effects that hold constant the years-to-maturity, the interaction between year-by-years-to-maturity fixed effects with the corporate bond's coupon rate, $\alpha_{c,t}$, controls for the bond's coupon rates. This rules out the potential "coupon effect", that bonds with higher coupon rates will have lower duration, which in turn lower the price sensitivities to change in the policy rates.

As introduced in the previous section, I exclude lower credit ratings like Bs and Cs due to insufficient observations in this analysis. The credit rating comprises of 4 level. A notch difference in Chinese credit ratings is associated with 58 basis points difference in yield, while the difference is associated with 9-18 basis points in investment grading in the US and Europe bond markets. A one-notch difference in credit ratings in China's bond market is likely equivalent to a one-letter (or three-notch) difference in international ratings.

Table VI shows the coefficient on the interaction between monetary shocks and credit risk is negative. The estimations indicate that the impact of one-standard-deviation monetary tightening (easing) shock on corporate bonds increases (decreases) 2.3 basis points with the credit rating lowering a notch. In other word, low credit rating bonds outperform at a monetary easing

TABLE VI

THE EFFECT OF MONETARY POLICY SHOCKS BY CREDIT RATING

Variable	(1) r	(2) r	(3) r
Monetary Shock × Credit_Risk	−0.0208***	−0.0230***	−0.0233***
	(0.0006)	(0.0005)	(0.0005)
Credit_Risk	−0.0385***	−0.0380***	−0.0353***
	(0.0025)	(0.0027)	(0.0036)
X_{it}			✓
Year × Years-to-maturity FE		✓	✓
Year × Industry FE		✓	✓
Year × Years-to-maturity × Coupon FE			✓
Observations	38,615	38,615	38,421
Adjusted R^2	0.13	0.21	0.22

while underperform during a monetary tightening. The R^2 of column 1 shows that the credit risk and the interaction of monetary shocks with credit risk explain 13% of the variance in corporate bond return at announcements. Column 2 and 3 include fixed effects and control variables. The results do not change much. The explanation power increases after includes the fixed effects. Most of the financial variables are not statistically significant in explaining the returns, and they add little explaining power to the existing models.

TABLE VII

THE EFFECT OF MONETARY POLICY SHOCKS BY CREDIT RATING: EASINGS VS. TIGHTENINGS

Variable	(1) r	(2) r
Monetary Shock (> 0, tightening) × Credit_Risk	0.0015	
	(0.0018)	
Monetary Shock (< 0, easing) × Credit_Risk		−0.0175***
		(0.0015)
Credit_Risk	0.0119***	−0.0562***
	(0.0031)	(.0046)
X_{it}	✓	✓
Year × Years-to-maturity FE	✓	✓
Year × Industry FE	✓	✓
Year × Years-to-maturity × Coupon FE	✓	✓
Observations	11,723	26,698
Adjusted R^2	0.12	0.45

Table VII investigates whether the effect is asymmetric across monetary tightenings and easings. The sample is split into two subgroups based on whether the shock is positive (a monetary tightening) or negative (a monetary easing). Among the 12 announcements, there are 4 times of monetary tightenings and 8 times of monetary easings. Column 1 shows the result of monetary tightenings and column 2 showing the result from monetary easings. As one can see from these results, the differential effect of monetary shocks on credit risk comes mainly from monetary easings, which is consistently in line with the "searching for yield". The R^2 also shows that the accommodative monetary policy explains about 45% of the variance in the movement of corporate bond prices across different credit risk groups.

TABLE VIII
INFORMATION SHOCKS ON CORPORATE BOND RETURNS BY CREDIT RATING

Variable	(1) r	(2) r	(3) r
Information Shock × Credit_Risk	0.0340^{***}	0.0415^{***}	0.0435^{***}
	(0.0012)	(0.0012)	(0.0012)
Credit_Risk	-0.0114^{***}	-0.0039	-0.0003
	(0.0025)	(0.0028)	(0.0038)
X_{it}			✓
Year × Years-to-maturity FE		✓	✓
Year × Industry FE		✓	✓
Year × Years-to-maturity × Coupon FE			✓
Observations	38,615	38,615	38,421
Adjusted R^2	0.09	0.16	0.18

Table VIII reports the results of interaction between information shock and credit ratings. The $\beta > 0$ shows that riskier bonds outperform under good news and underperform under bad news. Specifically, the bond return increases (decrease) around 4 basis points along with a notch lowering of the credit rating of the bonds at good (bad) news. The interaction term explains a significant part of the variance of bond returns during the policy announcements (16%-18%). The results is robust to various specifications. The result does not change much when fixed effects and firm specific financial variables controls are added to the regression.

7. CONCLUSION

This paper estimates the effect of China's monetary policy on its domestic corporate bond markets. The documented effects in this paper are economically important. It is shown that monetary policy significantly affects corporate bond pricing. According to the estimation, a one-standard-deviation monetary policy easing shock instantly raises the market by 7.36 bps, which is about 2 billion RMB market valuation increase based on the current market size[11]. The result documents the immediate effects of monetary policy on financial market.

More importantly, the research finds that the effect is heterogeneous across firms, which is closely related to the issuers' credit risks. The estimation shows that risky bonds outperform the safer bonds following monetary easings. The effect of a monetary easing shock is raising bond prices associated one notch decline in credit quality by 2.3 bps more, which is equivalent to an additional 0.6 billion RMB instant increase in total market value. The result shows monetary policy induced risk-taking in China's financial market. It also sheds light on how the risk-taking significantly affects the transmission mechanism of monetary policy.

[11]Based on data from the latest S&P China Corporate Bond Index market data. The total par value of China corporate bonds is about 27 trillion RMB in 2022

REFERENCES

J. Ammer, S. Claessens, A. Tabova, and C. Wroblewski. Searching for yield abroad: risk-taking through foreign investment in us bonds. *FRB International Finance Discussion Paper*, (1224), 2018. [5]

M. Amstad and Z. He. *Chinese Bond Markets and Interbank Market*, pages 105–148. Princeton University Press, 2020. [8, 9]

P. Andrade and F. Ferroni. Delphic and odyssean monetary policy shocks: Evidence from the euro area. *Journal of Monetary Economics*, 117:816–832, 2021. [4]

K. Assenmacher and S. Gerlach. Monetary policy, asset prices and macroeconomic conditions: a panel-var study. *National Bank of Belgium Working Paper*, (149), 2008. [6]

C. Baumeister and J. D. Hamilton. Sign restrictions, structural vector autoregressions, and useful prior information. *Econometrica*, 83(5):1963–1999, 2015. [13]

B. Bernanke and A. S. Blinder. The federal funds rate and the transmission of monetary policy. *American Economic Review*, 82(4):901–921, 1992. [5, 10]

B. S. Bernanke and K. N. Kuttner. What explains the stock market's reaction to federal reserve policy? *The Journal of finance*, 60(3):1221–1257, 2005. [11]

O. J. Blanchard and D. Quah. The dynamic effects of aggregate demand and supply disturbances, 1988. [14]

C. Borio and H. Zhu. Capital regulation, risk-taking and monetary policy: a missing link in the transmission mechanism? *Journal of Financial stability*, 8(4):236–251, 2012. [5]

M. K. Brunnermeier, M. Sockin, and W. Xiong. China's model of managing the financial system. Report, 2020. [8]

V. Bruno and H. S. Shin. Capital flows and the risk-taking channel of monetary policy. *Journal of monetary economics*, 71:119–132, 2015. [5]

C. W. Calomiris, M. Larrain, S. L. Schmukler, and T. Williams. Search for yield in large international corporate bonds: Investor behavior and firm responses. Report, 2019. [1, 5]

F. Canova and G. De Nicolo. Monetary disturbances matter for business fluctuations in the g-7. *Journal of Monetary Economics*, 49(6):1131–1159, 2002. [13, 14]

H. Chen, K. Chow, and P. Tillmann. The effectiveness of monetary policy in china: Evidence from a qual var. *China Economic Review*, 43:216–231, 2017. [4, 6]

K. Chen, J. Ren, and T. Zha. The nexus of monetary policy and shadow banking in china. *American Economic Review*, 108(12):3891–3936, 2018. [3, 6]

L. Christiano, M. S. Eichenbaum, and C. Evans. The effects of monetary policy shocks: some evidence from the flow of funds, 1994. [10]

A. Cieslak and A. Schrimpf. Monetary and non-monetary news in central bank communication. *VOX CEPR Policy Portal*, 2018. [4]

T. Cook and T. Hahn. The effect of changes in the federal funds rate target on market interest rates in the 1970s. *Journal of monetary economics*, 24(3):331–351, 1989. ISSN 0304-3932. [3]

C. Danne. Varsignr: Estimating vars using sign restrictions in r. 2015. [15]

M. D. Delis, I. Hasan, and N. Mylonidis. The risk-taking channel of monetary policy in the us: Evidence from corporate loan data. *Journal of Money, Credit and Banking*, 49(1):187–213, 2017. [1]

G. Dell'Ariccia, L. Laeven, and G. A. Suarez. Bank leverage and monetary policy's risk-taking channel: evidence from the united states. *the Journal of Finance*, 72(2):613–654, 2017. [1, 5]

Y. Ding, W. Xiong, and J. Zhang. Overpricing in china's corporate bond market. 2020. [8]

Y. Dong, C. Meng, M. Firth, and W. Hou. Ownership structure and risk-taking: Comparative evidence from private and state-controlled banks in china. *International Review of Financial Analysis*, 36:120–130, 2014. [6]

J. Fang, C.-K. M. Lau, Z. Lu, Y. Tan, and H. Zhang. Bank performance in china: A perspective from bank efficiency, risk-taking and market competition. *Pacific-Basin Finance Journal*, 56:290–309, 2019. [6]

J. Faust. The robustness of identified var conclusions about money, 1998. [13]

R. Fry and A. Pagan. Sign restrictions in structural vector autoregressions: A critical review. *Journal of Economic Literature*, 49(4):938–60, 2011. [14]

L. Fu and C.-Y. Ho. Monetary policy surprises and interest rates under china's evolving monetary policy framework. *Emerging Markets Review*, page 100895, 2022. [6]

M. Gertler and P. Karadi. Monetary policy surprises, credit costs, and economic activity. *American Economic Journal: Macroeconomics*, 7(1):44–76, 2015. [11]

S. Gilchrist and E. Zakrajšek. Credit spreads and business cycle fluctuations. *American economic review*, 102(4): 1692–1720, 2012. ISSN 0002-8282. [5]

R. S. Grkaynak, B. P. Sack, and E. T. Swanson. Do actions speak louder than words? the response of asset prices to monetary policy actions and statements. *The Response of Asset Prices to Monetary Policy Actions and Statements (November 2004)*, 2004. [6]

R. S. Grkaynak, B. Sack, and E. Swanson. The sensitivity of long-term interest rates to economic news: Evidence and implications for macroeconomic models. *American economic review*, 95(1):425–436, 2005. [11]

M. Jarociski and P. Karadi. Deconstructing monetary policy surprises—the role of information shocks. *American Economic Journal: Macroeconomics*, 12(2):1–43, 2020. [4, 11, 13, 15, 16, 17]

M. Kerssenfischer. Information effects of euro area monetary policy: New evidence from high-frequency futures data. 2019. [4, 13]

R. Krussl, T. Lehnert, and K. Rinne. The search for yield: implications to alternative investments. *Journal of Empirical Finance*, 44, 2017. [1]

K. N. Kuttner. Monetary policy surprises and interest rates: Evidence from the fed funds futures market. *Journal of monetary economics*, 47(3):523–544, 2001. [11]

J. Li, S. Hsu, and Y. Qin. Shadow banking in china: institutional risks. *China Economic Review*, 31:119–129, 2014. [6]

X. Li and H. Wang. The effective of china's monetary policy: Quantity versus price rules. *The North American Journal of Economics and Finance*, 54:101097, 2020. [6]

R. B. Litterman and et al. Techniques of forecasting using vector autoregressions. Report, 1979. [13]

M. Livingston, W. P. H. Poon, and L. Zhou. Are chinese credit ratings relevant? a study of the chinese bond market and credit rating industry. *Journal of Banking & Finance*, 87:216–232, 2018. [4, 6, 8]

K. G. Lunsford. Policy language and information effects in the early days of federal reserve forward guidance. *American Economic Review*, 110(9):2899–2934, 2020. [11]

E. S. Maskin. Theories of the soft budget-constraint. *Japan and World Economy*, 8 , issue= 2:125–133, 1996. [8]

S. Miranda-Agrippino. Unsurprising shocks: information, premia, and the monetary transmission. 2016. [4]

S. Miranda-Agrippino and G. Ricco. The transmission of monetary policy shocks. *American Economic Journal: Macroeconomics*, 13(3):74–107, 2021. [4]

F. S. Mishkin. The transmission mechanism and the role of asset prices in monetary policy. 2001. [5]

E. Nakamura and J. Steinsson. High-frequency identification of monetary non-neutrality: the information effect. *The Quarterly Journal of Economics*, 133(3):1283–1330, 2018. [3, 4, 11]

M. Paustian. Assessing sign restrictions. *The BE Journal of Macroeconomics*, 7(1), 2007. [15]

R. Rigobon and B. Sack. The impact of monetary policy on asset prices. *Journal of monetary economics*, 51(8): 1553–1575, 2004. [6]

C. D. Romer and D. H. Romer. Federal reserve information and the behavior of interest rates. *American economic review*, 90(3):429–457, 2000. [11]

J. F. Rubio-Ramirez, D. F. Waggoner, and T. Zha. Structural vector autoregressions: Theory of identification and algorithms for inference. *The Review of Economic Studies*, 77(2):665–696, 2010. [14]

M. Smolyansky and G. Suarez. Monetary policy and the corporate bond market: How important is the fed information effect? 2021. [21]

G. Sun. China's shadow banking: Bank's shadow and traditional shadow banking. 2019. [6]

R. Sun. What measures chinese monetary policy? *Journal of International Money and Finance*, 59:263–286, 2015. [6]

R. Sun. A narrative indicator of monetary conditions in china. *55th issue (September 2018) of the International Journal of Central Banking*, 2018. [6, 10]

H. Uhlig. What are the effects of monetary policy on output? results from an agnostic identification procedure. *Journal of Monetary Economics*, 52(2):381–419, 2005. [13, 14, 15]

R. Wang, J. Liu, and H. Luo. Fintech development and bank risk taking in china. *The European Journal of Finance*, 27(4-5):397–418, 2021. [6]

M. Weale and T. Wieladek. What are the macroeconomic effects of asset purchases? *Journal of monetary Economics*, 79:81–93, 2016. [5]

M.-W. Wu and C. H. Shen. Effects of shadow banking on bank risks from the view of capital adequacy. *International Review of Economics & Finance*, 63:176–197, 2019. [6]

G. Yi. China's monetary policy framework - supporting the real economy and striking a balance between internal and external equilibrium. 2018. [3, 10]

Q. Zhang. The past, current, and the future of reserve requirement. *China economists*, 1(1):109–118, 2021. [9]

S. Zhou and D. D. Tewari. Shadow banking, risk-taking and monetary policy in emerging economies: A panel cointegration approach. *Cogent Economics & Finance*, 7(1):1636508, 2019. [6]