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Do foreign investors affect the volatility of local currency bond prices? Empirical evidence from China

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ABSTRACT

How does the participation of foreign investors on local bond markets impact the volatility of bond prices and yields? An answer to this question is important for policy makers from emerging markets in their attempts to liberalize access to financial markets. However, empirical literature gives inconclusive answers to this question. Reasons are that studies analyze diverse types of bonds and apply their analyses to different samples of countries and for different phases in the opening up of markets. We add to existing knowledge by empirically investigating the impact of foreign investors' participation on the volatility of prices of two types of Chinese bonds, government bonds and policy bank bonds, as well as for three stages in the liberalization of the Chinese bond market. We find that foreign investors' participation does not exert significant effects on volatility until late in the opening of the bond market. In addition, we uncover that those bonds which are more influenced by government policies, policy bank bonds, are also more strongly affected by international capital flows. From a policy perspective, our results emphasize the importance of increasing the openness of China's local currency bond market, of stabilizing foreign investors' expectations and, in turn, international capital flows.

1. Introduction

China's capital market opened up in 2002 with the introduction of the Qualified Foreign Institutional Investors Act (QFII). Since then, the size of China's bond market capitalization has increased by about 36 times, starting from Chinese RMB 3.80 trillion at the end of 2002 to RMB 138.95 trillion in June 2022. The bond market has greatly increased the proportion of direct financing and has strongly supported the growth of China's real economy. The bond market is crucial to the development of the overall financial market and the financial system in China.

The participation of foreign investors in China's onshore bond market has accelerated over time. At the end of 2014, holdings of RMB bonds by foreign institutions and individuals stood at RMB 3989.8 billion. By the end of March 2022 the holdings of such bonds reached RMB 3.95 trillion. This value accounts for about 3.4% of the total position, with an average annual increase of 32.2%. After the launch of the "Northbound Trading" in the "Bond Connect" scheme in 2017, the rate of increase in foreign holdings exceeds 40%, and as of June 2022, "Bond Connect" has successfully facilitated access to China's bond market for more than 757 investors from 36 jurisdictions around the world, with an average daily trading volume of RMB 27.3 billion.

Foreign investors' investment and trading behaviors may have a significant impact on the bond market. The increased participation

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of foreign investors not only implies an increase in bond demand and a diversification of the investor base, but it - to a certain extent - also boosts the liquidity of RMB bonds and may systematically depress RMB bond yields. Although the internationalization of China's bond market is still low [1], the risks that are associated with the influx of foreign capital need to be considered. Specifically, international capital flows may cause sharp fluctuations in RMB bond yields and, thus, may destabilize not only the bond market but also the entire financial market. Indeed, Grigorian [2] stresses that a country needs to provide a stable economic and policy environment for foreign investors to stabilize their expectations and, in turn, to stabilize in- and outflows of capital. And, Caballero and Krishnamurthy [3] point out that international capital inflows expose a country's markets to the risk of capital reversals and that the level of development of the domestic financial sector is important for the specific responses to increased risk.

Due to the significance of US debt among global assets, the US Treasury market has been frequently used as a case study to investigate the impacts foreign investors' participation may have on bond markets. A central finding is that the growth in international investors' holdings of US Treasuries is a key factor for the reduction of long-term US bond yields [[4,5]]. However, scholars also study emerging markets, not least as in the wake of the Asian financial crisis non-resident investors have become important participants in the local currency bond markets of emerging economies. Studies usually find that an increased demand for a country's local currency bonds by foreign investors leads to higher bond prices and lower yields [[6,7]]. This finding is not surprising, given basic supply and demand considerations.

More recently, scholars started to concentrate on yield volatility rather than on the yield level. Some scholars argue that emerging markets may be subject to capital reversals due to rising global risk aversion and that foreign participation is susceptible to market turbulence [8], while others argue that non-resident investors reduce market volatility in countries with stronger economic fundamentals [[9–11]]. Moreover, the impact of foreign investors on the local currency bond market is heterogeneous across countries [12], which means that one cannot extrapolate findings for a specific country to other countries.

Turning to China, Farhi and Maggiori [13] and Chernov [14] point out that China is becoming a challenger to the dominance of the US dollar in the international monetary and pricing systems. According to the Bank for International Settlements (BIS), since 2016 China has become the second largest bond market in the world, second to the US. China has a more favorable investment environment compared to other emerging markets [15]. Wang et al. [16] stress that China now has the most beneficial interest tax exemptions, the fewest investment limitations, the highest sovereign rating, and it is the only BRICS country whose currency has joined the SDR. The facts that, first, Chinese bonds make up a high proportion of international investors' asset portfolios that are allocated to the debt markets of emerging market countries, and that, second, the IMF raises the weighting of the RMB in the SDR from 10.92% to 12.28% in May 2022, are strong indications that the Chinese RMB bond market is attractive to global investors. Indeed, about 200 sovereign and commercial institutions around the world use Chinese Bond Yield Curves as an investment reference. For China, the opening up of the bond market is conducive to fostering a capital market for direct financing and for avoiding excessive concentration on economic and financial risks in the banking system, which is strategically important for the long-term development of China's economy.

Against this background, the purpose of this paper is to explore the impacts foreign investors' participation has on the volatility of Chinese local currency bond prices and, thus, yields. The contributions of this paper are threefold: First, China is the second largest economy and the second largest bond market in the world, and the relationship between the Chinese bond market and non-resident investments is worth exploring due to the increased international status of the RMB and of RMB assets, respectively. Second, we investigate the volatility of Chinese local currency bond yields under different degrees of openness, i.e., different levels of participation by foreign investors. This phased examination not only helps to explain the reasons for the wide divergence of findings on yield volatility in previous studies, but it also enables a more detailed portrayal of the impact of foreign investors on the level of local currency bond yields in the short and the long run. Third, we examine policy bank bonds alongside with local currency government bonds. This multi-bond discussion allows for a comparison of the sensitivity of different types of bonds to changes in nonresident investments.

The findings of our study are also relevant from an economic policy perspective. The enhancement of cross-border capital flows often necessitates new regulatory frameworks [17]. An investigation of the impacts of the introduction of international capital helps to inform Chinese policy makers in their attempt to steadily improve the regulatory framework targeted at the internationalization of the debt market following the idea of "opening up one item when it is ripe" [18]. Moreover, an investigation into the Chinese case provides valuable information to policy makers from other emerging market countries in their pursuit of capital account opening.

The remainder of the article is structured as follows. Section 2 reviews the existing literature and it includes a brief outline of the theoretical background of the study. Section 3 empirically examines the impact of foreign investors' participation on the volatility of market yields. Section 4 summarizes the findings of the paper, and it puts forward some policy recommendations.

2. Literature review and theoretical background

2.1. Literature review

The bulk of the existing literature examines the effect of foreign investors' participation on the level of yields. Consistent with basic supply and demand considerations, there is consensus that an increase in foreign investors' holdings lowers bond yields. Peiris's [19] findings, which are based on data from a selection of emerging economies, indicate a 6 Basis Points (BP) reduction in yields for every 1% increase in the share of bonds held by foreign investors. Likewise, using quarterly data for 22 developed economies, Arslanalp and Poghosyan [20] find that for every 1% point increase in the share of foreign investors in the government bond market the long-term sovereign bond yields falls by 6–10 BPs. According to Xie [21], a reduction of $100 billion in official purchases of US Treasuries by other countries in a single month will lead to an increase by 40–60 BPs in the 5-year US Treasury rate. Several studies [e.g., [22,23]]

conclude that the level-effect is more pronounced in the post-2008-crisis era. For China, relatively few empirical studies are available. Lu [24] constructs a VAR model to show that the entry of international capital increases demand on the government bond market, which leads to an increase in the equilibrium price and a decrease in the yield of government bonds. Thereby, the international capital flows mainly affect medium- and long-term government bond yields. Long [25], by using quarterly data on 10-year government bonds from 2014 to 2019, finds that for every 1% increase in the share of bonds held by foreign investors, the yield decreases by 12.6 BPs.

Compared to the findings regarding the level-impact, findings on the impact of foreign investors on the volatility of local currency bond yields are rather inconclusive. Ebeke and Lu [22] conclude that the participation of foreign investors in a country's bond market increases the volatility of yields. Likewise, Daniel [26], by using data for 16 emerging market countries over the period 2006 to 2011, finds that foreign capital outflows lead to greater yield volatility during periods of global risk aversion. Andritzky [27] uses a dataset for the G20 economies and the euro area and finds that a higher share of non-resident holdings is associated with a small but significant increase in the volatility of bond yields. Christensen et al. [28] conclude that foreign investors' participation in the local currency bond market carries both, benefits and risks, which vary significantly over time. They find, with the help of the AFNS-L model, that foreign investors put upward pressure on the liquidity premium of Mexican government bonds.

Several authors, for example [[9,19]], stress that the effect of greater foreign investor participation on bond yield volatility is not necessarily in the upward direction. Foreign participation may dampen volatility. Wei and Deng [29] examine the impact of foreign investors on Treasury yields of the US, Japan and Korea, respectively, and find that rising foreign holdings exacerbated the volatility of Korean Treasury yields during the financial crisis but reduce volatility under normal circumstances. Foreign investors play a volatility dampening role for both, US and Japanese bond yields.

Turning to China's bond market, Long [25] uses a GARCH(1,1) approach and data over the period 2010–2019 to analyze the volatility in the yields of Treasury bonds with different maturities. His results indicate that Chinese government bond yields have typical volatility characteristics, and that foreign investors have a negligible impact on the volatility of yields. By constructing a weighted-yield parity model, Gao and Ren [30] analyze the time-varying impact of capital account liberalization on bond market stress. These authors find that portfolio investment liberalization reduces bond market stress in the long- and the short-run. With our analyses we complement these two studies, first by focusing on two types of bonds with distinct levels of policy intervention and, second by analyzing the volatility-impact of foreign investors' participation during three distinct stages of financial market liberalization.

2.2. Theoretical background of the study

Burger et al. [31] outline the concept of a "virtuous circle", which holds that foreign institutions' investment in a country's local currency bond market can help in expanding the demand in the bond market and help in increasing liquidity. Foreign investors' participation can contribute to the stability of bond prices and yields. Foreign investors also play a pivotal role in the construction of bond market infrastructure and institutions. As the improvement of the infrastructure and of the legal system will attract even more foreign investors, a virtuous circle is launched which is conducive for achieving stability of the domestic bond market.

With the participation of multiple types of foreign investors on the Chinese bond market, the investor structure has become diversified, effectively avoiding the drawbacks of homogeneous investment behavior caused by a homogenous investor structure, and effectively diversifying market risks. When local investors' demand shrinks due to excessive risk aversion in the local market, foreign investors can help to compensate for domestic demand and "iron out" bond price and yield volatility.

The opening up of China's bond market follows the principle of "gradual progress". The initial access threshold for institutional investors to be approved to enter the market is high, and institutional investors tend to fully exploit market information. Rational investor theory suggests that institutional investors tend to have optimal investment levels, information advantages, ample capital resources, and their investment strategies are cautious and net-benefit focused. Studies like [[9,32,33]] suggest that foreign institutional investors tend to trade more actively than domestic central banks and commercial banks, which should help prices to fulfill their "discovery function". The interaction of distinct groups of investors with different risk profiles, views, and trading strategies should force bond prices to better reflect all the market-related information that is given on a country's bond market. This will facilitate "price discovery" in a country's bond market, and could put pressure on policymakers and bond issuers alike to improve the efficiency of bond asset pricing, not least by improving the bond market trading infrastructure and by promoting bond market development. These developments, in turn, should reduce bond price and yield volatility.

Against this background, this paper tests the hypothesis (H1) that "Foreign investors' participation will dampen the volatility of Chinese local currency bond yields." Thereby, three distinct stages of foreign investors' access to the market are used as the basis for discriminating the volatility-impacts over time. Distinct opening up policies imply different investment signals to foreign investors, affecting their investment decisions and behaviors. Alterations in decisions and in behaviors clearly feedback to the bond market.

3. Empirical methodology

3.1. Methodology

Modelling volatility, that is, changes in the variance of a series over time, requires specialized methodologies. ARCH (Autoregressive Conditional Heteroscedasticity) and GARCH (Generalized Autoregressive Conditional Heteroscedasticity) models and the corresponding estimators are normally used to study volatility in time series [34]. In this study a GARCH model is applied. However, leverage effects are often present in asset return data and the fit of the GARCH model may be poor. Leverage effects arise, for example,

due to market news that impact asset prices. Zakoian [35], therefore, uses the TGARCH model to study asymmetric volatility arising in the risk-and-return relationship. Thereby, the asymmetry arises in case "good" news impact differently on volatility compared to "bad" news. TGARCH has been especially developed to cope with this issue.

The GARCH model is proposed by Bollerslev [36]. It captures volatility aggregation, long-term memory and other characteristics of financial index data. The general GARCH(p, q) model is defined in Equation (1) as follows [37]:

$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \ldots + \alpha_q\varepsilon_{t-q}^2 + \beta_1\sigma_{t-1}^2 + \ldots + \beta_p\sigma_{t-p}^2 \quad (1)$$

where σ_t^2 is the variance of the local currency bond price or yield at month t, p is the autoregressive order of σ_t^2, q is the lagged order of ε_t^2. ε_{t-i}^2 is the ARCH term, ε_{t-i}^2 is the GARCH term.

In this paper, the multivariate GARCH(1, 1) model is chosen for empirical testing because, first, in ARCH models, if the number of squared residuals and lagged orders is large, it is necessary to estimate many parameters, which results in a loss in degrees of freedom [38]. Second, Tsay [39] points out that the low-order GARCH model can adequately characterize the volatility process of financial asset returns. The GARCH(1,1) model is given in Equation (2):

$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \beta_1\sigma_{t-1}^2 \quad (2)$$

where ε_{t-1}^2 is the mean squared error (MSE) of equation (2), that is the ARCH term which represents the shock from new information; σ_{t-1}^2 is the variance of the local currency bond price or yield at month *t-1*, that is the GARCH term which represents the shock from old information; and α_1 and β_1 measure the size of the shock, respectively.

Since the opening up policy of China's bond market is gradual, in order to cope with the possibility of asymmetric effects of "good" and "bad" news, a TGRACH(1,1) model is used [40] as shown by Equation (3):

$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \beta_1\sigma_{t-1}^2 + \varphi_1\varepsilon_{t-1}^2 \bullet 1(\varepsilon_{t-1} > 0) \quad (3)$$

where 1 (•) is the indicator function: when >0, that is, when positive news are given, the function takes the value of 1; conversely, when <0, that is, in case of negative news, the function takes the value of 0; $\varepsilon_{t-1}^2 \bullet 1(\varepsilon_{t-1} > 0)$ is known as the TGARCH term.

3.2. Sample data and variable characteristics

3.2.1. Data selection and data pre-processing

The China Treasury Bond Aggregate Index (CTBAI) and the China Finance Bond Aggregate Index (CFBAI) ranging from January 8, 2002, to June 30, 2022, are used to measure government bond prices and policy bank bond prices, respectively. Daily bond price data are obtained from China Central Depository & Clearing Co., Ltd. (CCDC) The sample period is divided into four phases which are selected based on the time of major events in the process of the opening up of China's bond market. The channels for foreign investors to enter China's bond market tend to liberalize gradually, and we can distinguish three stages of liberalization (Phases 2 to 4).

Phase 1: Before the opening up of the debt market (January 8, 2002–April 29, 2005.

Phase 2: Pilot Phase (April 30, 2005–August 13, 2010). During this period, foreign institutions could only enter the Chinese bond market through the highly restrictive QFII system, and their actual participation in the domestic bond market was minimal.

Phase 3: Liberalization Phase (August 16, 2010–February 16, 2016). During this period, the CIBM and RQFII systems are established in addition to the traditional QFII system, thereby broadening the access of foreign investors to the Chinese debt market.

Phase 4: Deepening Phase (February 17, 2016–June 30, 2022). During this period, the quota restrictions of the original investment channels QFII and RQFII systems are abolished, and the "Bond Connect" Programme is launched, which greatly improves the access of foreign investors to the market.

Since the daily market price index is not smooth and does not meet the requirements of the GARCH model, the price indices are logged and differenced to obtain the approximate growth rates of the CTBAI (r_{nd}) and of the CFBAI (r_{pfd}), respectively.

3.2.2. Descriptive statistics and unit root tests

Tables 1 and 2 include descriptive statistics as well as the results of unit root tests (ADF and PP tests). In terms of averages, as the opening up of the bond market continues to deepen and foreign investors' participation continues to increase, the demand for bonds also increases, and the overall price level of government bonds and policy bank bonds rises, further validating the conclusion in the previous studies that the increase in foreign investors' positions depresses bond yields.

Table 1
Descriptive statistics for the growth rate of CTBAI.

Growth rate of CTBAI	Number of samples	Average value	Standard deviation	Skewness	Kurtosis	ADF statistics	PP statistics
Phase 1	831	0.0000582	0.0030912	−0.1620588	6.192482	−4.932***	−43.177***
Phase 2 (Stage 1)	1325	0.0001891	0.0015812	2.058104	26.14083	−5.607***	−25.928***
Phase 3 (Stage 2)	1373	0.0001609	0.0014323	−0.0425314	10.94041	−5.674***	−27.266 ***
Phase 4 (Stage 3)	1591	0.0001381	0.0012112	0.250148	13.30407	−6.466***	−30.570 ***

Note: *** indicates significant at the 1% level.

Table 2
Descriptive statistics for the growth rate of CFBAI.

Growth rate of CFBAI	Number of samples	Average value	Standard deviation	Skewness	Kurtosis	ADF statistics	PP statistics
Phase I	831	0.0001104	0.0054841	−0.2554333	6.405616	−4.714***	−54.835***
Phase 2 (Stage 1)	1325	0.0001588	0.0013391	0.1665518	11.2338	−5.642***	−36.962***
Phase 3 (Stage 2)	1373	0.0001632	0.0010181	0.4138817	13.35288	−6.153***	−23.212***
Phase 4 (Stage 3)	1591	0.0001536	0.0009814	−0.0612594	21.90614	−6.554***	−29.119***

Note: *** indicates significant at the 1% level.

In terms of standard deviation, the volatility of both, government bonds and policy bank bonds, has decreased since the opening up of the bond market. This is probably because the types of foreign investors participating in the Chinese bond market have become more varied with the continuous opening up of the bond market. This leads to a diversification of market risks and reduces volatility.

In terms of skewness and kurtosis, both indicators show some degree of skewness. The kurtosis is greater than 3. A value different from 3 indicates the likely absence of normal distribution and a contradiction of the efficient market hypothesis. Bond prices and yields may be characterized by cluster fluctuations. From the ADF and PP unit root test statistics we conclude that the variables are weakly dependent and stationary (at the 1% significance level). The null-hypothesis of a unit root is rejected for each period.

3.3. Empirical results

3.3.1. ARCH effect test: ARCH-LM test

The ARCH-LM method is first combined with the ARCH test for the first-order autoregressive residuals of r_{nd} and r_{pfd} to determine whether there is significant heteroskedasticity in the data. Table 3 shows that the ARCH-LM tests reject the null-hypothesis of homoscedasticity at the 1% significance level, indicating that the residual series has a significant ARCH effect. Therefore, a GARCH model is applied.

3.3.2. GARCH(1,1) model

Estimation results of the GARCH(1,1) model are shown in Table 4. First, the coefficients capturing the ARCH term and the GARCH term (denoted by α and β, respectively) are significant in the different periods. The GARCH(1,1) model fits the data well, indicating that the volatility of prices is clustered. For both, government bond and policy bank bonds, the of the ARCH term (α) are below 0.3, which is relatively small, indicating weak volatility aggregation. The GARCH regression coefficients (β) are above 0.7, which is large, indicating that the impact of "old" information shocks on the volatility of Chinese local currency bond yields is persistent.

A valid GARCH model requires $\alpha + \beta$ to be less than 1, indicating that the series' volatility is smooth. A low value for $\alpha + \beta$ indicates that volatility persistence is short [41]. For the *CTBAI*, $\alpha + \beta$ is about 0.95 or less in each period, indicating that the smoothness of the price series in the government bond market has not changed due to the participation of foreign investors. The volatilities of prices decay over time but they may persist for multiple periods in the future. It is worth noting that the persistence of volatility tends to rise at the beginning of the opening up of the bond market ($\alpha + \beta$ is increasing in the first three stages). However, with the continuous improvement of various investment channels and the increasing variety of foreign investors in the government bond market, the persistence in the volatility decreases. This is consistent with the view that, as the market environment changes and foreign investors become more sensitive to information and less influenced by the previous period ($\alpha + \beta$ reaches the minimum), the persistence in the volatility decreases but short-term risks increase.

Interest rates of government bonds are, first, more stable because they are backed by the government, and in cases of abnormal market fluctuations the central bank often stabilizes interest rates through monetary policy to "iron out" the fluctuations and, thus, to stabilize the financial market. Therefore, given that the proportion of foreign investors' holdings in China is still low, the fluctuations caused by their investment and trading behavior on the government bond market is not strong enough to have a significant impact on the macroeconomic control of China's monetary policy. Second, with the broadening of market access channels, the range of foreign investors entering the market has broadened too. Commercial banks, hedge funds, and other financial institutions are accounting for the majority of these investors. These types of investors tend to operate on a volatile basis to gain spreads, are sensitive to market information, and trade flexibly, thus causing short-term price and income fluctuations. These findings are consistent with the results of Trinh et al. [42], who use a GARCH model to investigate Vietnamese government bonds and who show that there is a strong effect of yield changes in the previous period on current government bond yield changes, and that the shock diminishes in the post-crisis period.

For the *CFBAI*, the $\alpha + \beta$ in the third and fourth stages is less than 1, while in the remaining stages it is greater than 1. That means that a constraint on the parameters is not universally satisfied. This finding suggests that policy bank bond prices and yields fluctuate

Table 3
ARCH-LM test results.

Time Period	Growth Rate of CTBAI				Growth Rate of CFBAI			
	Phase 1	Phase 2	Phase 3	Phase 4	Phase 1	Phase 2	Phase 3	Phase 4
LM statistic	181.627	217.877	17.387	38.198	56.410	176.617	65.202	74.333
P value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 4
GARCH(1,1) estimation results.

GARCH(1,1)	Parametes	Phase 1	Phase 2	Phase 3	Phase 4
Growth Rate of CTBAI	α	0.1259709***	0.1195869***	0.1653667***	0.1967983***
	β	0.8458141***	0.8657649***	0.8229422***	0.7462916***
	α+β	0.9717850	0.9853518	0.9883089	0.9430899
Growth Rate of CFBAI	α	0.1358126***	0.3087526***	0.1489029***	0.3120834***
	β	0.8651346***	0.7391882***	0.8493765***	0.6860314***
	α+β	1.0009472	1.0479408	0.9982794	0.9981148

Note: *** represents significant at the 1% level.

widely in response to past volatility and external shocks, requiring a longer period of adjustment. Their response to shocks has an amplified and sustained effect in the early stage of the opening up of the bond market. The reason for this may be that at the early stage of China's debt market liberalization, foreign institutions' preference for policy bank bonds was lower compared to that for government bonds, and the significant increase in their positions was mainly due to China's temporary exemption from corporate income tax and VAT on bond interest income earned by foreign institutions investing in the domestic bond market. With the deepening of the liberalization of the bond market, foreign investors can obtain higher returns while taking less risk by investing in policy bank bonds.

The above empirical results are consistent with hypothesis H1. The findings, thus, indicate that the participation of foreign investors increases market volatility at the initial stage, but once foreign investors give full play to their role in "price discovery" and once they promote the improvement of bond market facilities and institutions, their presence helps to stabilize RMB bond prices and yields. These findings are consistent with related studies. According to Wang and Yuan [43], foreign capital will have a destabilizing impact on the bond market in the short term, but the impact will turn favorable to the Chinese bond market in the long term as domestic policies and fundamentals improve. Gao [44] also points out that with the increase in the level of financial openness and development, the expansion and efficiency of financial markets will significantly reduce the uncertainty of transactions, and the bond market will be more tolerant of cross-border risks. Shocks caused by cross-border capital flows will also be mitigated via monetary policy.

The GARCH model explains the volatility of the Treasury bond market to a sufficient extent. However, it cannot provide a reasonable explanation for the possible asymmetry of the volatility of the policy bank bond market. Therefore, the asymmetric TGARCH model is used in the next section to further assess the volatility of the policy bank bond market.

3.3.3. TGARCH(1,1) and asymmetric effects of policy bank bonds

In order to test the existence of asymmetric effects, a TARCH(1,1) model is adopted. The regression results are displayed in Table 5. Most importantly, the φ term, which shows the size of the asymmetric effect, is statistically significant. Specifically, in the first two stages of the bond market opening up (i.e., Phases 2 and 3), φ is significantly negative, indicating the existence of asymmetric effects in the volatility of the returns of the CFBAI. Thereby, the volatility caused by negative effects is much larger than that caused by positive effects, that is, bad news have a larger impact on the bond market than good news. In case of negative news, the market experiences shocks of 0.16 and 0.36 times, respectively, while in case of positive news, the market sees shocks of $\alpha+\varphi = 0.1608–0.0702 = 0.09$ and $0.3556–0.0938 = 0.26$ times, respectively. Thus, negative shocks, such as large international capital outflows, have a larger impact, and the volatility of policy bank bond prices and yields increases. At the early stage of the opening up of the bond market there are many restrictions on foreign investors' investment in policy bank bonds, and investors' reactions are rather muted in the face of good news, while when there is negative news, the risk aversion of foreign investors will cause overreaction or even a "herding effect" leading to pronounced effects of shocks.

In the second stage (Phase 3), φ remains negative but it is not statistically significant. This suggests that the asymmetric effect is weakened, i.e., there is minor difference between the volatility caused by foreign investors buying policy bank bonds in the presence of positive news and the volatility caused by selling their holdings in the presence of negative news. The reason may be that the opening up of China's bond market during this time (2010–2015) coincides with the improvement of the global liquidity environment brought about by the monetary policy easing in developed countries, which jointly drove international capital inflows into China's bond market. In this period, foreign investors begin to increase their holdings of domestic RMB bond assets at an accelerated pace after gaining more investment channels. Using the first two stages for observation and testing, foreign investors remain optimistic about the Chinese bond market. Even after 2013, when the international financial and liquidity environment took a turn for the worse, capital inflows into the Chinese bond market do not reverse. At that time, despite signs of a slowdown in international capital inflows to bond markets of several emerging Asian economies, capital inflows to the Chinese bond market remain large, reflecting the profound influence of institutional factors such as the opening up of the Chinese bond market and the internationalization of the RMB [45].

Table 5
Results of TGARCH(1,1) for the growth rate of CFBAI.

TGARCH(1,1)	Parameters	Phase 1	Phase 2	Phase 3	Phase 4
Growth Rate of CFBAI	α	0.1607614***	0.3556448***	0.164310***	0.2559867***
	β	0.8701481***	0.7409874***	0.851242***	0.6848358***
	φ	−0.070196**	−0.093753*	−0.0285303	0.1399116***

Note: ***, **, and * represent significant at the 1%, 5%, and 10% levels, respectively.

With the opening up of the debt market in the third stage (Phase 4) φ switches signs from negative to positive. This indicates that a new asymmetric effect emerges in the volatility of the policy bank bond prices and yields. The volatility caused by positive news is greater than that caused by negative news. The market experiences shocks $\alpha + \varphi = 0.2560 + 0.1339 = 0.39$ times in case of positive news, while shocks happen 0.26 times in case of negative news. The reasons may be that the proportion of policy bank bonds in the total RMB bond position of foreign investors increases rapidly, trading is active, the market environment is favorable, and the implementation and extension of tax incentives lead to increases in net-returns of investments. This further validates the conclusion obtained by the GARCH model that with the relaxation of investment restrictions and the continued deepening of the debt market opening up, foreign investors have a dampening effect on the volatility of bond market prices and yields. This finding is consistent with related research. Using panel data for 175 countries, Mali et al. [46] argue that a well-developed institutional environment can escort capital account opening and promote financial stability. These authors also point out that capital account opening and an improvement of the institutional environment will promote financial stability through capital inflows.

4. Conclusions and policy recommendations

4.1. Summary and main conclusions

This paper investigates the relationship between foreign investors' participation on Chinese bond markets and the volatility of bond prices and yields. The analyses are carried out for Chinese data on government bond and policy bank bond prices. The paper adds to existing stock of knowledge via the focus on two types of bonds and three stages of liberalizations of the Chinese bond markets. The main findings are as follows:

(1) Based on a GARCH(1,1) model, we find that foreign investors' participation suppresses the volatility of RMB bond market prices in the late stage of bond market liberalization. Further, we use a TGARCH model and find that there is a significant asymmetric effect for the case of policy bank bonds. Specifically, negative market news have less impact on the volatility in policy bank bond prices in the late stage of bond market liberalization than positive news. This indicates that this type of bond gradually gains the preference of international investors. Overall, we conclude that for RMB bond prices and, thus, yields, the participation of foreign investors has a dampening effect on their volatility, especially in latter stages of liberalization.
(2) The split of our analyses in several types of bonds and in three stages of liberalization help to explain why related studies disagree on the effects of foreign participation on bond prices and yields. Prior studies ignore the fact that opening up policies change over time and that foreign capital inflows actually have different impacts on prices and yields of distinct types of bonds in distinct stages of liberalization.

4.2. Policy recommendations

The positive effects of foreign investors' participation on China's bond markets generally outweigh their negative implications. To further enhance the participation of foreign capital and to improve the level of opening up of China's bond markets and their abilities to resist risks, we put forward the following policy recommendations:

First, (i) take the lead in opening up the bond market and promote the process of opening up the RMB bond market to a system-based approach. (ii) Continue to promote the opening up of the bond market, establish good policy credibility to positively shape expectations of investors, and enhance the value of RMB asset allocation steadily and gradually. (iii) Increase the supply of risk management tools, expand the scope of pilot banks participating in treasury bond futures, continuously optimize the rules and mechanisms, and continuously improve the quality of market services to facilitate risk management by foreign investors so that they can have a stabilizing role in the interest rate bond market. (iv) Establish a credit rating system that is in line with international standards to facilitate foreign investors access to the credit bond market and promote the balanced opening up of the bond market.

Second, (i) based on the effectiveness of the policy and the actual operation of the market, timely review the policy and plan for optimal operation. (ii) Guide market expectations and capital flows, scientifically assess the policy of opening up the debt market and the opportunities and risks at distinct stages, grasp the domestic and international economic situation, adjust the scale and frequency of different bond issues to guide the structure and the flow of foreign capital into the market.

Third, for other emerging economy countries, China's local currency bond market opening up provides a valid reference. The opening up of the bond markets and of capital accounts should follow the principle of "gradual and orderly progress", avoiding sudden and drastic liberalization that may lead to events like the Southeast Asian financial crisis. Give the market sufficient time to react and adjust, so that policy arrangements also have more buffer and room for improvement.

4.3. Limitations of the study

First, this paper studies two types of interest rate bonds without considering interbank certificates of deposit or credit bonds. Future research could consider separate studies by bond type. A comparison of interest rate bonds and credit bonds would better depict the state of the overall bond market. Studies could also explore the impact of foreign investors on the maturity structure of local currency bonds, such as difference in the impacts on short-, medium- and long-term bonds or the impact on the risk premium of credit bonds, which would provide a microscopic and more complete picture of the impact of foreign investors on the Chinese bond market.

Second, we divide bond market liberalization into three distinct phases in this paper and examine the effect of the gradual widening

of liberalization channels on price volatility. Future studies could examine the impacts of more specific events such as the US-China trade friction, the Russia-Ukraine conflict and other black swan events on local currency bond prices and yields.

Author contribution statement

Qian Wang: Conceived and designed the experiments.
Shengting Gao: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.
Jiayin Li: Contributed reagents, materials, analysis tools or data.
Markus Leibrech: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Data availability statement

Data will be made available on request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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