Università Ca'Foscari Venezia

Aix*Marseille université
Socialement engagée

Master's Degree in Finance

Master 2 Finance: Management des Risques Financiers

Final Thesis

China's Monetary Policy and Treasury Bond Term Structure

Supervisor
Ch. Prof. Eric Girardin

Graduand
Sara Gregoletto
Matriculation Number 873070

Academic Year
2022 / 2023

Acknowledgments

I would like to acknowledge both Ca' Foscari University and Aix-Marseille University for giving me the opportunity to take part in this double degree program. I want to thank all the professors I met during these years for what they taught me and for making me more aware of my aspirations.

I most importantly want to thank my parents for their constant support, love, encouragement, and for always believing in me.

Thanks to all my hometown friends, which have always been there for me even when we were distant. Thanks to the friends I met at Ca' Foscari, your presence has made university more pleasant and exciting. Thanks to the other students of this program who made me enjoy this abroad experience to the fullest. Lastly, thank you to the special people I met in Aix, you have made these five months unforgettable.

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1. Introduction

The channels of monetary policy transmission have been investigated for decades, to assess in which ways the actions of policy authorities have influenced the economy. However, while monetary policy in western countries has been traditionally conducted exploiting an interest rate channel *(Mishkin, 1996)*, the existence and effectiveness of the latter for China's case are not so evident, due to the particularity of both its bond market and policy conduct.

The finding that the development of a transmission channel through interest rates is happening could be helpful to Chinese regulators in understanding the consequences of their interventions and hence guide their work. This is particularly true in the context of China as monetary policy is here conducted through a variety of instruments, which makes it difficult to always identify the clear direction taken by the policymakers.

The main objective of this work is to assess whether there is the possibility that monetary policy transmission in China happens through an interest rate channel. Hence, such assessment will be conducted by analyzing the interbank segment of the Treasury bond[1] market in China, justified by its larger magnitude and by the fact that it is in the interbank that the monetary policy is mainly conducted. In particular, the research aims at investigating the effects that changes in the monetary policy stance in China have on the term structure of interest rates of such interbank Treasury bond market. Particular attention is then drawn to which parameters of the yield curve are mainly affected and how, and if such effects are constant in time.

The bond market in China has experienced a sustained evolution in the past decade, as the financial system reform of the country has aimed at developing a more market-oriented system. Hence bond markets in general and bond yield curves in particular are likely to obtain increasing importance in the Chinese economy. This especially applies to the Treasury yield curve for its benchmarking potential. The term structure of interest rates represents the relationship between interest rates of bonds and their maturities, hence giving information on how the yields of bonds of similar characteristics change depending only on the different maturities of such bonds. Given this high information potential that the yield curve holds, it is important to adopt an interpretation approach that allows us to

[1] Treasury bonds are a type of Government bonds and are issued by the Ministry of Finance.

fully exploit it. One of the most useful approaches in this sense is the decomposition of the yield curve into three factors: level, slope and curvature (*Nelson and Siegel, 1987; Diebold and Li, 2006)*. These three factors provide information on different parts of the yield curve at each point in time, hence helping in summarizing the entire evolution and behavior of the whole term structure in just a limited number of variables. The level factor refers to the average yield and is mainly represented by the behavior of the long-maturity yields, the slope represents the spread between long and short-maturity yields, hence in a sense capturing the behavior of the latter, while the curvature factor encompasses the behavior of the medium-term yields. Therefore, inspecting the changes of these factors, rather than directly inspecting the shape of the whole yield curve itself, simplifies the interpretation of its interactions with other variables, like the monetary policy stance in our case.

Monetary policy in China is conducted in a more complicated way than to what happens in other main industrial countries. Indeed, while the US and Europe rely their monetary policy mainly (at least until the Great Financial Crisis) on a single instrument, such as short-term interest rate, Chinese monetary authorities adopt a multiplicity of instruments and intermediate targets to reach their policy objectives. Such instruments are both quantity-based and price-based[2]. An additional type of instrument, referred as administrative, is also largely used. The quantity-based instruments are the Reserve Requirement Ratio[3] (RRR), and the Open Market Operations[4] (OMOs), price-based instruments are deposit and lending rates, interest rates for required and excess reserves, lending rate on PBoC[5] refinancing. The administrative measures mainly refer to the practice of window guidance, by which the central bank guides commercial banks' lending using persuasion and indirect pressure. From 2013, the PBoC also introduced other instruments such as the Standing Lending Facility[6] (SLF), Medium-term Lending Facility[7]

[2] Quantity-based instruments aim at influencing liquidity and monetary aggregates. Price-based instruments aim at influencing interest rates.
[3] The RRR indicates the portion of a commercial bank's deposits that must be kept in reserve at the PBoC. It is used to implement credit control by injecting liquidity (lower RRR) or draining it (higher RRR).
[4] OMOs are securities transactions conducted in the open market by the PBoC. Aside from outright transactions, OMOs are also mainly conducted through repurchase or reverse repurchase agreements.
[5] The People's Bank of China (PBoC) is the Chinese Central Bank.
[6] The SLF is a liquidity supply channel to meet the temporary liquidity needs of financial institutions. The SLF 7-day rate is seen as the upper bound of the interest corridor. The lower bound of the interest corridor is instead the interest rate paid by the PBoC on excess reserves.
[7] The MLF allows the PBoC to provide funds with longer maturities (3-months to 1 year).

(MLF) and Pledged Supplemental Lending[8] (PSL) to build an interest rate corridor system. This change of instruments shows the intention of the Chinese central bank to shift from a quantity-based framework to an interest rate one.

The reaction of bond yields to monetary policy in the Chinese framework has been until now investigated by only a small portion of literature, which however seems to confirm the hypothesis of monetary policy transmission through bond markets. *Porter and Cassola (2011)* suggest the rise of a price-based transmission mechanism for monetary policy, relying such statement on their results of policy changes feeding through yield curves, among which the interbank Treasury one. Also *He and Wang (2012)* find evidence of monetary policy instruments influencing interbank market interest rates and attribute the opening of a transmission channel to the recent development of the interbank market in China. *El-Shagi and Jiang (2023)* focus in particular on the Treasury yield curve and find that it reacts to various monetary policy shocks, thus again suggesting policy transmission to the Treasury term structure.

To contribute to the existing literature, the present study analyses the relationship between the Treasury yield curve and monetary policy in China over a ten-year period (2009-2019). The yield curve is decomposed into the usual three factors, of which only the level and slope are studied as considered more informative. To assess what influences these two variables, we operate in a multiple linear regression framework. Bank credit growth is used as proxy for monetary policy, as the amount of loans provided by commercial banks is expected to in a sense reflect the monetary policy stance (including the window guidance component). The size of the People's Bank of China's balance sheet is also used as a proxy for monetary policy, albeit not being the principal one to be used here. Additional explanatory variables have been included to make the analysis more complete. Such variables are the Shanghai Interbank Offered Rate (SHIBOR) and the level and slope factors extracted from the Treasury term structure of the US.

Our results provide evidence of the possible existence of an interest rate channel as transmission mechanism, through the Treasury bond market. First, we show that changes in (the proxy of) monetary policy have an overall significant influence on both the level and slope factors of the yield curve. Both high- and short- maturity yields react negatively

[8] The PSL is introduced to guide long-term interest rates and money supply. It consists in large amounts of financing to support specific key sectors of the national economy.

to changes in bank credit thus confirming traditional monetary policy theory. Second, such effects appear to be more constant over time for the level parameter, while the slope appears to react to bank credit only in the initial part of our sample. Additional results coming from the analysis are the following. We find evidence of the size of the PBoC's balance sheet influencing the growth in bank credit, thus confirming the assumption of bank credit reflecting in an acceptable way the policy stance. We also find very significant effects of the SHIBOR impacting the behavior of the slope parameter and evidence of the US yield curve factors influencing the Chinese ones.

This research contributes to the literature in three ways. First, we confirm what previous studies found on the Chinese Treasury yield curve responding to monetary policy in China, hence fostering the hypothesis of a nascent interest rate transmission channel. Second, we hint the possibility of the SHIBOR becoming a means of monetary policy transmission, should the PBoC be able to exert its influence on it. Third, we recognize the difficulty of the Treasury yield curve in being a transmission channel of the Chinese monetary policy only, given the spillover effects from the US Treasury term structure.

This work distinguishes itself from previous ones as it does not rely on one specific policy instrument of the PBoC's toolkit but rather selects a proxy for the overall stance of monetary policy. Additionally, this work does not try to link directly monetary policy to macroeconomic variables but rather stays one step back to assess if the interbank Treasury bond market can be seen as an intermediate node of transmission, hence inspecting the possibility of the People's Bank of China to convey its actions through it.

The dissertation is organized as follows: the next section provides a review of the literature; section 3 presents the data and the methodology, with subsections dedicated to the explanation of the monetary policy proxies and the interbank Treasury bond term structure. Section 4 discussed the results on the relationships between monetary policy proxies and term structure factors. Section 5 concludes.

2. Review of literature

Over the past years, there has been an increase of literature analyzing the bond yields and term structure in China. Parallel to this, some authors have tried to explain the unconventional monetary policy stance of the Chinese authorities. Considering this last theme, a portion of literature has tried to evaluate links between Chinese monetary policy and macroeconomic performance, to assess whether the policy stance affected the real economy. However, up to now, only a small portion of researchers has focused on the potential transmission of Chinese monetary policy on bond yields rather than on macroeconomic variables.

The plurality of monetary policy instruments adopted by the PBoC makes it particularly difficult to straightforwardly identify the periods of tightening or easing of the policy stance. For this reason, a piece of literature focused on compounding these different instruments in a unique monetary policy indicator. In this framework, *Girardin et al (2017)*, based on previous works of *He and Pauwels (2008)* and *Xiong (2012)*, construct a new discrete monetary policy index that encompasses all the pre-2013 policy instruments. An increase in such MPI, which is scaled in basis points, indicates a tightening change of policy, while a decrease in the MPI indicates an easing. The dynamic of their index shows the presence of an accommodating monetary policy starting at the end of 2008 and lasting until the end of 2009. Then a period of tighter policy follows until mid-2011, where the policy stance starts to be again looser. The MPI stops in May 2013, when the new monetary policy instruments were introduced. This monetary policy re-orientation is instead captured in the work of *Funke and Tsang (2019)*, which derive an indicator of China's monetary policy from May 2012 to December 2018 considering the post-2013 instruments. This indicator allows tracing the evolution of the monetary policy stance, which can be divided into four sub-periods. From May 2012 to January 2015, monetary policy was tightened, while it was eased in the following period from February 2015 to March 2016. Then, the policy stance becomes tighter again for the following two years (April 2016 – March 2018). The last sub-period from April to December 2018 is characterized by a loosening of monetary policy.

Returning on the potential transmission of Chinese monetary policy on bond yields *Fan and Johansson (2009)* are among the firsts to address this hole in the literature, as they try to understand how monetary policy influences bond yields in China. In their model, they use the one-year deposit rate as a measure of the policy stance. They recognize the fact that the, at that time, recently introduced SHIBOR was created to try to improve the monetary transmission system, but they follow the at the time common practice of market participants to still use other official rates as benchmarks, the most used of which was indeed the one-year deposit rate. Final results show that the inclusion of the latter as a measure of monetary policy helps describe the shape and behavior of the yield curve well.

Porter and Cassola (2011) describe the behavior of bond yields in China and their response to changes in monetary policy, in order to understand whether the development of a transmission channel is in place. The authors consider five types of bonds, among which also the Interbank Treasury ones, and extract the three latent factors of their term structures through the Nelson-Siegel parametrization. In this research, monetary policy is represented by the changes in PBC yields and by the changes of administered interest rates (benchmark lending and deposit rates), so the authors are considering only the price-based part of the policy stance. Their results state that the post-crisis policy stimulus that was implemented from December 2008 caused major responses in the behavior of the short-term drivers of the yields. Thus, the policy loosening that led to a decline in interest rates affected mainly the slope factor, which registered a persistent rise. Similar conclusions are extracted by looking at the impact that the regulated interest "margin" (difference between lending and deposit rates) have on the structure of bond yields: a narrowing of this margin is associated to a loosening of monetary policy and to a steeper yield curve (higher slope parameter). Hence, given these responses of yield curve behavior to policy changes, Porter and Cassola give an important contribution to the literature by suggesting the rise of a price-based transmission mechanism for monetary policy.

He and Wang (2012) find again evidence of monetary policy instruments influencing the interbank market interest rates. These rates are in fact influenced by administered interest rates in the banking system, in addition to being determined by market forces. The results of the authors' work prove that, despite the interbank rates not being very reactive to open market operations, they are instead very sensitive to the dynamics of the benchmark deposit interest rates and to changes in the reserve requirements. Hence, the authors state that the development of the Chinese interbank market has opened a channel of monetary policy transmission. *Fu and Ho (2022)* give an updated overview compared to older literature. By considering the changes in various monetary policy instruments (RRRs, BIRs, OMOs, SLF and MLF rates), they find that a tightening in monetary policy is followed by an increase in government bond yields. This effect is found at all maturities, but it weakens as the maturity lengthens. In addition to that, they find that from 2015, price-based policy instruments have increasing effectiveness in affecting Treasury bond rates. *El-Shagi and Jiang (2023)* also attempt to assess monetary policy transmission through the yield curve in China; however taking into account the segmentation of policy instruments and of bond markets. The authors make a distinction between market-based and regulation-based policies and aim at analyzing their effect on both the interbank and the exchange Treasury bond yield curves by decomposing them into the three latent factors. As highlighted by the authors the difference of their work compared to other studies is to not use a compound indicator that accounts for a variety of measures, but they rather focus on the effect of different indicators taken separately. The authors share the belief that the PBoC, when conducting monetary policy, pays also particular attention to the long end of the yield curve, thus controlling the yield curve as a whole rather than just focusing on its short end. Their results state that the interbank market yield curve responds to both market-based (7-day repo rate) and authority based (loan benchmark rate) monetary policy shocks, thus suggesting monetary policy transmission to the Treasury term structure.

Yoshino and Angrick (2016) approach the topic of monetary policy transmission through an analysis of the role that bank financing has on the real economy, as well as investigating which instruments influence bank credit. The authors recognize that monetary policy in China is conducted not only through quantity- and price-based instruments, but it is also highly influenced by the practice of window guidance. Hence, effects of window guidance on bank credit are expected. Using a text-based analysis of the Monetary Policy Reports of the PBoC, they construct a "window guidance indicator", and through impulse responses they find that window guidance is positively associated with bank financing. This latter result concerns the post-GFC period, where accelerating loan growth was registered. The authors then proceed to investigate the transmission of bank financing growth to some macroeconomic variables, and they find that bank credit indeed has some impact on the broader economy. Despite their research focusing on the final impact on the real economy and not on the interbank yield curve, it still provides a useful contribution on the role of window guidance and bank credit in Chinese monetary policy.

Another type of contribution to the literature on Chinese bond yields comes from authors aiming at highlighting possible transmission coming from the United States' monetary policy. *Spantig (2012),* suggests that a decrease in the U.S. interest rates is likely to transmit to peripherical countries, China included, which experience a reduction in their interest rates. Similar conclusions are drawn by *Bi and Anwar (2017),* who find that an increase in U.S. short-term interest rates by monetary authorities results in an increase in short-term interest rates in China. In addition to that, *Ho et al (2018),* find that the U.S. monetary policy moves are not only captured by Chinese interest rates, but they also influence Chinese monetary policy first. The authors use the shadow rate measure constructed by *Wu and Xia (2016)* to extend the effective federal funds rate during the Zero Lower Bound period. Impulse responses during this ZLB period provide evidence that an expansionary U.S. monetary policy shock leads to an increase in the Required Reserved Ratio, one of the main monetary policy instruments implemented by the PBoC.

3. Data and Methodology

3.1. Data

To analyze the possible existence of a relationship between China's monetary policy and the Treasury bond yield term structure, the present work focuses on a ten-year period, using end-of month data from January 2009 to June 2019. These dates have been selected in order to avoid the turbulent periods of the Great Financial Crisis and the outbreak of the Covid-19 pandemic.

This study is carried out relying on the following data[9]: Treasury bond yields, both for China and for the U.S., Shanghai Interbank Offered Rate (SHIBOR), total assets of the People's Bank of China, and bank credit growth in China (represented by loan growth). Chinese data, if not differently specified, has been extracted from Wind.

To obtain the necessary latent factors of the term structure in China, the yields of interbank fixed-rate Treasury bonds have been extracted. Data was originally obtained at daily frequency, from which end-of month values have been considered. Nine maturities were used: 1, 2, 3, 5, 7, 10, 20 and 30 years. The extraction of the latent parameters is presented later in following sections.

The SHIBOR considered is the one-week SHIBOR (seven days maturity), given its major importance as a benchmark rate compared to its other maturities. The rationale behind the inclusion of the SHIBOR in the analysis is the following. The Shanghai Interbank Offered Rate was launched by the Chinese Central bank in 2006 with the aim of establishing it as a target rate and help the transmission of monetary policy. Despite the SHIBOR not being able to replace the other well established benchmark rates shortly after its introduction, there is still a part of literature that claims the SHIBOR transmits monetary policy effectively, finding evidence of its link to indicators of monetary policy operations (*Huo and Feng, 2009*). The SHIBOR has been therefore included in the analysis to assess whether the yield curve is affected by this developing operational target of the PBoC. This rate being a market measure, no seasonal adjustments have been made.

Next, total assets of the People's Bank of China have been directly downloaded from the *Balance Sheet of Monetary Authority* section under *Money and Banking Statistics* on the PBoC website. This data was already in end-of month format. First of all, it got seasonally

[9] Visual representation of such data is presented either in this section or in Appendix A.

adjusted. The unit of measure was 100 million Yuan. To remove this scale, as well as to make interpretation easier, the rate of change was computed. The role that this variable has in the present work is to possibly proxy monetary policy for the whole considered sample.

Bank credit growth information is represented by end-of month loan growth, as suggested in *Girardin et al (2017)* work. Data source is CEIC. As in the case of the total assets, seasonal adjustment has been applied. As said, data comes already in rate of change format. This variable is as well considered for its possible role in proxying monetary policy in China. Its usefulness compared to the PBoC's total assets comes from the fact that it captures also the unobservable role of window guidance in the conduct of Chinese monetary policy, as previous literature has stated that window guidance does indeed influence bank financing.

Finally, similarly to what done with Chinese yields, U.S. Treasury par yield curve rates have been extracted from the U.S. Department of the Treasury website, in order to later compute the latent factors. The inclusion of U.S. data is justified by the need to take into account possible spillovers effects from the United States to China, as suggested by previous literature. Again, data came at daily frequency and then processed to obtain an end-of month dataset. The maturities considered are here eleven, as the 1-, 3- and 6-months maturities have been considered in addition to Chinese ones. The 2-month maturity yields have been purposefully excluded from the sample as these bonds have been introduced in 2018.

The two following sections aim at describing in more detail the two main components of the analysis, namely the Chinese monetary policy proxies and the Chinese Treasury bond yields.

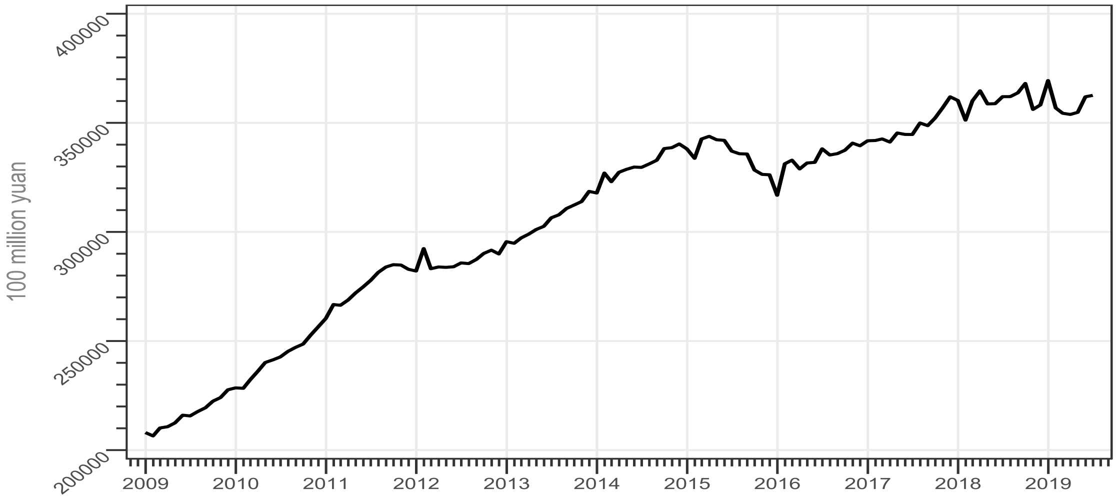
3.1.1. Monetary policy proxies in China

As already anticipated, monetary policy in China is conducted through a vast toolkit of instruments, and past literature has tried to link some of these instruments to the Chinese Treasury term structure. For the purpose of the present analysis however, it is more useful to select a proxy that can in a certain sense "summarize" the overall monetary policy stance, rather than focusing on just one of these policy instruments. It is for this reason that two variables have been selected as such proxies, to test whether they could have an influence on the term structure: total assets of the People Bank of China and bank credit growth. Such variables are also useful as they are continuous variables and are available for the whole ten-years period considered.

The total assets of the PBoC can be more generally interpreted as the size of its whole balance sheet. Such a variable is important as the balance sheet of a country's central bank is one of the tools that it uses to conduct monetary policy. As seen in Figure 1, the size of the PBoC balance sheet has registered a sustained growth from 2009 onwards, with just a contraction happening between 2015 and 2016. The overall increase was driven by a rapid expansion of the asset side caused by a surge in foreign exchange reserves[10]. The buildup of foreign reserves, however, causes the release of domestic currency into the economy, hence causing an increase in liquidity and domestic credit, as well as inflationary pressures. In order to neutralize such fluctuations of the money supply caused by heavy foreign capital inflows, but also probably caused by the accommodative monetary policy of 2009, the PBoC has implemented some sterilization policies such as conducting open market operations (mainly through central bank bills), adjusting the reserve requirement ratio, and implementing loan allocations (*Chung et al., 2014; Wang et al., 2019; Pauwels, 2019*). The two most important tools deployed have been central bank bills and RRR adjustments. The formers were used until around 2012, when their issuance stopped (*Qian and Woo, 2014*), leaving space to RRR to become the major instrument used by the PBoC to control the level of liquidity in the system[11]. Both the procedures presented above influence the central bank's balance sheet, which therefore can in a sense capture these quantity-based instruments. Additionally, OMOs and particularly the RRR, have the effect of influencing the quantity of funds available for banks to loan out, so we might think that the size of the balance sheet itself can influence credit in the banking system. On this matter *Cook and Yetman (2012)* find, in some emerging Asian economies, the presence of a negative relationship between increase in foreign reserve holdings and the growth rate of bank lending, a finding that makes the previous intuition more reasonable.

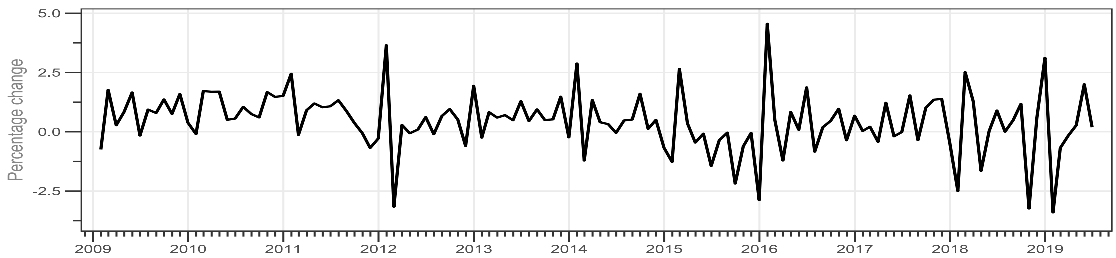
[10] An increase in foreign reserves is due to the fact that the central bank intervenes on the foreign exchange market by selling its own currency for foreign currency assets, all this to prevent the appreciation of the domestic currency. An appreciation of the domestic currency is the consequence of a surplus in the balance of payments. This was the case for China, but the reasons of such won't be investigated further in this work.
[11] RRR have been adjusted several times, being in general increased to face increasing liquidity and domestic credit. This happened from 2009 to 2011, then around late 2011 the RRR was decreased, with a further cut around 2015.

Figure 1 – Total Assets of the PBoC. In level, seasonally adjusted



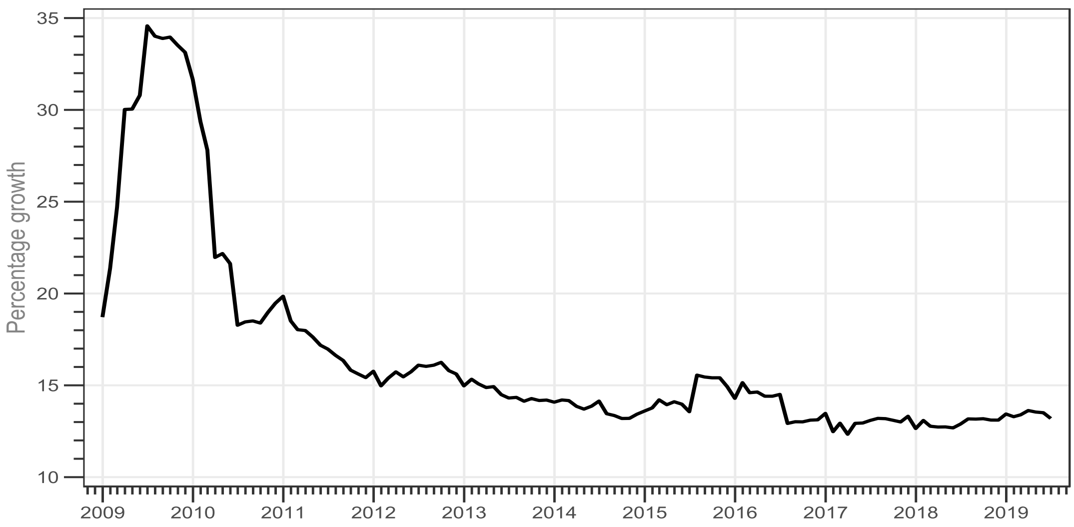
Source: Balance Sheet of Monetary Authority, Money and Banking Statistics, People's Bank of China.

Figure 2 – Total Assets of the PBoC. Growth rate



Next, the growth in bank credit was also selected as a proxy for monetary policy, and it was chosen as it appeared to be even more appropriate than the growth in total assets. Bank credit represents the amount of funds that the banking sector provides to borrowers such as individuals or firms. The bank credit channel plays an important role especially in economies where alternative sources of financing are not as easily available (*Smant, 2002)*. Hence, in a country such as China, where capital markets are still developing and have not unleashed their full funding potential, access to bank credit still plays a vital role for economic development. Such a framework makes one think that the Chinese policy authority would want to exploit the bank lending channel as an additional mean to convey monetary policy to the real economy. What makes the use of bank credit as a policy proxy even more useful, is the fact that it is not only influenced by the observable policy instruments, but it is also mainly determined by the practice of window guidance and informal credit quotas, as also stated in previous literature. Hence considering bank credit in the present analysis allows us to have insights on the effect that monetary policy has on bond yields by considering also the qualitative and not directly observable measure that is window guidance. Figure 3 presents bank credit growth over the period 2009-2019. We can notice that the first year of the sample is characterized by massive credit expansion, which resulted as a consequence of the stimulus package started at the end of 2008 to recover from the GFC. From 2010 onwards, bank lending growth slowed down, and gradually continued to do so until the end of the sample. Only between mid-2015 and mid-2016, bank financing experienced a slight increase, however not even coming close to the extreme growth that characterized 2009.

Figure 3 – Bank Credit growth, seasonally adjusted

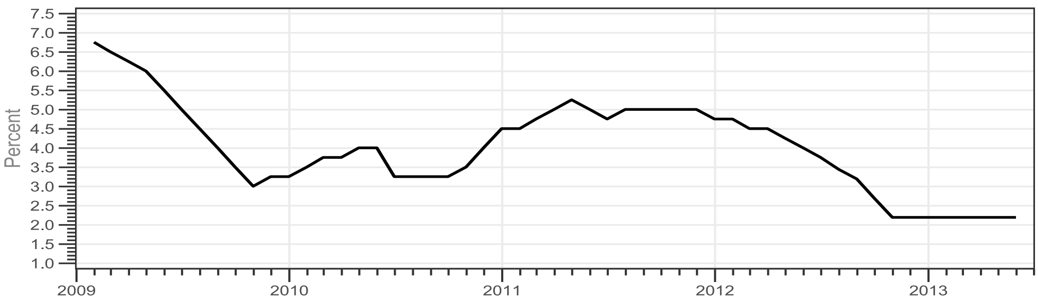


Source: CEIC.

Total assets and bank credit are useful for proxying monetary policy on the whole 2009-2019 period, but still do not fully represent an actual "monetary policy indicator (MPI)" as those elaborated by previous literature, which are constructed by rigorously combining the changes in policy tools. For this reason, a parallel analysis to the main one has been conducted with the use of two monetary policy indicators, one constructed by *Girardin et al. (2017)*, and the second elaborated by *Funke and Tsang (2019)*, to assess whether they could play a role in explaining the behavior of the Treasury term structure. The analysis of the two indicators allows us to gain a better understanding of the conduct of monetary policy, in particular by signaling the periods of tightening and of easing. For both the MPIs, a rise in value represents a tightening of monetary policy, while a decrease represents a loosening of monetary policy. Given that none of the two indicators covered the full sample under analysis, the discrete Monetary Policy Indicator constructed by *Girardin et al.*

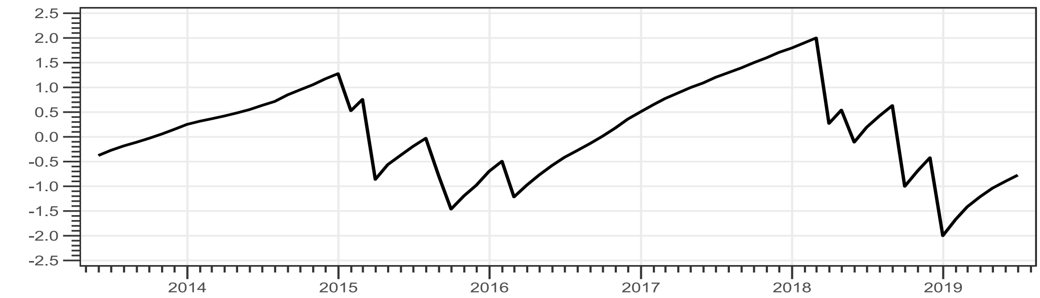
(2017) has been used in the analysis from January 2009 to May 2013 (Figure 4) while from May 2013 to June 2019 the policy indicator of *Funke and Tsang (2019)* was used (Figure 5). The former encompasses the lending and deposit rates, interest rates on required reserves, lending rate to refinancing, reserve requirement ratio, open market operations, and window guidance (loan growth). The latter is constructed starting from the 7-day pledged repo rate, reserve requirement ratio, open market operations (including standing lending facility), medium-term lending facility and pledged supplemental lending. Despite these two indicators being particularly useful as they capture the conduct of monetary policy through its evolution in time, they are computed with different approaches, and this might not guarantee that results between the two samples can be compared, as we might not know if differences in results are actually attributable to change in monetary policy influence or to the way the indicators are computed. For this reason, the main analysis will remain the one using total assets and bank credit, while the analysis conducted with the MPIs will be presented in Appendix B.

Figure 4 – Monetary Policy Indicator by Girardin et al (2017)



Source: Girardin E., Lunven S., Ma G., 2017, China's evolving monetary policy rule: from inflation accommodating to anti-inflation policy, No 641, BIS Working Papers.

Figure 5 – Monetary Policy Indicator by Funke and Tsang (2019)



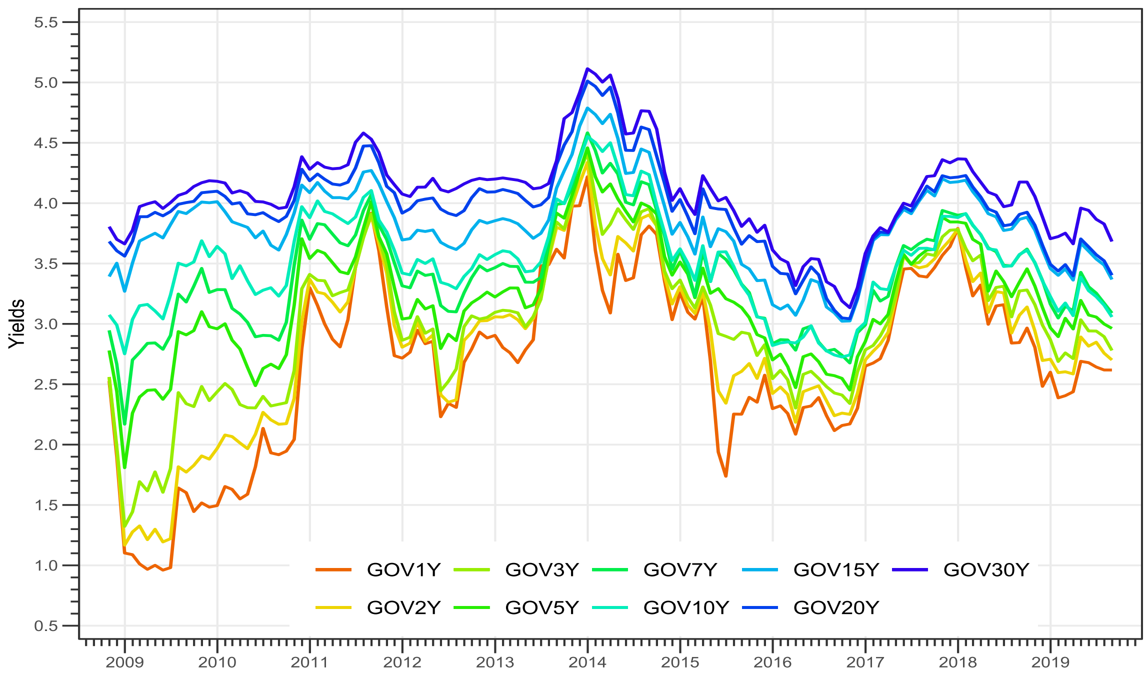
Source: Funke M., and Tsang A., 2019, The direction and intensity of China's monetary policy conduct: A dynamic factor modelling approach, No 8, BOFIT Discussion Papers, Bank of Finland.

3.1.2. China's Treasury bond yields and term structure parameters

Given the focus that this research has on the behavior of the Chinese Treasury yield curve, this section presents in a more detailed way its characteristics and its decomposition in latent factors that will help better understand its dynamics.

Figure 6 represents the evolution of the interbank Treasury bond yields in China for the nine maturities considered.

Figure 6 – Treasury Interbank Bond Yields



Source: Wind.

It can be clearly seen that in the first months of 2009 all the yields lowered, but this decrease was steeper the shorter the maturity of the yields. Hence, at the beginning of the considered period, short-term yields decreased more than long-term yields did. This spread later narrowed, as from middle 2009 the yields with maturities from 1 to 5 years increased more than what the longer maturities yields did. Then, from 2011 onwards, all the yields show a correlated behavior, as they all followed more or less the same trajectory, even if short-term yields have more marked movements. Indeed, when there is a change in the trajectory, we can note that the short-term rates react "more" compared to the long-term yields. Despite this visual explanation already being informative of the yield curve behavior, the analysis will focus on the latent factors rather than on the single yields themselves. Following the idea of the Nelson-Siegel parametrization of the yield curve would indeed help conduct a more intuitive analysis with more informative results.

As explained by numerous authors in the literature, the term structure of bond yields can be decomposed in three factors that simplify the understanding of the whole curve's behavior. These factors are the level, slope and curvature. The level provides information on the average yield, by capturing the long-maturity yield, the slope represents the spread between long and short maturity yields, and thus captures the behavior of short-maturity yields, while the curvature reflects expectations on whether the interest rates will change or not in the long run compared to the medium one, thus reflecting the behavior of mid-maturities yields. Given their higher explanatory potential and easier interpretation, only the level and the slope parameter will be analyzed in this study. Moreover, the present work does not extract these factors using the Nelson-Siegel parametrization approach, but uses a simpler and more intuitive, yet still efficient method, which relies on the computation of empirical proxies for the factors, as in *Girardin et al (2021)*. The level is simply proxied by the longest-maturity bond yield, which in this case is the 30 years one. The slope is proxied following its definition, hence through the difference between the longest- and shortest maturity yields. Hence the slope is here represented by the spread between the 30-years yields and 1-year yields.

Figure 7 represents the empirical proxy for the level, and Figure 8 represents the empirical proxy for the slope.

Figure 7 - Empirical proxy for level parameter of China's Treasury interbank yield curve

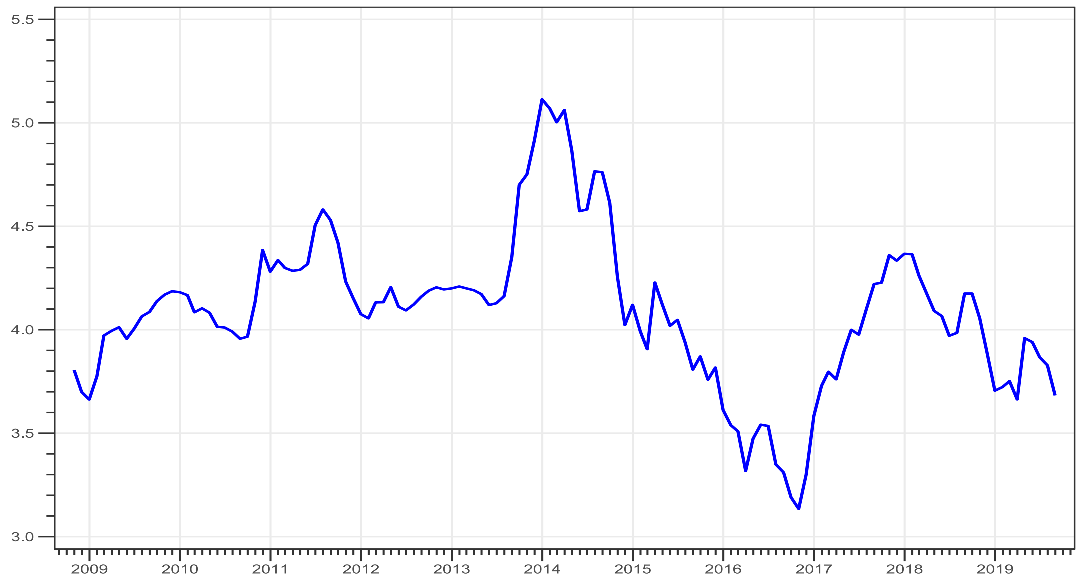
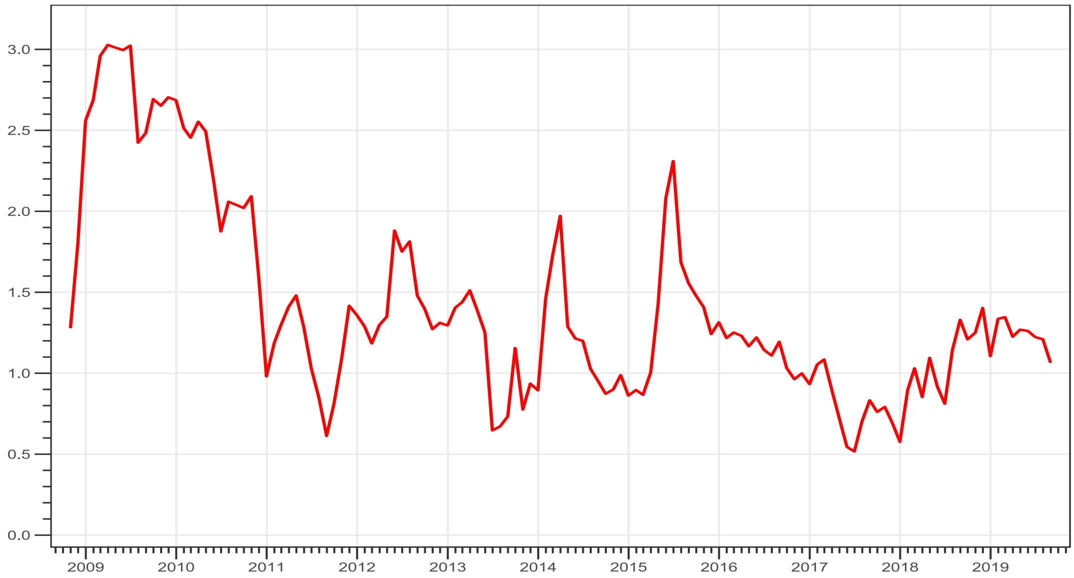


Figure 8 - Empirical proxy for slope parameter of China's Treasury interbank yield curve



Before trying to relate econometrically and explain the dynamics of such factors, it is interesting to find some correspondence in the behavior of the factors and major financial events happening in that period.

As explained in the previous monetary policy proxies section, January 2009 marked the beginning of a short period of large stimulus to recover from the damages of the Great Financial Crisis of late 2008. In fact, China adopted an expansionary monetary policy, particularly through the increase of bank credit (as already stated). An expansionary monetary policy is known to have particular influence on short-term interest rates, which experienced a decline, as was pictured in Figure 6*.* Following common knowledge, the 2009 increase in bank credit should have lowered also the long end of the yield curve, hence diminishing the level parameter. However, that does not seem to be the case. On this matter, *Porter and Cassola (2011)* seem to confirm this interpretation, stating that: *"The remarkable monetary stimulus beginning in late-2008 did not lower long-term interest rates perhaps because the monetary stimulus was accompanied by a large fiscal expansion or because it was perceived as only temporary".* Nevertheless, it is obvious that the short-term yields declined more than the long-term ones, and this caused an explosion in the slope parameter for the first half of 2009.

In September 2009 after the policy easing carried out to reduce the damages from the GFC, the regulators reintroduced a tightening policy to contain inflation. The tightening monetary policy led to a rise in interest rates, especially short-term ones, and a decline in the slope.

A noticeable increase in the slope happened in the first months of 2014, corresponding to a sudden drop in short-term yields. Even though it is not a straightforward conclusion, this could be a consequence of an event happening in the corporate bond market around that period. In March 2014, the first-ever default in Chinese corporate bond market happened, as the bond issuer "Shanghai Chaori Technologies Inc." did not pay its interests in full in the exchange market. This default event was also partly due to China's no-bailout reform, with which the Chinese government stopped its practice of bond bailout, thanks to which no corporate bond defaults had been registered before 2014. Hence from this moment onwards, investors understood that corporate bonds could not continue to be considered as safe as Treasury ones. Evidence of the increase of the Treasury spread after this default event is provided by *Mo et al (2021).* The shock from this first corporate bond default could have shifted the investments from the corporate bond market to the safer short-maturity Treasury bond market, hence decreasing its yields and increasing the slope parameter.

The 12th of June 2015, the China stock market experienced the burst of a market bubble which gave start to a market turbulence that calmed down only in January 2016. In this occasion, the slope factor of the Treasury bonds surged. This is due to the fact that short-term interest rates dropped (clearly seen in Figure 6*)*. The cut of interest rates was a measure adopted by the government to stem the tide of the turbulence, but it is also likely that this was due to the fact that stock investors decided to exit the stock market and enter the safer bond market, increasing the demand of the short-term bonds (safer than long-term bonds), which saw their price rise and yields decline.

3.2. Methodology

The level and slope parameters' behavior for Chinese bond yields will be investigated by using an Ordinary Least Square (OLS) regression, one for each factor. OLS regression is a suitable approach when all the variables are stationary, hence unit-root tests were run on all variables. The tests used to assess stationarity are the Augmented Dickey-Fuller test and the Phillips-Perron test. It is straightforward to notice that all the variables except for the growth in total assets are not stationary. Therefore, to still be able to use the OLS framework, first differences were taken. Results of these tests both on level and first differenced data are reported in Table 1. For both tests, the null hypothesis states the presence of unit-root, meaning non-stationarity, while the alternative hypothesis states stationarity. Therefore, a small p-value allows to reject the null and accept the alternative hypothesis of a stationary variable.

Table 1 – Unit-root tests

	In level		In first difference	
	ADF *	Phillips-Perron *	ADF *	Phillips-Perron *
Level (China)	0.3904	0.4474	< 0,01	< 0,01
Slope (China)	0.435	0.3139	< 0,01	< 0,01
Shibor	0.416	0.018	< 0,01	< 0,01
Assets Growth	< 0,01	< 0,01	-	-
Bank Credit	0.01	0.4669	< 0,01	< 0,01
Level (USA)	0.231	0.025	< 0,01	< 0,01
Slope (USA)	0.485	0.057	< 0,01	< 0,01

** p-values*

The results of the stationarity tests clearly show the need to use the variables in their first differenced form[12]. Hence, the present research will not be on the level of the variables, but rather on the dynamics.

The general, starting-point, specifications of the regressions are the following:

$$\Delta CLev = \alpha + \beta_1 \Delta CLev_{t-j} + \beta_2 \Delta CSlo_{t-j} + \beta_3 \Delta Shib_{t-j} + \beta_4 \Delta\% Assets_{t-j} + \beta_5 \Delta BankCredit_{t-j} + \beta_6 \Delta USLev_{t-j} + \varepsilon$$

And

$$\Delta CSlo = \alpha + \beta_1 \Delta CSlo_{t-j} + \beta_2 \Delta CLev_{t-j} + \beta_3 \Delta Shib_{t-j} + \beta_4 \Delta\% Assets_{t-j} + \beta_5 \Delta BankCredit_{t-j} + \beta_6 \Delta USSlo_{t-j} + \varepsilon$$

Where $\Delta CLev$ and $\Delta CSlo$ respectively represent the change in the level parameter and slope parameter in China, $\Delta Shib$ is the change in the one-week SHIBOR rate, $\Delta\% Assets$ represents the rate of change in the total assets of the PBoC's Balance Sheet, $\Delta BankCredit$ represents bank credit growth in China, and $\Delta USLev$ and $\Delta USSlo$ respectively indicate the change in the level parameter and slope parameter for the U.S. yield curves.

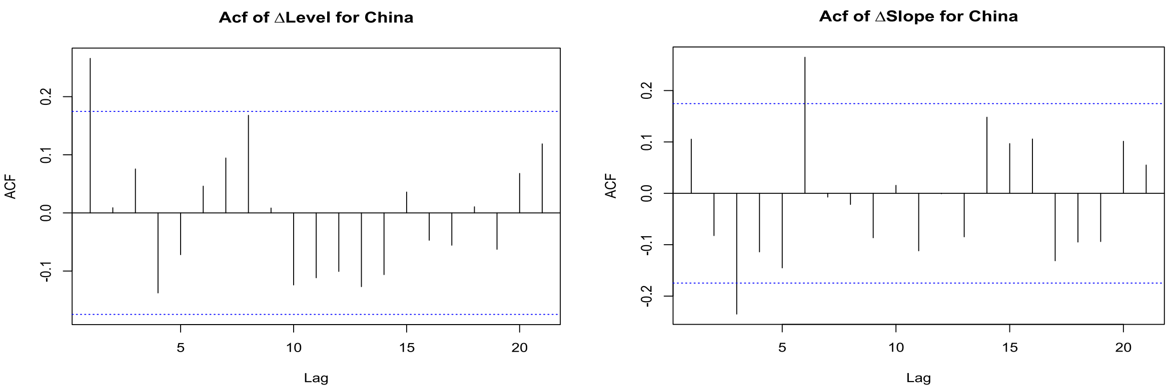
In order to avoid the omitted variable bias, the general to specific model specification is adopted: the starting point is testing the regression with all the regressors indicated

[12] Plots of the variables in first difference are in Appendix A.

above, and then correcting the model according to the (in)significance of the various resulting coefficients.

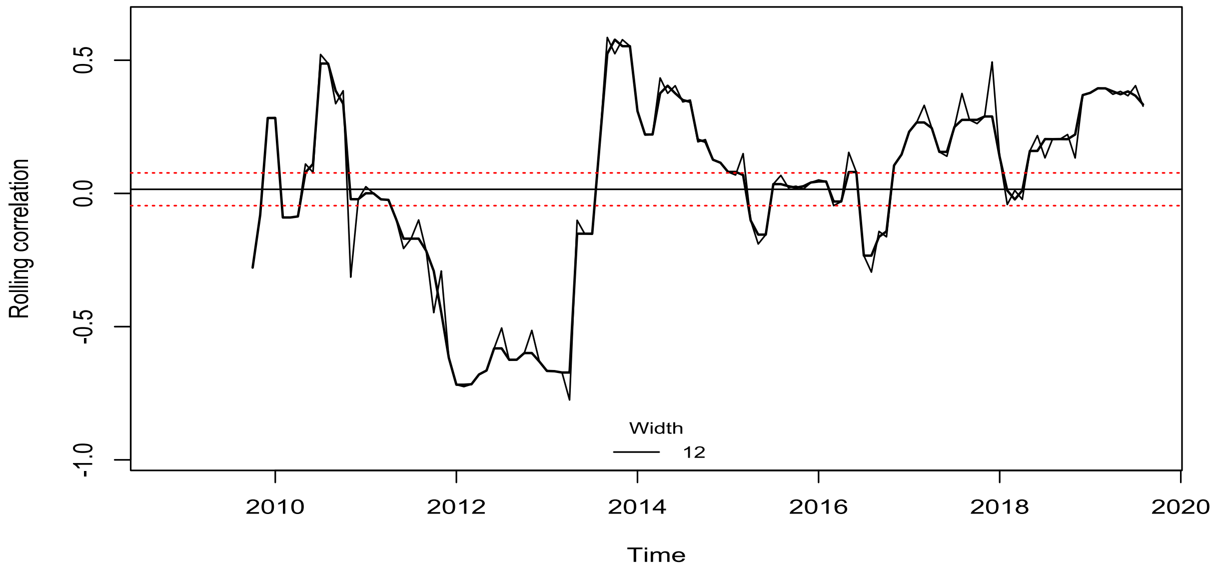
The inclusion of an autoregressive component (lagged independent variable) in the equation comes from the need to take into account the autocorrelation of the dependent variable, which can be seen in the autocorrelation function plots in Figure 9. We can notice that the first difference of the level parameter is autocorrelated at lag 1, while the first difference of the slope parameter is autocorrelated both at lag 3 (negatively) and at lag 6 (positively).

Figure 9 – Autocorrelation functions ΔLevel (left) and ΔSlope (right)



Then, in addition to comparing the correlation that the two dependent variables have with their own past values, the correlation across them has been inspected. The rolling correlation with a 12-month window has been computed and is represented in Figure 10. We can notice that the beginning of the sample is characterized by a brief moment of positive correlation between the first difference of the level and the slope variables, which lasts until the end of October 2010. After some months of unsignificant correlation between the two variables, the period from beginning 2011 to June 2013 is characterized by highly negative correlation. This latter finding is particularly useful. Starting from the way that the two parameters are defined, one could conclude that the behavior of the level influences the one of the slope, and at first thought this relationship should be positive. However, this is not the case for the period from 2011 to mid-2013. The level in this period experienced a decline, but the slope experienced a rise. One possible reason that could explain this dynamic is the fact that in that same period, short-term rates still decreased more than what long-term ones did. Referring to the plot of all yields in Figure 6, this hypothesis is indeed confirmed, thus justifying a negative correlation between the two variables. After June 2013, the correlation returns to be overall positive, with some periods of insignificant or negative correlation.

Figure 10 - Rolling Correlation between Level and Slope (first differences)



The red dashed lines represent the confidence interval for a significance level of 0.05. The thin line shows the actual rolling correlation for the 1-year width window. The bold line is a smoothed average of the correlation.

The results of the correlation analysis between the first difference of the level and slope, determined the decision to include the change in the slope parameter inside the equation explaining the dynamics of the level parameter, and to include the change in the level parameter in the equation explaining the dynamics of the slope parameter. This is done to investigate whether the influence between the two factors is reciprocal or if just one of the two influences the other.

The analysis starts by looking at the level parameter, and this is no random choice. As presented before, the slope parameter is empirically computed as the difference between long-term yields and short-term yields. Being the long-term yields the proxy for the level parameter, it is straightforward that there might be a response from the slope to what happens to the level, rather than the other way around. It will be subsequently found that the slope does not play any significant role in the determination of the level parameter.

The inclusion of lagged variables holds not only for the autoregressive component, but also for the explanatory variables. In this framework, it is more reasonable to take into account the possibility that the independent variable reacts to the different potential explanatory variables after a certain amount of time, rather than assuming an immediate response. Therefore, different regressions with different lags for the variables have been tested to obtain the final results. This would also help understand whether one of the two parameters' responses are quicker than those of the other parameter.

Given the high chance of the relationships between variables changing over time, the full sample from January 2009 to June 2019 has been split into subsamples and the regressions have been tested both on the subsamples and on the full set. A break has been imposed at end of May 2013, in order to reflect the change of monetary policy that happened at that time with the introduction of new instruments. The break appears also to fall in the time period when the correlation between the first difference of the level and slope factors changed from negative to positive, hence giving an additional reason to think that splitting the analysis at that date could be useful.

Concerning the level, the following regression was tested on both the set January 2009 – May 2013 and June 2013 - June 2019:

$$\Delta CLev = \alpha + \beta_1 \Delta CLev^*_{t-1} + \beta_2 \Delta\% Assets_{t-6} + \beta_3 \Delta BankCredit^*_{t-5} + \beta_4 \Delta USLev_{t-1} + \varepsilon$$

Where the variables marked by the * come from the application of the two-stage residual inclusion approach where it was needed. The two-stage residual inclusion approach is an implementation of the two-stage instrumental variable approach. It consists of a first regression between two variables ($z \sim x$) which display some correlation when inserted in the main regression. Then the residuals of this first regression are inserted in the main one, substituting the *z* variable. What this does is "remove" the effect that the *x* has on the *z* variable, which can then show its autonomous explanation potential. Then of course the *x* variable itself is inserted in the regression to account for the direct effect that it has on the relationship. Hence, this procedure is useful when the regression presents multicollinearity, which is pinpointed by checking the Variance Inflation Indicator (VIF) and the Tolerance. The VIF is a measure of how much the behavior of an independent variable is influenced by its interaction with other independent variables. Tolerance is just the reciprocal of VIF. The closer to 1 are these values, the less correlated are the regressors, however some authors consider a VIF value of maximum 2.5 to still be acceptable. In the present work, the VIF values from the calculations do not go above 1.5, but in some cases the two-stage residual inclusion has still been adopted in order to remove some marginal correlation. This helped to improve the results, but most importantly it gave insights on how the variables interact with each other.

In the regression for the level parameter, the procedure was applied to $CLev_{t-1} \sim USLev_{t-1}$. It was also applied to $BankCredit_{t-5} \sim Assets_{t-6}$, but only in the second set and in the full one, as it will be shown that it could not be used in the first subsample.

However, the above presented model for the level was not stable during the two periods, so further investigation pointed out that it was best to shorten the beginning of the sample to obtain solid results. It resulted that the optimal segmentation of the whole sample was January 2009 – March 2010, April 2010 – May 2013, June 2013 – June 2019. The above presented model appeared very solid in the second and third periods, and it worked also when these two periods got merged together. Thus, the final breaking of the sample is: January 2009 – March 2010, April 2010 – June 2019.

Since the previous model left out the period January 2009 – March 2010, an alternative model for the level parameter was researched, to try to cover the entirety of the sets. However, as will be explained later, no satisfactory models to explain this period were found.

Concerning the slope equation, the original sample from January 2009 to June 2019 has been kept and divided at the usual date of May 2013. However, a single equation that could hold for both the subsets could not be found. The first subset January 2009 – May 2013, is the one giving better results; hence the focus has been kept on that period. The equation is:

$$\Delta CSlo = \alpha + \beta_1 \Delta CSlo_{t-3} + \beta_2 \Delta CLev_t + \beta_3 \Delta Shib_t + \beta_4 \Delta \% Assets_{t-4} + \beta_5 \Delta BankCredit_{t-3} + \beta_6 \Delta USSlo_{t-2} + \varepsilon$$

The dependent variable at lag 3 has been included to take into account the autocorrelation that this variable displayed (at lag 3 and 6). The level parameter at time 0 has been included to inspect whether there is a simultaneous relationship between the level and the slope, as was at first investigated through the rolling correlation plot. The growth of total assets and growth in bank credit have been included with a one-month lag between them to maintain their same possible relationship used in the level parameter regression. To stay consistent with the segmentation applied when investigating the level parameter, the presented equation for the slope was also tested on the shortened period April 2010 – May 2013. However, this makes the results not significant, so it could mean that the significance of the relationship is mainly influenced by what happens in the first year of the original sample.

Given that the specification for the first set did not hold for the second, alternative specifications for the latter have been attempted and are presented in Appendix C (Table C. 7).

To assess the goodness of the results, tests were run to ensure that the assumptions needed under an OLS framework were respected. In particular, the Ljung-Box and Breusch-Godfrey tests were carried out to ensure there was no autocorrelation in the residuals. The Breusch-Pagan test was implemented to ensure homoscedasticity. The Shapiro-Wilk and Kolmogorov-Smirnov were used to assess the normality of the residuals, the first was used on the subsets, as this test works better in smaller samples, the latter was instead used on the full sample.

4. Bank credit influencing the term structure parameters

This section presents the results into four parts. Subsection 1 presents the results for the Level parameter, subsection 2 presents an insight on the relationship between the growth in total assets and the growth in bank credit, subsection 3 presents the results for the Slope, subsection 4 presents the overall conclusions considering bank credit effects on both the parameters.

4.1. Negative effect of bank credit on the Level parameter

Table 2 presents the results of the first model applied to the reduced set of data (April 2010 – June 2019):

$$\Delta CLev = \alpha + \beta_1 \Delta CLev_{t-1} + \beta_2 \Delta\% Assets_{t-6} + \beta_3 \Delta BankCredit_{t-5} + \beta_4 \Delta USLev_{t-1} + \varepsilon$$

The model holds on the whole (reduced) sample, and on the pre- and post- May 2013 subsets. On the whole sample, we can see how the dynamics of the level parameter positively depends on its behavior of the previous month, confirming what seen from its ACF plot presented before.

The level parameter in China also positively depends on the behavior of the level parameter of the U.S. yield curve, always with a one-month lag. This latter result is particularly useful in proving the presence of a spillover effect from the United States to China, confirming what previous literature already suggested.

Next, the most important finding in the context of this analysis: bank credit growth has a significant, negative influence on the dynamics of the level, which appears to manifest after five months. An increase in bank credit, which proxies an expansionary monetary policy, happens to decrease the long-term yields. Conversely, a decrease in bank credit, which stands for a tightening policy, will result in an increase in the long-term yields. These results are coherent with what the theory on monetary policy and interest rates states. These results therefore prove that monetary policy effectively transmits to the level of the yield curve and confirms that the Chinese authorities are targeting the yield curve as a whole and do not just focus on its short-term end. On the other hand, the change in total assets of the PBoC does not seem to directly influence the level of the yield curve. However, during the implementation of the two-stage residual inclusion, it appeared that the dynamics of these assets significantly influence those of bank credit, with a negative relationship and with a one-month lag (more on this in the following dedicated section).

Note that the two-stage residual inclusion procedure was not applied on the first subset as it gave insignificant results. Nonetheless, the problem of multicollinearity does not arise in this first sample as the VIF is low, and results are hence still reliable. The two-stage residual inclusion was used only on the full sample and on the second subset. Here, even after removing from the dynamics of bank credit the component due to the dynamics of the total assets, the latter do not show to have a meaningful direct impact on the level of yields. This finding is particularly interesting: given that the total assets do not have explanatory power on their own, but bank credit "cleaned" from the assets influence still has a meaningful role in the relationship, it means that there is something else that is determining bank credit, and this could be window guidance.

The goodness of the model is tested, and the results of the various tests are reported in Table 3 below. The residuals appear to be non-autocorrelated, homoscedastic, and normally distributed.

Table 2 - Results of regressions for the Level parameter in China

Variable		China Level					
Date		04/2010 - 05/2013		06/2013 - 06/2019		04/2010 - 06/2019	
Adjusted R-squared		0.45		0.11		0.1869	
Residual standard error		0.0649 on 27 DF		0.129 on 62 DF		0.1145 on 100 DF	
F-Statistics		7.318 on 4 and 27 DF		3.041 on 4 and 62 DF		6.975 on 4 and 100 DF	
p-value		3.97E-04		0.024		5.40E-05	
	lag						
China Level (IV on U.S. Level)	t-1	0.06 *[0.15]*		0.16 *[0.12]*		0.18 * *[0.09]*	
Assets Growth	t-6	0.003 *[0.01]*		0.001 *[0.01]*		0.003 *[0.009]*	
Bank Credit (IV on Assets)	t-5			-0.09 * *[0.04]*		-0.07 ** *[0.02]*	
Bank Credit	t-5	-0.06 ** *[0.02]*					
U.S. Level	t-1	0.17 ** *[0.05]*		0.19 * *[0.09]*		0.19 *** *[0.06]*	
Standard Error in square brackets. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1							
		Tolerance	VIF	Tolerance	VIF	Tolerance	VIF
China Level (IV on U.S. Lvl)		0.940	1.064	1.000	1.000	0.993	1.007
Assets Growth		0.943	1.060	0.996	1.004	0.998	1.002
Bank Credit (IV on Assets)						0.992	1.008
Bank Credit		0.955	1.047	0.992	1.008		
U.S. Level		0.968	1.034	0.988	1.012	0.998	1.002

The intercept is not reported as never significant.

Table 3 - Residuals diagnostics of regressions for Level parameter presented in Table 2

Date	04/2010 - 05/2013		06/2013 - 06/2019		04/2010 - 06/2019	
	Test statitics	P-value	Test statitics	P-value	Test statitics	P-value
Ljung-Box (H0: no autocorrelation)	21.05	0.39	15.52	0.75	16.60	0.68
Breush-Godfrey (H0: no autocorrelation)	24.15	0.24	14.13	0.82	15.48	0.75
Breush-Pagan (H0: homoskedasticity)	0.18	1.00	4.59	0.33	2.82	0.59
Shapiro-Wilk (H0: normality)	0.98	0.65	0.99	0.80		
Kolmogorov-Smirnov (H0: normality)					0.06	0.89

To make the results of the significance of bank credit even more accountable, the same model presented above, but without the total assets, has been tested. Their exclusion was possible since the total assets never appeared to be significant. The rationale for this further test is the following: removing the total assets from the regressors is an alternative way to the two-stage residual inclusion procedure when they display some correlation with bank credit. We saw how this procedure was applicable in the second and full sample, but it was not on the first. Even if the VIF values in such set did not signal collinearity problems, it was considered useful to test the regression on all three sets by using the same method of dealing with multicollinearity. The results (reported in Appendix C, Table C. 1), still show the significance of bank credit on the level parameter, with same negative coefficient, hence confirming that the previous findings still hold.

As said, the initially presented main relationship holds for the reduced sample April 2010 to June 2019, the evidence that the significance of bank credit didn't hold for the full sample January 2009 – June 2019, and for the set January 2009 - May 2013, is reported in Appendix C (Table C. 3).

To try to somehow explain what happens in the first year of the sample, from January 2009 to March 2010, many alternative specifications have been tested on the first set from January 2009 to May 2013, as it was not feasible to test this relationship directly on the missing year because the period was too short to provide trustable results. However, specifications using the growth in total assets at different lags as well as bank credit at different lags did not provide any significant results, except for the usual positive influence that the U.S. level parameter has on the Chinese one, with a one-month lag. Hence, it is not possible to provide evidence of the influence that the selected monetary policy proxies have on the level parameter of yields for the period January 2009 – March 2010. This could be due to the particular dynamics of bank credit exactly in this period, as the extreme credit stimulus that followed the GFC caused abrupt changes in its growth pattern, which could fail to be captured by the level parameter dynamics. This is also confirmed by the already presented suggestion by *Porter and Cassola* (2011), which recognized that the long-term yields did not react to the 2009 policy stimulus.

4.2. Total assets of the PBoC affecting bank credit

A further investigation into the relationship between total assets and bank credit has been conducted. To have a coherent analysis with the variables inserted in the main regression for the level parameter, the same lags are used, and the following relationship is tested:

$$\Delta BankCredit_{t-5} = \alpha + \beta_1 \Delta\% Assets_{t-6} + \varepsilon$$

On the full sample, the assets appear to be insignificant in explaining bank credit. However, if the full sample is reduced and the starting date is changed from January 2009 to April 2010, which is the same sectioning used in the main level parameter model, total assets appear to be significant in influencing bank credit. The results of the regression between bank credit and the growth in total assets for the period April 2010 – June 2019 are reported in Table 4. In Appendix C, Table C. 4 reports the results of the insignificant regression that takes January 2009 as the starting date. The coefficient of total assets growth is negative and significant; hence this means that an increase in the total assets of the PBoC leads to a decrease in the level of bank credit in China. Given that in the analysis of the level parameter it appeared that this relationship did not hold in the first subset of data, results of the regressions for the periods pre- and post- May 2013 are also reported. It is confirmed that before May 2013, bank credit was not influenced by the growth in total assets, while it was significantly and negatively influenced in the sample starting in May 2013.

To make sure that the above results were not influenced by the use of the t-5 and t-6 lags for bank credit and assets respectively, which in a sense "shorten" the sample at its beginning, the same procedure has been applied to a regression with shorter lags, namely:

$$\Delta BankCredit_{t} = \alpha + \beta_1 \Delta\% Assets_{t-1} + \varepsilon$$

Again, the results show that the growth in total assets negatively affects the amount of bank credit in the following month. The results are displayed in Table 5.

Table 4 - Regression results on the influence of Total Assets growth on Bank Credit growth. Same lags as in the full regression for the Level

Variable	Bank Credit (t-5)
Date	04/2010 - 06/2019
Adjusted R-squared	0.03399
Residual standard error	0.5266 on 103 DF
F-Statistics	4.659 on 1 and 103 DF
p-value	0.03321
Assets (t-6)	-0.09 *
	[0,04]

Variable	Bank Credit (t-5)
Date	04/2010 - 05/2013
Adjusted R-squared	-0.03017
Residual standard error	0.722 on 30 DF
F-Statistics	0.0922 on 1 and 30 DF
p-value	0.7635
Assets (t-6)	-0.04
	[0.12]

Variable	Bank Credit (t-5)
Date	06/2013 - 06/2019
Adjusted R-squared	0.08486
Residual standard error	0.4216
F-Statistics	7.12 on 1 and 65 DF
p-value	0.009612
Assets (t-6)	-0.10 **
	[0.04]

Standard Error in square brackets. Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table 5 – Regression results on the influence of Total Assets growth on Bank Credit growth. Lags t-0 and t-1

Variable	Bank Credit (t)
Date	04/2010 - 06/2019
Adjusted R-squared	0.03774
Residual standard error	0.515 on 108 DF
F-Statistics	5.276 on 1 and 108 DF
p-value	0.02356
Assets (t-1)	-0.09 *
	[0.04]

Variable	Bank Credit (t)
Date	04/2010 - 05/2013
Adjusted R-squared	-0.02799
Residual standard error	0.6788 on 35 DF
F-Statistics	0.01992 on 1 and 35 DF
p-value	0.8886
Assets (t-1)	-0.01
	[0.11]

Variable	Bank Credit (t)
Date	06/2013 - 06/2019
Adjusted R-squared	0.08876
Residual standard error	0.4083 on 70 DF
F-Statistics	7.916 on 1 and 70 DF
p-value	0.006356
Assets (t-1)	-0.1 **
	[0.04]

Standard Error in square brackets. Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Given the results presented above, an interesting conclusion is that for at least the last part of the studied period, the amount of bank credit in the Chinese economy is negatively determined by the rate of change of the PBoC’s balance sheet size. This instead does not hold for the first part of the period. The date of May 2013 to divide the sample has been used to be coherent with the segmentation used in the analysis of the level parameter, but it could be that the turning point between the insignificance and significance of the results falls on another date. A Bai-Perron break test has been conducted on the regression, to assess whether it could suggest another date. However, the test gave inconclusive results and hence the May 2013 date has been kept. What is interesting is trying to justify the negative relationship between the growth in total assets and bank credit. A not so straightforward, but still reasonable explanation could be the following. As already explained, the size of the PBoC balance sheet has expanded from the beginning of the century, with the increase of its asset side being determined by an increase in foreign exchange reserves, and with the effects of such increases being sterilized through the use of the quantity-based policy instruments that are OMOs (issuance of PBoC bills) and upward adjustments of RRR (liability side of the balance sheet). As briefly discussed previously in this work, such measures would impact bank lending negatively. Indeed, higher RRR and more pronounced issuance of PBoC bills (if the latter are purchased by banks), require commercial banks to lock up a higher portion of money they have available through deposits. Therefore banks will have less liquidity available for lending, hence hindering loan expansion and decreasing the amount of bank financing. Such mechanisms therefore confirm the negative coefficient that has been found and the intuition that an increase in total assets (or more generally, in the size of the balance sheet), which summarizes the quantity measures, leads to a decrease in bank credit[13]. The same would happen in the reverse case, with a decrease in the balance sheet size freeing up liquidity available to commercial banks for increased lending[14].

The fact that such a relationship between assets and bank credit is significant only from 2013 onwards could be due to two possible reasons. The first could be the higher effectiveness that RRR adjustments have on influencing commercial banks behavior compared to the issuance of PBoC bills, as such bills were used only prior to 2012, leaving then full space to RRR adjustments to sterilize the effect of foreign inflows. The second could be simply the fact that in the first years of the study, bank credit did not respond to either OMOs, or RRR adjustments, but credit control was determined majorly by the administrative measure of window guidance instead.

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[13] Recall the previously presented findings of *Cook and Yetman (2012)*, according to which, in some emerging Asian economies, there is a negative relationship between the increase in foreign reserve holdings (constituting the great majority of total assets) and the growth rate of bank lending.

[14] Such a situation can be seen by looking at the graphs of the total assets and bank credit presented in the previous data section. Between 2015 and 2016, there was a slight decrease of total assets, and in the same period bank credit growth experienced a slight rise. This happened in a period of monetary easing following the stock market turbulence of June 2015. Despite visual interpretation not being infallible, it in this case can be helpful to support the econometric findings.

4.3. Positive effect of bank credit on the Slope parameter

Table 6 presents the results for the equation explaining the slope parameter:

$$\Delta CSlo = \alpha + \beta_1 \Delta CSlo_{t-3} + \beta_2 \Delta CLev_t + \beta_3 \Delta Shib_t + \beta_4 \Delta\% Assets_{t-4} + \beta_5 \Delta BankCredit_{t-3} + \beta_6 \Delta USSlo_{t-2} + \varepsilon$$

As anticipated, this specification appears to fit only the first subset and not the second, as it is likely that after the first period the relationships between variables changed, requiring the use of different lags. Nonetheless, the model appears solid when applied to the first set and we can draw some explanations from it.

First, we can see how the dynamics of the slope parameter are influenced by the dynamics of the level parameter in the same month. This comes as no surprise, considering the fact that the slope parameter is linked by its definition to the level (especially when considering the empirical proxy). The coefficient shows a negative sign, meaning that a decrease in the level of yields leads to an increase in the slope. This is in line with what was suggested in the rolling correlation plot (remember that it showed a negative correlation between 2011 and mid-2013, a timespan very similar to the one considered in this regression). However, such a result might seem counterintuitive, since at first thought a decrease in the level would lead to a decrease also in the slope. This would be true if we assumed the short-term rates, the other "component" of the slope to stay constant. In the case that the short-term interest rates decrease as well, and they decrease more than what the long-term ones do, this relationship between level and slope makes sense. Next, also the SHIBOR plays a significant role. This result is particularly important since the SHIBOR is a short-term rate that has been introduced by the PBoC with the goal of making it a benchmark rate, even if it failed to cover this role. The SHIBOR being a short-term interest rate, we could assume that its effect is on the short-term yields in the yield curve. This would explain its negative coefficient, since as we have already said, an increase (decrease) in short-term yields leads to a decrease (increase) in the slope parameter.

The results show that also the growth in bank credit affects the dynamics of the slope, with a lag of three months. The effect of such growth in bank financing is positive, hence we could say that this is due to the response of the short-term yields, which decrease in response to a policy stimulus conducted through bank credit increase. Confirming again spillover effects from the U.S. to China, the U.S. slope parameter influences the Chinese one.

Again, as for the level parameter, the growth in total assets does not directly influence the slope parameter. Such growth in total assets is, however, still negatively influencing bank credit after May 2013, although in this period we do not find proof of such bank credit being significant on the slope parameter. For the same reasons presented when analyzing the level parameter, which is the impossibility of applying the two-stage residual inclusion between bank credit and total assets on the first subset (VIF values still acceptable), the same model without the growth in total assets has been tested. Results (Table C. 5 in Appendix C) still confirm that bank credit is significantly and positively influencing the slope parameter with a three-month lag for the period January 2009 – May 2013.

In the second subset however, bank credit does not have any influence on the slope parameter. This insignificance is also found when the lags of other variables are changed to provide a better fit of the overall model, as reported in Appendix C (Table C. 7). Different lags of bank credit itself have been tested but did not improve the results. Hence, we can conclude that the slope parameter does not seem to be affected by bank credit after May 2013, while it is instead influenced by bank financing growth in the first period of the analysis.

Table 6 – Results of regressions for the Slope parameter in China

Variable		China Slope		
Date		01/2009 - 05/2013	06/2013 - 06/2019	01/2009 - 06/2019
Adjusted R-squared		0.3579	0.04102	0.1636
Residual standard error		0.174 on 42 DF	0.2108 on 62 DF	0.2036 on 115 DF
F-Statistics		5.46 on 6 and 42 DF	1.485 on 6 and 62 DF	4.944 on 6 and 115 DF
p-value		3.01E-04	0.1982	1.55E-04
	lag			
China Slope	t-3	-0.14	-0.15	*-0.19 **
		[0.12]	*[0.12]*	*[0.08]*
China Level	t	-0.72 *	0.02	*0.07*
		[0.35]	*[0.19]*	*[0.16]*
Shibor	t	-0.05 *	-0.16 *	-0.08 ***
		[0.02]	*[0.06]*	*[0.02]*
Assets Growth	t-4	*0.03*	0.01	0.02
		[0.03]	*[0.02]*	*[0.02]*
Bank Credit (IV on Assets)	t-3		0.001	
			[0.06]	
Bank Credit	t-3	0.04 *		0.04 *
		[0.02]		*[0.02]*
U.S. Slope	t-2	-0.25 *	*-0.07*	-0.14
		[0.10]	*[0.16]*	*[0.09]*

Standard error in brackets. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF
China Slope	0.864	1.158	0.958	1.044	0.966	1.035
China Level	0.929	1.077	0.950	1.053	0.979	1.022
Shibor	0.848	1.179	0.944	1.059	0.954	1.048
Assets Growth	0.881	1.135	0.940	1.064	0.938	1.066
Bank Credit (IV on Assets)			0.952	1.050		
Bank Credit	0.929	1.076			0.957	1.044
U.S. Slope	0.921	1.085	0.918	1.090	0.940	1.063

The intercept is not reported as never significant.

Residuals diagnostics of the regressions presented above are reported in Table 7.

Table 7 – Residual diagnostics of regressions for Slope parameter presented in Table 6

Date	01/2009 - 05/2013		06/2013 - 06/2019		01/2009 - 06/2019	
	Test statitics	P-value	Test statitics	P-value	Test statitics	P-value
Ljung-Box (H0: no autocorrelation)	11.79	0.92	20.12	0.45	18.32	0.57
Breush-Godfrey (H0: no autocorrelation)	10.54	0.96	21.67	0.36	16.99	0.65
Breush-Pagan (H0: homoskedasticity)	7.93	0.24	5.82	0.44	4.56	0.60
Shapiro-Wilk (H0: normality)	0.97	0.32	0.97	0.08		
Kolmogorov-Smirnov (H0: normality)					0.07	0.55

4.4. Analysis of Level and Slope together

Disentangling the relationship between the considered factors of the yield curve is not easy, especially when both are influenced by a common variable such as the growth in bank credit. However, some conclusions can still be drawn. We found evidence of bank credit growth influencing the level of yields with a 5-month lag and with a negative relationship, and this happens from 2010 onwards. Such results imply that an increase (decrease) in bank credit, which proxies an expansionary (contractionary) monetary policy, causes a decrease (increase) in the higher maturity yields of the Treasury term structure in China. This conclusion being in line with common monetary policy theory, it confirms the attention paid by the policy authorities also to the long end of the yield curve, even if these effects did not arise during the intense 2009 credit stimulus, but rather manifested after that. Then, the level in turn has an effect on the slope parameter, and it was stated that this is mainly due to the way the empirical proxies of these factors are computed. The slope, however, is itself influenced by bank credit growth, with a shorter lag of 3 months. Such influence is found in the first period of the analysis, especially in the first years, hence capturing the effect of the post-GFC, 2009 loan growth. This would mean that, despite the massive bank financing stimulus not impacting the level of yields, it did instead impact the slope. Such a result implies that it was the short end of the yield curve to respond to the 2009 monetary easing, with the short-term rates decreasing, as usually happens in such a policy framework.

An interesting conclusion would be that monetary policy proxied by bank credit growth affected the short-term interest rates in the period immediately following the crisis, characterized by unusual and extreme policy easing moves that the authorities had to implement to face the damages of the GFC. After that, the influence of bank credit shifted from the short-term interest rates to the long-term ones, with the level parameter responding to monetary policy only once the period of abnormal credit expansion was over and brank credit dynamics stayed more constant over time. Moreover, it seems overall that monetary policy proxied by bank credit growth transmitted faster to the slope (maybe because short-term interest rates are more receptive) and a bit slower to the level.

5. Conclusions

The analysis carried out in the present work provides precious insights to better understand how the Chinese monetary policy influences the term structure of interest rates of the interbank Treasury bond market.

Indeed, we find evidence of both the term structure parameters here considered (level and slope) reacting to changes in bank credit, our monetary policy proxy, although in different periods and with different reaction times. The results confirm common policy theory as both the short- and long-term yields decrease in response to a loosening of monetary policy and increase in response to a tightening. The short-term yields appeared in particular to react faster, and to be receptive of the great post-GFC stimulus in the first part of our sample, while the long-term yields showed a slightly slower reaction which appeared only after the massive 2009 stimulus program was over.

We confirm previous literature in finding a spillover effect from the US Treasury term structure to the Chinese one.

We additionally unveil the influential role that the size of the PBoC's balance sheet had in determining bank credit growth from 2013 onwards. Such a result has a twofold importance: first, it confirms the influence that the monetary authority has on the banking system through the use of its observable quantity-based policy instruments. Second, it suggests the presence of a residual component of window guidance influencing bank credit, and in turn, the yield curve.

Lastly, evidence of the SHIBOR influencing the slope parameter, suggests the potential of such rate of becoming an operational target of the PBoC and helping in the transmission of monetary policy, which was the initial reason why it was introduced.

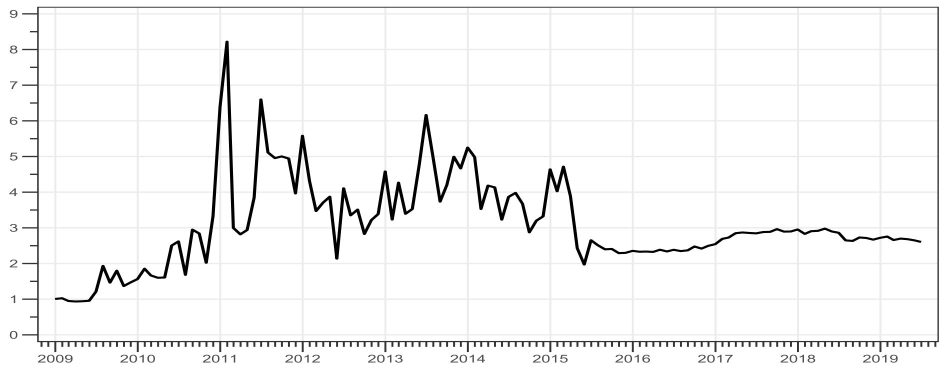
This study confirmed the initial hypothesis of the Treasury yield curve possibly becoming a viable channel for monetary policy transmission, which could be very useful to reach People's Bank of China's objective of implementing an efficient interest rate channel as transmission mechanism.

Having explored the first half of a possible transmission mechanism of monetary policy to the real economy, this study paves the way for further research on the other half, hence on whether such reactions of the yield curve to changes in policy effectively transmit down to macroeconomic variables.

Appendix

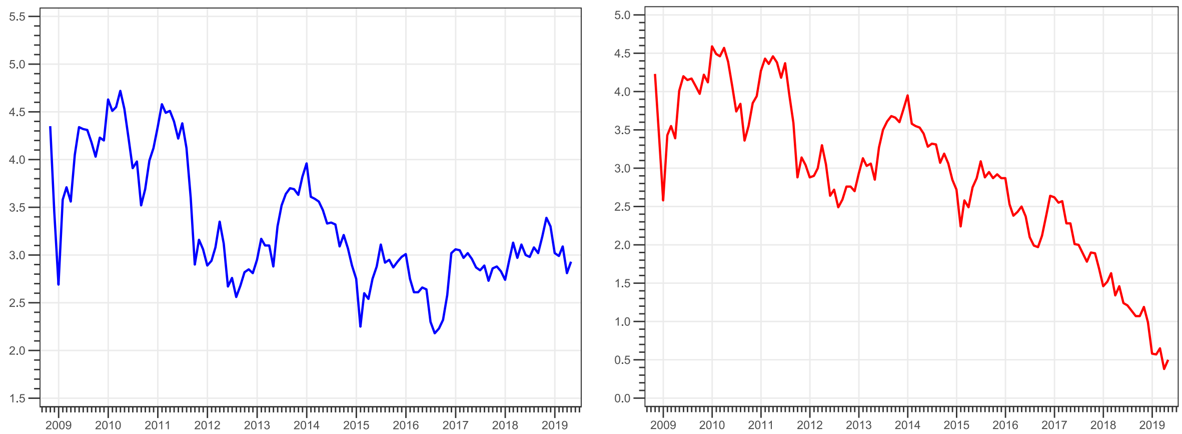
Appendix A – Additional plots

Figure A. 1 – One-week SHIBOR, in level



Source: Wind.

Figure A. 2 - Empirical proxies for the level parameter (left, in blue) and slope parameter (right, in red) of US Treasury yield curve.



Source: U.S. Department of the Treasury.

Figure A. 3 – First difference of Chinese level parameter (left) and slope parameter (right).

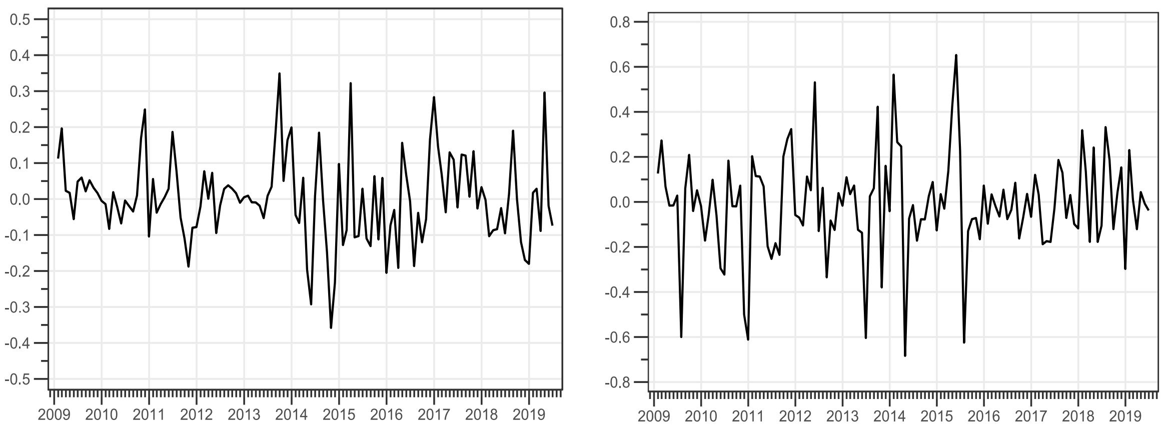


Figure A. 4 – First difference of bank credit

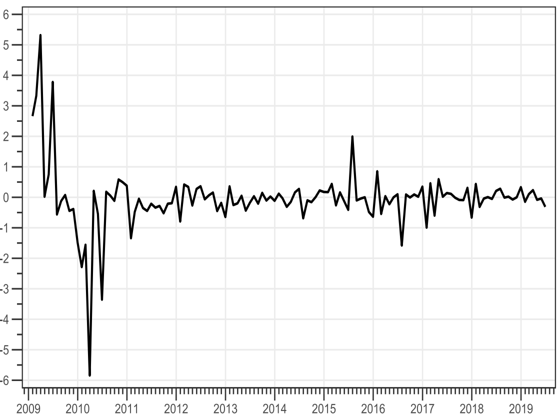


Figure A. 5 – First difference of SHIBOR

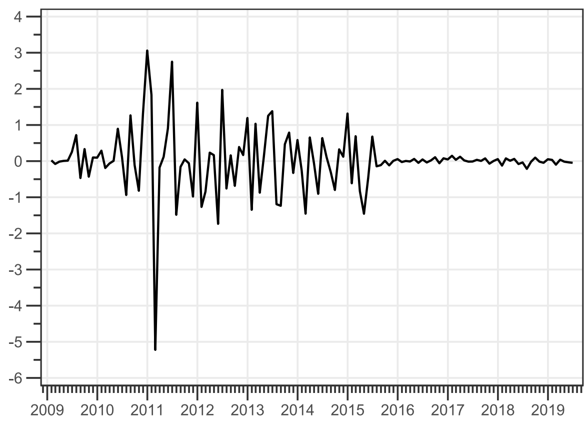
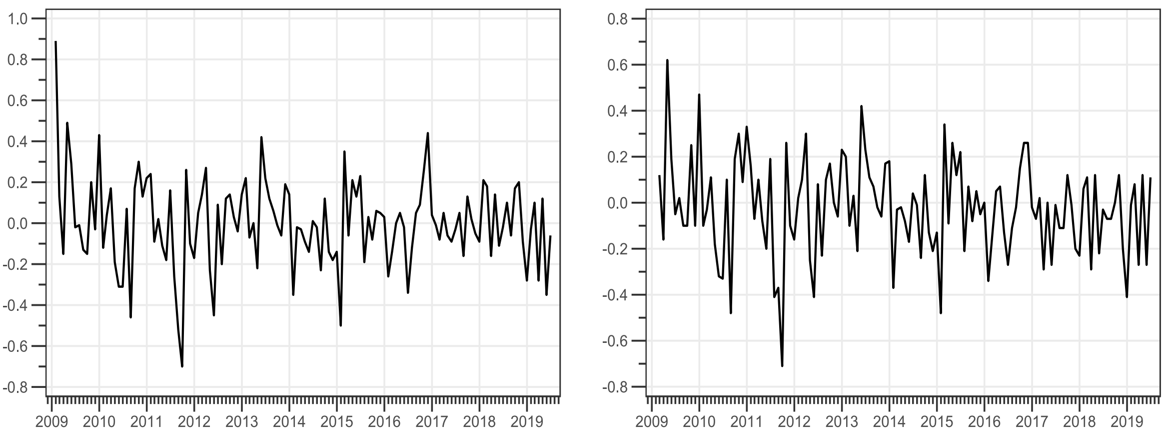


Figure A. 6 – First difference of US level parameter (left) and slope parameter (right).



Appendix B – Attempts with Monetary Policy Indicators (MPIs)

In an attempt to obtain additional insights on the transmission of monetary policy, the reaction of the yield curve parameters to monetary policy indicators coming from previous literature has been tested.

The discrete monetary policy indicator elaborated by *Girardin et al (2017)*, has been used in the sample January 2009 – May 2013. Such MPI appears to be particularly useful as it summarizes all the main pre-May 2013 policy instruments in just one single variable. To ensure stationarity, the first difference of the MPI has been computed and used in the analysis. Bank credit has been removed from the set of regressors as the MPI already incorporates the effect of loan growth, and the inclusion in the model of bank credit would have caused redundancy.

For the Level parameter, the usual segmentation from April 2010 to May 2013 has been used, mainly to be coherent with the segmentation used when using bank credit. The only specification that provided significant results implied the inclusion of the MPI with a 6-months lag. Hence the specification is:

$$\Delta CLev = \alpha + \beta_1\,\Delta CLev_{t-1} + \beta_2\Delta \mathrm{MPI}_{\mathrm{t-6}} + \beta_3\Delta USLev_{t-1} + \varepsilon$$

Results are displayed in Table B. 1 (first column). The MPI has a significant effect on the level parameter of the yield curve with a positive coefficient. Such a relationship is reasonable, as an increase in the MPI implies a tightening of monetary policy, hence an increase in yields. On the other hand, a decrease in the MPI proxies a looser monetary policy which would make yields decrease. The second column of Table B. 1 shows the attempt of extending such relationship to the whole first sample, hence taking as starting point January 2009, to see if such MPI, contrary to bank credit, already had effect on the level parameter in the first year of the analysis. Unfortunately, even though the results seem to confirm the impact of the MPI from 2009 already, the model applied to such entire first sample presents heteroskedastic residuals (see Breusch-Pagan test in Table B. 2, second column, p-value = 0.03). Such a result does not guarantee that this specification is correct for the period January 2009 – May 2013. Other attempts have been made by decreasing or increasing the lag of the MPI. It again appeared significant, and on the whole first sample (January 2009 - May 2013) with a 13-month lag (third column of Table B. 1). However, it is hard to believe that such results are reasonable, since they imply that the level parameter would react after more than a year to monetary policy. In addition to that, the coefficient has opposite sign to that one would normally expect. Hence these high-lags results are not retained as informative.

Table B. 1– Results of regressions for the Level parameter in China using MPI from Girardin et al. (2017)

	Variable	China Level					
	Date	04/2010 - 05/2013		01/2009 - 05/2013		01/2009 - 05/2013	
	Adjusted R-squared	0.40		0.28		0.2812	
	Residual standard error	0.06774 on 28 DF		0.06395 on 43 DF		0.0681 on 36 DF	
	F-Statistics	7.881 on 3 and 28 DF		6.829 on 3 and 43 DF		6.085 on 3 and 36 DF	
	p-value	5.78E-04		0.001		1.85E-03	
	lag						
China Level (IV on U.S. Level)	t-1	0.18 *[0.15]*		0.21 *[0.13]*		0.10 *[0.15]*	
MPI (*Girardin et al.*)	t-6	0.14 ** *[0.05]*		0.09 * *[0.03]*			
MPI (*Girardin et al.*)	t-13					-0.09 * *[0.04]*	
U.S. Level	t-1	0.23 *** *[0.05]*		0.17 *** *[0.04]*		0.15 ** *[0.05]*	
Standard Error in square brackets. Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1							
		Tolerance	VIF	Tolerance	VIF	Tolerance	VIF
	China Level (IV on U.S. Lvl)	0.995	1.005	0.998	1.002	0.975	1.025
	MPI (t-6)	0.910	1.099	0.876	1.141		
	MPI (t-13)					0.972	1.028
	U.S. Level	0.915	1.093	0.878	1.139	0.997	1.003

The intercept is not reported as never significant.

Table B. 2 – Residuals diagnostics of regressions for Level parameter presented in Table B. 1

Date	04/2010 - 05/2013		01/2009 - 05/2013		01/2009 - 05/2013	
	Test statitics	P-value	Test statitics	P-value	Test statitics	P-value
Ljung-Box (H0: no autocorrelation)	16.55	0.68	17.59	0.61	23.63	0.26
Breush-Godfrey (H0: no autocorrelation)	15.91	0.72	15.32	0.76	17.66	0.61
Breush-Pagan (H0: homoskedasticity)	3.05	0.38	8.77	0.03	3.36	0.34
Shapiro-Wilk (H0: normality)	0.96	0.23	0.99	0.81	0.95	0.07
Kolmogorov-Smirnov (H0: normality)						

The MPI from *Girardin et al (2017)* has also been tested on the slope parameter. First, lower lags, approximately in line with those for the specification that used bank credit, have been tested. However, no significance of the MPI has been found. The first column of Table B. 3 reports the results for one of the specifications among the tested ones. Then also higher lags have been tested. Again, similarly to what was found for the level, the MPI appears to be significant at a 14-months lag. The coefficient affecting the slope parameters is positive, hence implying that in increase in the MPI (tightening policy) should increase the slope, which would only make sense if the high-maturity yields registered a rise (an increase in the slope due to the decrease in short-term yields would go against common monetary policy theory). It seems however not logical to assume that the yield curve reacts this late to changes in policy, and hence, as for the level parameter, these results are not retained as informative.

Table B. 3 - Results of regressions for the Slope parameter in China using MPI from Girardin et al. (2017)

Variable	lag	China Slope	
Date		01/2009 - 05/2013	01/2009 - 05/2013
Adjusted R-squared		0.2666	0.4276
Residual standard error		0.186 on 43 DF	0.1666 on 33 DF
F-Statistics		4.49 on 5 and 43 DF	6.678 on 5 and 33 DF
p-value		2.22E-03	2.13E-04
China Slope	t-3	-0.14	-0.29 *
		[0.13]	*[0.14]*
China Level	t	-0.72 .	-0.56
		[0.37]	*[0.36]*
Shibor	t	-0.06 **	-0.05 *
		[0.02]	*[0.02]*
MPI (*Girardin et al.*)	t-4	*-0.11*	
		[0.09]	
MPI (*Girardin et al.*)	t-14		*0.25 **
			[0.09]
U.S. Slope	t-2	0.18 .	-0.25 *
		[0.11]	*[0.11]*

Standard error in brackets. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

	Tolerance	VIF	Tolerance	VIF
China Slope	0.864	1.157	0.777	1.288
China Level	0.937	1.067	0.884	1.131
Shibor	0.916	1.092	0.884	1.132
MPI (t-4)	0.968	1.033		
MPI (t-14)			0.938	1.066
U.S. Slope	0.989	1.011	0.975	1.026

The intercept is not reported as never significant.

Table B. 4 - Residuals diagnostics of regressions for Slope parameter presented in Table B. 3

Date	01/2009 - 05/2013		01/2009 - 05/2013	
	Test statitics	P-value	Test statitics	P-value
Ljung-Box (H0: no autocorrelation)	28.39	0.10	15.78	0.73
Breush-Godfrey (H0: no autocorrelation)	20.48	0.43	16.52	0.68
Breush-Pagan (H0: homoskedasticity)	6.63	0.25	4.08	0.54
Shapiro-Wilk (H0: normality)	0.98	0.41	0.98	0.66
Kolmogorov-Smirnov (H0: normality)				

Next, for the period June 2013 – June 2019, the monetary policy indicator elaborated by *Funke and Tsang (2019)* has been tested, both on the level and the slope parameters.

Again, to ensure stationarity, the first difference has been used. Various attempts with various lags have been made, however with discouraging results.

For the level parameter, the MPI is never significant at any lag, neither with the inclusion or exclusion of bank credit. The analysis proceeded on the slope parameter. In such specification, the SHIBOR has been purposefully omitted from the regressors, as the indicator of *Funke and Tsang (2019)* comprises the 7-day pledged repo rate. Despite these being two different rates, some authors (*Porter and Xu, 2009*) argue the presence of high correlation between the two, hence the choice to omit the SHIBOR to avoid possible redundancy. Again no significance of the MPI is found at any lag. Table B. 5 represents one of the attempts for each of the parameters. In the level parameter model, the MPI is included at lag 9. While testing all the different lags for the MPI, bank credit at lag 5 was always significant. The only exception was when the MPI was at lag 9, as in that case bank credit was only weakly significant. Hence this suggested a possible problem of collinearity. Indeed, when doing the two-stage residual step inclusion procedure, it appeared that the MPI at lag 9 significantly influenced bank credit at lag 5. Unfortunately doing this procedure did not improve the overall results for the level parameter, but it at least gave useful insights on the relationship between the MPI and bank credit. The same procedure was adopted for the slope parameter. The inclusion of the MPI at any lag never provides significant results, but it was again found that the MPI at lag 7 influenced bank credit at lag 3 (same 4-month distance as in the level). Table B. 7 presents the results of the regressions between bank credit and the MPI that were computed for the two-stage residual inclusion procedure. The coefficient of the MPI is negative, and this is a reasonable result. Indeed an increase (decrease) in the MPI indicates a tightening (easing) of the monetary policy. Hence the negative coefficient leads to the logical conclusion that an increase (decrease) in the MPI leads to a decrease (increase) in bank credit. The monetary policy stance indicator by *Funke and Tsang (2019)*, despite not being useful in explaining the term structure factors dynamics, provides some interesting information on how the new instruments of monetary policy that were introduced in 2013 have effect on the growth in bank credit in China.

Table B. 5 - Results of regressions for Level (left) and Slope (right) in China using MPI from Funke and Tsang

Variable		China Level
Date		06/2013 - 06/2019
Adjusted R-squared		0.10
Residual standard error		0.1301 on 59 DF
F-Statistics		2.753 on 4 and 59 DF
p-value		3.62E-02
	lag	
China Level (IV on U.S. Level)	t-1	0.15 *[0.12]*
MPI (*Funke&Tsang*)	t-9	0.05 *[0.04]*
Bank Credit (IV on MPI)	t-5	-0.07 . *[0.04]*
U.S. Level	t-1	0.19 . *[0.10]*

Standard Error in square brackets. Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

	Tolerance	VIF
China Level (IV on U.S. Lvl)	0.999	1.001
MPI	0.992	1.009
Bank Credit	0.999	1.001
U.S. Level	0.992	1.008

Variable		China Slope
Date		06/2013 - 06/2019
Adjusted R-squared		0.2129
Residual standard error		0.1899 on 60 DF
F-Statistics		4.516 on 5 and 60 DF
p-value		1.47E-03
	lag	
China Slope	t-3	-0.17 *[0.11]*
China Level	t-7	-0.49 ** *[0.18]*
MPI (*Funke&Tsang*)	t-7	0.03 *[0.05]*
Bank Credit	t-3	0.09 *[0.06]*
U.S. Slope	t-5	-0.44 ** *[0.14]*

Standard error in brackets. Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

	Tolerance	VIF
China Slope	0.942	1.061
China Level	0.895	1.118
MPI	0.985	1.016
Bank Credit (IV on MPI)	0.879	1.137
U.S. Slope	0.978	1.023

The intercept is not reported as never significant.

Table B. 6 - Residuals diagnostics of regressions on Level (left) and Slope (right) presented in Table B. 5

Date	06/2013 - 06/2019 (Level)		06/2013 - 06/2019 (Slope)	
	Test statitics	P-value	Test statitics	P-value
Ljung-Box (H0: no autocorrelation)	12.80	0.89	15.22	0.76
Breush-Godfrey (H0: no autocorrelation)	11.69	0.93	16.53	0.68
Breush-Pagan (H0: homoskedasticity)	4.72	0.32	3.58	0.61
Shapiro-Wilk (H0: normality)	0.99	0.77	0.97	0.12
Kolmogorov-Smirnov (H0: normality)				

Table B. 7 – Results of regressions of Bank Credit on MPI by Funke and Tsang. On the left, same lags used in the regression for the Level, on the right, same lags used in the regression for the Slope

Variable	Bank Credit (t-5)
Date	06/2013 - 06/2019
Adjusted R-squared	0.1056
Residual standard error	0.4255 on 62 DF
F-Statistics	8.439 on 1 and 62 Df
p-value	0.005084
MPI (t-9) *Funke&Tsang*	-0.35 ** *[0.12]*

Variable	Bank Credit (t-3)
Date	06/2013 - 06/2019
Adjusted R-squared	0.09794
Residual standard error	0.4219 on 64 DF
F-Statistics	8.057 on 1 and 64 DF
p-value	0.006067
MPI (t-7) *Funke&Tsang*	-0.34 ** *[0.12]*

Standard Error in square brackets. Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Appendix C – Alternative models and failed ones

Table C. 1– Results of regressions on Level parameter without growth in total assets

Variable	lag	China Level					
Date		04/2010 - 05/2013		06/2013 - 06/2019		04/2010 - 06/2019	
Adjusted R-squared		0.42		0.12		0.1868	
Residual standard error		0.06546 on 29 DF		0.129 on 64 DF		0.114 on 102 DF	
F-Statistics		8.771 on 3 and 29 DF		4.019 on 3 and 64 DF		9.039 on 3 and 102 DF	
p-value		2.70E-04		0.011		2.31E-05	
China Level (IV on U.S. Level)	t-1	0.06 *[0.15]*		0.17 *[0.12]*		0.18 * *[0.09]*	
Bank Credit	t-5	-0.06 ** *[0.02]*		*-0.08 ** *[0.04]*		-0.07 ** *[0.02]*	
U.S. Level	t-1	0.15 ** *[0.05]*		0.20 * *[0.09]*		0.18 ** *[0.06]*	
Standard Error in square brackets. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1							
		Tolerance	VIF	Tolerance	VIF	Tolerance	VIF
China Level (IV on U.S. Lvl)		0.964	1.037	1.000	1.000	0.994	1.006
Bank Credit		0.959	1.043	0.996	1.004	0.992	1.008
U.S. Level		0.994	1.006	0.996	1.004	0.998	1.002

The intercept is not reported as never significant.
Bank credit is significant even without the (insignificant) growth in total assets.

Table C. 2– Residuals diagnostics of regressions on Level parameter without growth in total assets (Table C. 1)

Date	04/2010 - 05/2013		06/2013 - 06/2019		04/2010 - 06/2019	
	Test statitics	P-value	Test statitics	P-value	Test statitics	P-value
Ljung-Box (H0: no autocorrelation)	23.01	0.29	16.21	0.70	17.00	0.65
Breush-Godfrey (H0: no autocorrelation)	19.22	0.51	14.67	0.80	15.84	0.73
Breush-Pagan (H0: homoskedasticity)	0.79	0.85	3.34	0.34	1.95	0.58
Shapiro-Wilk (H0: normality)	0.98	0.91	0.98	0.55		
Kolmogorov-Smirnov (H0: normality)					0.06	0.83

Table C. 3 – Results of regressions on Level parameter, full sample January 2009 to June 2019

Variable	lag	China Level					
Date		01/2009 - 05/2013		06/2013 - 06/2019		01/2009 - 06/2019	
Adjusted R-squared		0.15		0.11		0.1074	
Residual standard error		0.06942 on 42 DF		0.129 on 62 DF		0.1129 on 115 DF	
F-Statistics		2.969 on 4 and 42 DF		3.041 on 4 and 62 DF		4.581 on 4 and 115 DF	
p-value		0.030		0.024		1.81E-03	
China Level (IV on U.S. Level)	t-1	0.22 *[0.15]*		0.16 *[0.12]*		0.22 * *[0.09]*	
Assets Growth	t-6	0.00 *[0.01]*		0.00 *[0.01]*		0.001 *[0.01]*	
Bank Credit (IV on Assets)	t-5			-0.09 * *[0.04]*			
Bank Credit	t-5	*-0.01* *[0.006]*				-0.01 *[0.01]*	
U.S. Level	t-1	0.13 ** *[0.04]*		0.19 * *[0.09]*		0.17 ** *[0.05]*	
Standard Error in square brackets. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1							
		Tolerance	VIF	Tolerance	VIF	Tolerance	VIF
China Level (IV on U.S. Lvl)		0.969	1.032	1.000	1.000	0.999	1.001
Assets Growth		0.953	1.050	0.996	1.004	0.989	1.011
Bank Credit (IV on Assets)							
Bank Credit		0.988	1.012	0.992	1.008	0.989	1.011
U.S. Level		0.971	1.029	0.988	1.012	0.997	1.003

The intercept is not reported as never significant.
Bank credit is insignificant on the Level when the starting date of the sample is January 2009.

Table C. 4 – Results of regressions of bank credit on total assets on the full sample starting January 2009.

Variable	Bank Credit (t-5)
Date	01/2009 - 06/2019
Adjusted R-squared	0.0006254
Residual standard error	1.041 on 118 DF
F-Statistics	1.074 on 1 and 118 DF
p-value	0.3021
Assets (t-6)	-0.08
	[0.08]

Variable	Bank Credit (t)
Date	01/2009 - 06/2019
Adjusted R-squared	0.001714
Residual standard error	1.02 on 123 DF
F-Statistics	1.213 on 1 and 123 DF
p-value	0.2729
Assets (t-1)	-0.08
	[0.07]

Standard Error in square brackets. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Total assets growth is insignificant on bank credit growth when the starting date of the sample is January 2009.

Table C. 5– Results of regressions on Slope parameter without growth in total assets

	Variable	China Slope		
	Date	01/2009 - 05/2013	06/2013 - 06/2019	01/2009 - 06/2019
	Adjusted R-squared	0.3473	0.07424	0.1635
	Residual standard error	0.1736 on 44 DF	0.2112 on 64 Df	0.2028 on 117 DF
	F-Statistics	6.215 on 5 and 44 DF	2.107 on 5 and 64 DF	5.769 on 5 and 117 DF
	p-value	1.93E-04	0.07596	8.51E-05
	lag			
China Slope	t-3	-0.16	-0.2 .	-0.19 *
		[0.12]	*[0.11]*	*[0.08]*
China Level	t	-0.76 *	0.28	*0.07*
		[0.35]	*[0.19]*	*[0.16]*
Shibor	t	-0.06 **	-0.15 *	-0.08 ***
		[0.02]	*[0.06]*	*[0.02]*
Bank Credit	t-3	0.04 *	-0.02	0.03 .
		[0.02]	*[0.06]*	*[0.02]*
U.S. Slope	t-2	-0.23 *	*-0.02*	-0.13
		[0.10]	*[0.15]*	*[0.09]*

Standard error in brackets. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF
China Slope	0.864	1.457	0.940	1.064	0.965	1.036
China Level	0.935	1.070	0.927	1.079	0.980	1.020
Shibor	0.912	1.097	0.932	1.073	0.968	1.033
Bank Credit	0.919	1.088	0.963	1.038	0.970	1.031
U.S. Slope	0.940	1.064	0.987	1.013	0.975	1.025

The intercept is not reported as never significant.

Bank credit in the first subsample is significant even without the (insignificant) growth in total assets.

Table C. 6– Residual diagnostics of regressions on Slope parameter without growth in total assets (Table C. 5)

Date	01/2009 - 05/2013		06/2013 - 06/2019		01/2009 - 06/2019	
	Test statitics	P-value	Test statitics	P-value	Test statitics	P-value
Ljung-Box (H0: no autocorrelation)	18.16	0.58	21.45	0.37	18.49	0.56
Breush-Godfrey (H0: no autocorrelation)	14.15	0.82	21.89	0.35	16.91	0.66
Breush-Pagan (H0: homoskedasticity)	5.93	0.31	3.65	0.60	4.23	0.52
Shapiro-Wilk (H0: normality)	0.97	0.18	0.98	0.23		
Kolmogorov-Smirnov (H0: normality)					0.07	0.56

Table C. 7– Alternative regressions for the Slope parameter that best fitted the second and full sample. First sample is the same as already presented.

		China Slope		
Date		01/2009 - 05/2013	06/2013 - 06/2019	01/2009 - 06/2019
Adjusted R-squared		0.3579	0.2598	0.2505
Residual standard error		0.174 on 42 DF	0.1842 on 59 DF	0.1936 on 114 DF
F-Statistics		5.46 on 6 and 42 DF	4.802 on 6 and 59 DF	7.684 on & and 114 DF
p-value		3.01E-04	4.76E-04	6.05E-07
	lag			
China Slope	t-3	-0.14 *[0.12]*	-0.2 . *[0.11]*	-0.23 ** *[0.08]*
China Level	t	-0.72 * *[0.35]*		
China Level	t-3			0.33 * *[0.15]*
China Level	t-7		-0.47 ** *[0.17]*	
Shibor	t	-0.05 * *[0.02]*	-0.12 * *[0.06]*	-0.07 *** *[0.02]*
Assets Growth	t-4	*0.03* *[0.03]*	0.01 *[0.02]*	0.01 *[0.01]*
Bank Credit	t-3	0.04 * *[0.02]*		
Bank Credit (IV on Assets)	t-3		0.08 *[0.06]*	
Bank Credit (IV on US Slope (t-5))	t-3			0.05 ** *[0.02]*
U.S. Slope	t-2	-0.25 * *[0.10]*		
U.S. Slope	t-5		-0.46 ** *[0.14]*	-0.22 ** *[0.08]*

Standard error in brackets. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF
China Slope (t-3)	0.864	1.158	0.948	1.055	0.970	1.031
China Level (t)	0.929	1.077				
China Level (t-3)					0.978	1.022
China Level (t-7)			0.888	1.126		
Shibor	0.848	1.179	0.962	1.039	0.956	1.046
Assets	0.881	1.135	0.979	1.022	0.935	1.070
Bank Credit	0.929	1.076				
Bank Credit (IV on Assets)			0.855	1.169		
BCr. (IV on US Slo t-5)					0.981	1.019
U.S. Slope (t-2)	0.921	1.085				
U.S. Slope (t-5)			0.958	1.044	0.969	1.032

The intercept is not reported as never significant. Bank Credit in the second sample is still insignificant.

Table C. 8– Residual diagnostics of Slope parameter alternative models presented in Table C. 7

Date	01/2009 - 05/2013		06/2013 - 06/2019		01/2009 - 06/2019	
	Test statitics	P-value	Test statitics	P-value	Test statitics	P-value
Ljung-Box (H0: no autocorrelation)	11.79	0.92	11.12	0.94	17.70	0.61
Breush-Godfrey (H0: no autocorrelation)	10.54	0.96	11.95	0.92	16.47	0.69
Breush-Pagan (H0: homoskedasticity)	7.93	0.24	3.60	0.73	2.39	0.88
Shapiro-Wilk (H0: normality)	0.97	0.32	0.96	0.06		
Kolmogorov-Smirnov (H0: normality)					0.08	0.46

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