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Greening Monetary Policy: Evidence from the People's Bank of China[1]

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Greening Monetary Policy: Evidence from the People's Bank of China

Camille Macaire and Alain Naef[1]

Abstract

In June 2018, the People's Bank of China (PBoC) decided to include green financial bonds into the pool of assets eligible as collateral for its Medium Term Lending Facility. The PBoC also gave green financial bonds a "first-among-equals" status. We measure the impact of the policy on the yield spread between green and non-green bonds. Using a difference-in-differences approach, we show that the policy increased the spread by 46 basis points. Our approach differs from the literature in that we match bonds under review with non-green bonds with similar characteristics and issued by the same firm, which allows for highly relevant firm fixed-effects. We also specifically investigate the impact on green bonds. The granularity of the data (daily) also allows us to conduct a dynamic analysis by dividing the sample into weekly, monthly and quarterly observations. We show that pre-trends are minor. Our results also show that the impact of the reform starts to materialize after three weeks, has a maximum effect after three months, and has a persistent effect over six months.

Keywords: People's Bank of China, central bank collateral framework, green bonds, bond yields, greenium.

JEL classification: Q58, Q51, G12, E52

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Introduction

Central banks have begun to investigate the impact of climate change on the stability of the financial system (Campiglio et al. 2018). They have also started to find possible ways to reduce the carbon intensity of their portfolio and support low-carbon initiatives.

One way monetary policy can support a transition towards a greener economy is through lending facilities. With these facilities, central banks supply loans to financial institutions in exchange for securities as collateral. Adding a security in the list of eligible collateral can affect its price, and in turn affect the real economy. On June 1, 2018, the People's Bank of China (PBoC) broadened the asset classes accepted as collateral for its Medium Term Lending Facility (MLF) to include financial bonds, in particular, green bonds, bonds issued by small and micro enterprises (Xiaowei bonds) and bonds issued by agricultural corporations (Sannong bonds).[2] The PBoC also gave green bonds priority over other financial bonds (a first-among-equals status). We study the impact of this policy on the yield differential between green and non-green bonds.

While many papers study the effect of accepting a bond as collateral, or "eligibility premium" (Mésonnier, O'Donnell, and Toutain 2017; Van Bekkum, Gabarro, and Irani 2018), here green bonds were not only accepted but also given a preferential status. This policy has, to the best of our knowledge, not been used in other countries. And the effects we find here are large in magnitude (46bp), suggesting that the policy had an important impact.

We use a difference-in-differences approach with higher frequency data than for most other studies.[3] We compare green financial bonds with other financial bonds issued by the same firm, hence with identical firm specifications. This means that our identification process focuses on analyzing green and non-green bonds with similar characteristics, except for their green status. We measure the spread between green and non-green bonds' yields before and after the reform. The premium of green assets over non-green assets has been labelled "greenium" and is subject to a large literature. 4 We show that the greenium, i.e. the average yield differential between green and non-green bonds, amounted to 32 basis points at the time 2018 reform in China. We find that the policy further increased the spread between green and non-green bonds by 46 basis points.

Green bonds are fixed-income assets, which finance projects meant to have a positive impact on the environment or reduce harm caused by current activities. The money raised needs to be used by banks to lend to green projects. A company financed by the bank can have both green projects and other projects, financed with different instruments. Here we will refrain from assessing whether these green bonds have an impact on the environment. We also refrain from assessing whether the Chinese green bond taxonomy is in line with international standards. For example, Chinese standards allow for clean coal projects to be financed by green bonds (Gilchrist, Yu, and Zhong 2021). Such projects reduce the carbon footprint of coal

[2] Note that these companies are either small or "micro", which usually involves one employee working on a freelance basis.

[3] Traditionally, the method is used with two time periods. Here we test the impact over a one-year time period with different length of time sub-periods, up to a week.

[4] See for example Harrison, Partridge, and Tripathy 2020; Larcker and Watts 2020; Larsson 2019; Alessi, Ossola, and Panzica 2019; Partridge and Medda 2020; Partridge and Romana 2020; Zerbib 2019.

mines but still represent investment in non-green technologies. The goal is to see whether a central bank can affect green bond pricing through its monetary policy, both through the direct impact of collateral eligibility, as well as via the signal effect that promotes the market for green financial bonds, which was still in its infancy in China at the time of the reform. This is useful as most central banks are currently trying to support low-carbon initiatives (Campiglio et al. 2018).

Literature review – green monetary policy in China and elsewhere

Central banks have started formal reviews of the impact of their monetary policy on the environment, and in this context the Chinese experience can prove useful. The Bank of England pioneer the idea that central banks should have an impact on climate (Carney 2015). Proposals for greener central banking by van 't Klooster and Tilburg (2020) and Dafermos et al. (2020), have suggested a broader understanding of central bank market neutrality, within the context of a green transition.[5] Market neutrality implies that monetary policy operations should not favor one industry over another. But the literature highlights the fact that the current market might be biased towards sectors more at risk of a climate transition shock and climate risks might not be priced in correctly (Campiglio 2016; Schnabel 2020). Findings suggest that a low carbon allocation could be done with no interference with the price stability mandate in the Eurozone (Schoenmaker 2021). Christine Lagarde has also questioned whether market neutrality is warranted, if there is a market failure linked to the pricing of assets exposed to climate risk.[6]

Several proposals have emerged to understand how central banks can better mitigate their impact on the climate. McConnell, Yanovski, and Lessmann (2020) suggest that central bank have a role to play because of their independence. They suggest using collateral haircuts based on assets' carbon intensity. Ferrari and Nispi Landi (2021) suggest using a temporary green QE and to temporarily tilt central bank's balance sheet toward green bonds.

In the European context for example, van 't Klooster and Tilburg (2020) suggest the ECB uses green Targeted Longer-Term Refinancing Operations (TLTRO) to finance transition to green housing. Dafermos et al. (2020) argued that because of the structure of the market, the ECB unwillingly had a bias towards brown assets and hence might not be market neutral. Oustry et al. (2020) suggest a "climate-hedging portfolio approach" where the central bank would align the aggregate of its portfolio rather than an asset-by-asset approach. Other central banks have questioned the concept of market neutrality in the light of catastrophic climate risks. The Swiss National Bank (SNB) has recently announced plans to divest from coal in the context of its monetary policy (van 't Klooster and Naef 2021).[7]

Researchers have tried to model how a monetary policy aligned with the Paris Accord might look like; Böser and Colesanti Senni (2020) offer a dynamic general equilibrium model and show how a climate-oriented monetary policy could help with

[5] On the market neutrality of the SNB and ECB, see also Klooster and Fontan (2019).
[6] "In the face of what I call the market failures" we have to ask "whether market neutrality should be the actual principle that drives our monetary-policy portfolio management" https://www.bloomberg.com/news/articles/2020-10-14/lagarde-says-ecb-needs-to-question-market-neutrality-on-climate.
[7] See the announcement by the SNB chairman here: https://www.snb.ch/en/mmr/speeches/id/ref_20201217_tjn

transition. While there is no clear consensus on how central banks can mitigate climate change, there is a consensus that central banks are thinking about ways to mitigate climate risks (Campiglio et al. 2018). In the European context, it is also clear that the financial system is exposed to climate-policy-relevant sectors (Battiston et al. 2017) and that an abrupt transition could pose systemic risks.

In terms of changes to securities accepted as collateral, our study relates to a broader literature. Mésonnier, O'Donnell, and Toutain (2017) found that when an asset becomes eligible in the Eurosystem's collateral framework, it translates into a reduction of 7bp yield for new loans issued by a firm, even when controlling for loan and firm specific effects. Giovanardi et al. (2021) run an analysis closely related to our in Europe. They find that after each ECB announcement favourable to green bonds, green bond yields drop by 9.3bp on average over a twenty trading day window.

In the Chinese context, Fang, Wang, and Wu (2020) also study the 2018 policy change analyzed here, but their focus is not specifically on the green bond market. They focus on the impact on asset prices of the inclusion of lower-graded bonds in the pool of eligible collateral for the PBoC's Medium Term Lending Facility. They present empirical evidence for the causal impact of the reform on the secondary bond market. By exploiting the fragmented nature of China's bond markets, with a dual-listing of similar bonds in two segmented markets, they use a triple-difference empirical design to assess the impact of the policy shift on the prices of the newly collateralizable bonds, using a series of indicators to construct bond issuer controls. They find that the policy reduced the spreads of these bonds to China Bond Government Bond (CGB) of the same term to maturity by 42-62 basis points on the secondary market (in line with our findings of 46bps spread increase between green bonds and similar non-green bonds). They also find that there is a pass-through effect to the primary market with a reduction in spreads at issuance by 53.8 basis points (ca. 100% pass through), thus a positive impact on the real economy.

They single out the different types of bonds from the overall pool: they find that *Xiaowei* (small and micro-firms) bonds seem to have experienced a particularly large spread reduction after the policy shock (additional 47.6 bps), while their estimates for the Green and *Sannong* (agricultural) bonds are quite noisy. On the primary market, they find that the Green and *Sannong* bonds see a significant decrease in spreads. Our approach differs from theirs in that we match bonds under review with non-green bonds with similar characteristics and issued by the same firm. Our approach largely refines the bond issuer controls and allows for more precise estimates when it comes to the analysis of green bonds.

Also looking at the Chinese market, Chen et al. (2019) analyse a policy change in 2014 when AA+ and AA bonds were excluded from the list of securities eligible as repo collateral. They find that the change in policy led to an increase in yields of excluded bonds between 40 to 83 basis points. Their study is essentially looking at the inverse situation of what we analyse here, namely an exclusion when we study an inclusion.

Wang and Xu (2019) study the impact on the primary bond market issuance price of a change in collateral accepted by the China Central Depository & Clearing Co (CCDC), a public central depository for Chinese government bonds. Before April 2017, the CCDC accepted AA rated bonds, which were no longer accepted after the reform. The change penalized AA rated bonds by 60-70 basis points.

Dikau and Volz (2021) argue that Chinese monetary authorities were pioneer in green finance. They show that the PBoC and the China Banking Regulatory

Commission (CBRC) used window guidance to encourage financial institutions to expand credit to sustainable activities. Cui et al. (2018) study a dataset of 24 Chinese banks that adding more green loans to bank's portfolio reduces the non-performing loan ration. Wang et al. (2020) document the existence of a greenium on Chinese debt and stock markets.

The contribution of this paper is to focus specifically on the impact of the policy change on green bonds, which can inform current policy choices in countries looking at ways to make their monetary policy more compatible with the Paris agreement.

We retrieve daily yields data for green and non-green bonds, pairing them by issuer. Using a difference-in-differences approach, we analyze whether the reform had a significant impact on the spread between the bond yields of each pair.

Institutional background – the PBoC reform of 2018

China is the world's biggest producer of greenhouse gases, with 28% of *worldwide* carbon dioxide emissions in 2018 according to the Energy Information Administration (EIA).[8] In September 2020, China's president Xi Jinping announced the country would be carbon neutral, meaning that it would cut its net carbon dioxide emissions to nearly zero, by 2060. This pledge would imply a dramatic reshaping of the Chinese energy consumption model, considering the fact that coal is still by large the main energy source (57.7% of total energy consumption in 2019). China's extremely rapid development over the last few decades has been at the expense of environmental issues. The current high level of pollution has major implications for public health. The Chinese authorities say they have become aware of the urgency of the situation. They have made the energy transition a key objective of the development strategy and have enshrined the concept of "ecological civilization" in the constitution in 2018. Achieving market neutrality in 2060 means that China will need to transition from peak in 2030 in only 30 years. This is much faster than other countries like Japan or the EU, and remains a huge challenge.

Concrete action in supporting the development of green finance through official guidelines dates back a decade (Aizawa and Yang 2010). China's government, banking regulator, and central bank have issued guidelines in 2012 to accelerate green lending and green bond issuance. In 2015, the PBoC released a taxonomy for projects eligible for green financing in the *Green Bond Endorsed Project Catalogue.* The introduction of taxonomies improved market integrity and led to a surge in green bond emissions in the country. In 2016, several ministerial agencies including the PBoC and the Ministry of Finance jointly released the *Guidelines for Establishing the Green Financial System*. This marked the start of structural reforms aiming to promote green finance in the country.

This new framework led to rapid development of green finance in the country. The first Chinese green bond was issued in 2015 (Volz 2018). The green bond market then expanded rapidly. With a USD 31.3bn emission of green bonds aligned with international standards in 2019, China accounted for 12% of the global market, ranking second after the US (20% of the total market), and closely followed by France. In addition, China's domestic green bond market includes securities that are not aligned with international standards but compliant with the local regulation (e.g. "clean coal" projects). In 2019, total issuance of such bonds amounted to

[8] https://www.iea.org/data-and-statistics

approximately USD25bn. This trend takes place in the context of a broader reform aiming at reinforcing domestic markets' attractiveness for international investors through broader openness and increased sophistication (Aglietta and Macaire 2019).

To support the green bond market, the PBoC expanded the pool of collateral eligible to borrow from its Medium Term Loan Facility (MLF) on 1 June 2018. Understanding the impact of this reform is the focus of this paper. This decision was the first time that monetary policy was directly used to promote green finance in the country. We build on the findings of the BIS's Committee on the Global Financial System Markets Committee (BIS 2015). The report shows that central bank operations on collateral markets can influence those markets through scarcity effects and structural effects. These choices have been in some cases used deliberately to support the functioning of those collateral markets.

The 2018 institutional change

On 1 June 2018, the PBoC expanded the pool of eligible collateral to borrow from its Medium-Term Lending Facility (MLF). The PBoC had launched the MLF in 2014. The scheme offers 3-, 6- and 12-month lending to financial institutions. Outstanding lending lines through the MLF accounted as of September 2020 for 52% of the PBoC's lending facilities to Chinese banks.

The 2018 reform was a broad reform of monetary policy (see Fang, Wang, and Wu 2020 for the broader context). Here we focus on two main aspects of this reform, the inclusion of green financial bonds into the pool of eligible collateral and their preferential status. Table 1 offers a summary of all the changes, which occurred to financial bonds during that time.[9]

As detailed in the introduction, the PBoC enlarged the pool of assets accepted as collateral to include financial green bonds, financial bonds issued to finance small and micro enterprises (*Xiaowei* bonds) and financial bonds issued to finance agricultural corporations (*Sannong* bonds). Moreover, the PBoC granted a first-among-equals status to green and SME financial bonds.[10]

Table 1 – 2018 institutional changes by asset classes

	Before June 2018	After June 2018
Green financial bonds (AAA, AA+ and AA)	Not accepted	Accepted and first-among equals status
Small and micro enterprises financial bonds (AAA, AA+ and AA)	Not accepted	Accepted
Agricultural bonds (AAA, AA+ and AA)	Not accepted	Accepted
All other financial bonds (AAA, AA+ and AA)	Not accepted	Not accepted

[9] Note that corporate bonds also underwent a reform, and AA and AA+ corporate bonds were also included in the list of eligible collaterals for the MLF facility. Prior to the reform, the MLF operations accepted government securities, central bank bills, China Development Bank bonds, policy financial bonds, local government debts, AAA-rated corporate bonds as collaterals.

[10] http://www.pbc.gov.cn/en/3688110/3688172/4048314/3711516/index.html

Chinese green and non-green financial bonds data

We use market data on Chinese bonds yields gathered from Bloomberg to study the impact of the policy change. We first select bonds that present the following characteristics: green-labelled, with above AA credit rating, issued by financial institutions, and for which the issue date was before 1/6/2017, and the maturity date after 31/5/2019 (hence, 6 months before the beginning and after the end of our timeframe, respectively) to avoid disturbances linked to the beginning and the end of a bond lifespan. Due to the narrowness and lack of liquidity of the market for green bond at the time of the reform, data limitation is strong and we are much constrained in the choice of securities. On the exhaustive list of 26 bonds featured in the Bloomberg database and matching those criteria, 11 only present exploitable data series.[11] Many bonds do not have available data since they were acquired at the time of their issuance, and never or very rarely traded on the market. This is linked to the fact that the major investors in the bond market in China are banks, which mostly have a buy-and-hold attitude. We chose to construct pairs of green and non-green bonds issued by the same firm. This methodology allows us to accurately incorporate company-specific characteristics (size, sector of activity) without having to add additional control variables.

As our identification relies on using firm fixed effects, we chose to exclude one green bond time series for which no non-green bond issued by the same institution can be found (but adding or removing this bond does not change our results). For the remaining 10 green bonds, we select non-green bonds issued by the same financial institutions, and with the closest matching characteristics (rating, coupon type, maturity etc.) to serve as a control group.

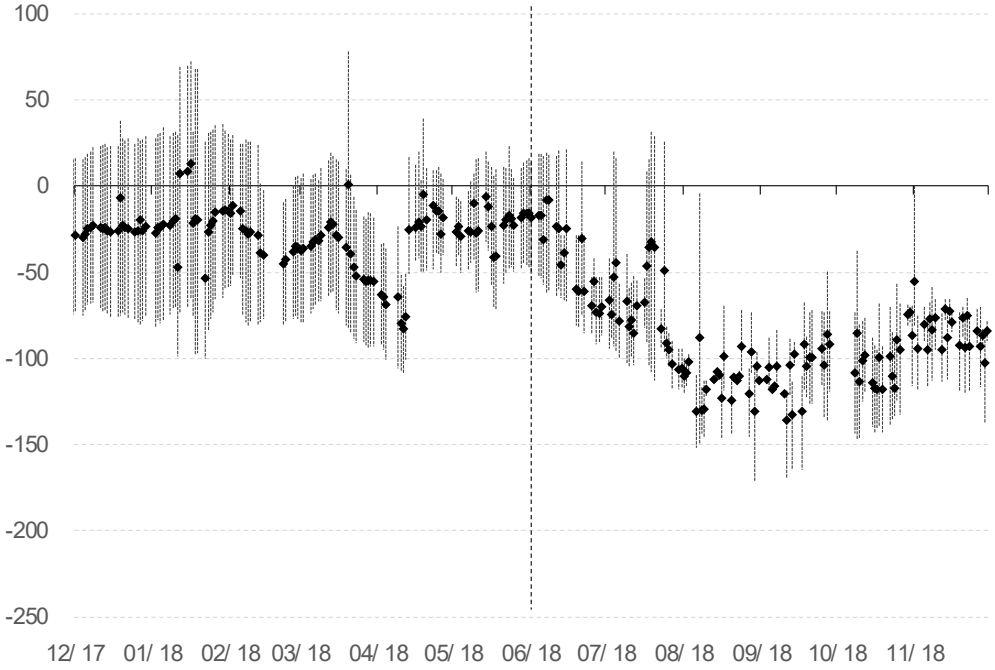
Our dataset is composed of yield series for 10 green and 8 non-green bonds, issued by 7 different financial institutions (Table 3 in the appendix shows the main characteristics of all the selected bonds). Data limitation and narrowness of the whole universe of securities presenting our search criteria do not allow for perfect matching. For example, the average residual maturity of all green bonds is 3.2 years, while the average residual maturity of matching non-green bonds is 7.6 years. This might cause a bias.

Our dataset is composed of 2609 observations over a total period of one year, or 261 workdays (01/12/2017 to 30/11/2018), six months before the reform and six after. We chose this timeframe as green bonds were virtually non-existent before 2016 and the market only really develops in 2017.

Figure 1 shows the difference in yield by green and non-green bonds issued by the same companies; we observe an increase in the differential after 1 June 2018.

[11] Series that we removed either presented insufficient number of data points, were extremely nonlinear or flat, suggesting that they did not reflect real market prices.

Figure 1 – Spread of non-green vs green bond yield, in basis points



Note: The perpendicular dotted line shows the policy change on 1 June 2018. The graph covers the period 01/12/2017 to 30/11/2018. Each point represents the average spread between green and non-green bonds from the same issuer. The vertical whisk around the point represents the min-max interval for each green and non-green pair of bonds.

What was the impact of the policy?

Our main identification uses a difference-in-differences approach. We have a large pre- and post-period (6 months, respectively), which shows the effect of the policy within a broader context. This yields results that are more robust and unlikely to misrepresent a temporary feature of the data, as a simple two periods difference-in-differences might.

To allow for perfect comparison between the treated and control groups, we compare bonds from the same financial institutions. This means that both groups would react similarly to any company specific news, such as for example an increase default risk after the announcement of a large loss. News regarding the company will affect both green and non-green bonds similarly. This means that the intrinsic default risk is the same for the green and non-green bonds compared. Doing so we control for firm-level factors. More specifically, the main difference between these bonds is their green status; the difference-in-differences setting therefore captures the change in the spread between green and non-green after the policy.

Scholars have traditionally used difference-in-differences methods with only two set of observations, one before the treatment and one after. Egami and Yamauchi (2019) discuss how longer time series also fit difference-in-differences designs. Callaway and Sant'Anna (2019) also offer identifications for difference-in-differences with multiple time periods. Here we offer not only multiple pre-treatment periods but also multiple post-treatment periods to have a broader overview of the impact of the

policy and its lasting effect. First we run the difference-in-differences dividing the data in a pre- and post- group, before fine tuning our approach in different time periods.

We focus on pairs of green and non-green financial bonds. Our model is as follows:

$$Y_{it} = \alpha + \beta_1 T_i + \beta_2 P_t + \beta_3 (T_i \times P_t) + \gamma FE + \varepsilon_{it}$$

where Y_{it} is the yield of bond i, at time t. T_i is a treatment dummy taking the value 1 for all *green* bonds (affected by the policy) and 0 for all *non-green* bonds. P_t is a treatment dummy taking the value 1 after the policy change, 0 before, γFE are company fixed effects. β_3 is the coefficient of interest measuring the impact of the policy of the PBoC on the treated group. Table 2 presents the results of the difference-in-differences estimation.

Our results show that the policy had a significant impact on the path of green vs. non-green bond yields, and that it reduced the yield of green bonds by 46 basis points over non-green bonds on average. The next section takes a more detailed approach dividing the sample into weekly, monthly and quarterly observations and showing the difference is not due to pre-trends. We also show the lasting effects of the reform.

Table 2

Dependent variable: Bond yields	
Intercept	4.45*** (0.024)
Treated dummy	-0.32** (0.11)
Post dummy	-0.41** (0.19)
Treated x Post	-0.46** (0.19)
Company fixed effects	YES
Adjusted R^2	0.69
Observations	2609

Standard errors rare clustered at the bond level.[12] *** signifies statistically significant at the 1% level of significance; ** at the 5% level of significance; * at the 10% level of significance.

Adding pre- and post-trends and counterfactual policy changes

The part above showed that there is evidence that the reform implemented on June 1 2018 had a significant impact on the treated green bonds, compared to non-treated non-green bonds. Now, we use multiple time periods to generate a counterfactual policy change. We sequence our dataset by quarters, months and weeks. We then conduct a difference-in-differences between the time period preceding the policy change and each of the other time periods separately, as if they had each experienced the change in policy. In a sense, for periods prior to the policy change, the check act as a placebo test and allows us to examine the parallel trend assumption. For each periods after the policy change, it gives a view of the timeliness and persistency of the shock.

[12] Note that clustering at the green/non-green level yield similar results. Using a non-clustered Newey-West standard errors yield results significant at 1%.

We estimate the following specification:

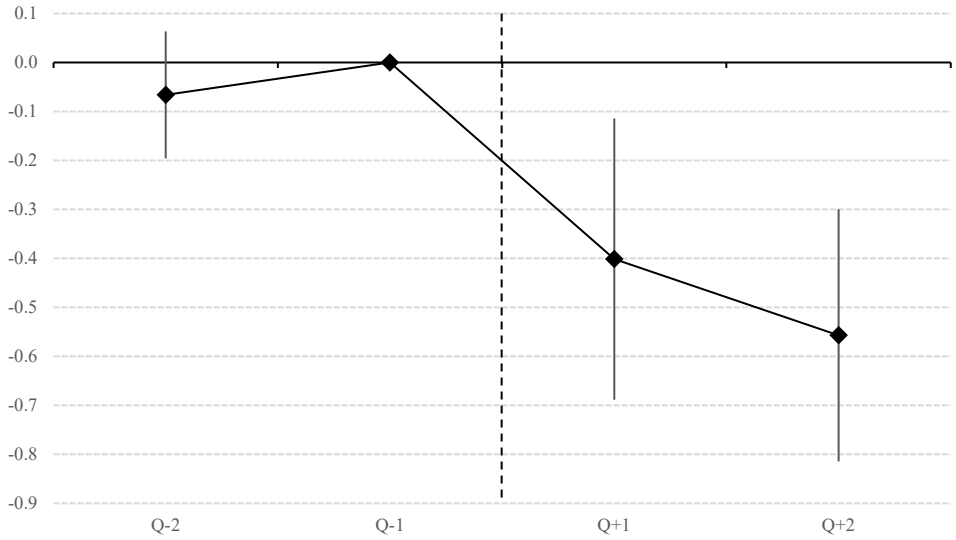
$$Y_{it} = \alpha + \beta'_1 T_i + \beta'_2 Test_{t'} + \beta'_3 (T_i \times Test_{t'}) + \gamma' FE + \varepsilon_{it'}$$

where Y_{it} are the yields of bond i, at time t, i.e. either during the period prior to the change (the reference period), or the tested time period. T_i is a Treatment dummy taking the value 1 for all green bonds (affected by the policy) and 0 for all non-green bonds. $Test_t$ is a treatment dummy taking the value 0 during the reference time period, and 1 during the tested time period, $\gamma' FE$ are company fixed effects. β'_3 is the coefficient of interest here measuring the impact of the policy of the PBoC on the treated group.

Figures 2 to 4 shows the estimated values of the treatment factors β'_3 for each period, on a quarterly, monthly and weekly frequency. They show that, prior to the policy shock, β'_3 are smaller and tend to be statistically insignificant (see the left side of Figure 3 and 4), especially for the time periods more closely preceding the reference period. During these periods, the difference between green and non-green bonds are not statistically different from what they are just before the reform. This means that the trends in green and non-green bonds' yields before the reform tend to be similar. This is less marked (see the very left of Figure 2 and 3) when testing earlier time periods, yet the factors tend to be lower than the value just before the reform, meaning that from the start of the timeframe up until 5 months before the reform, the spread between green and non-green bonds (the greemium) tend to decrease.

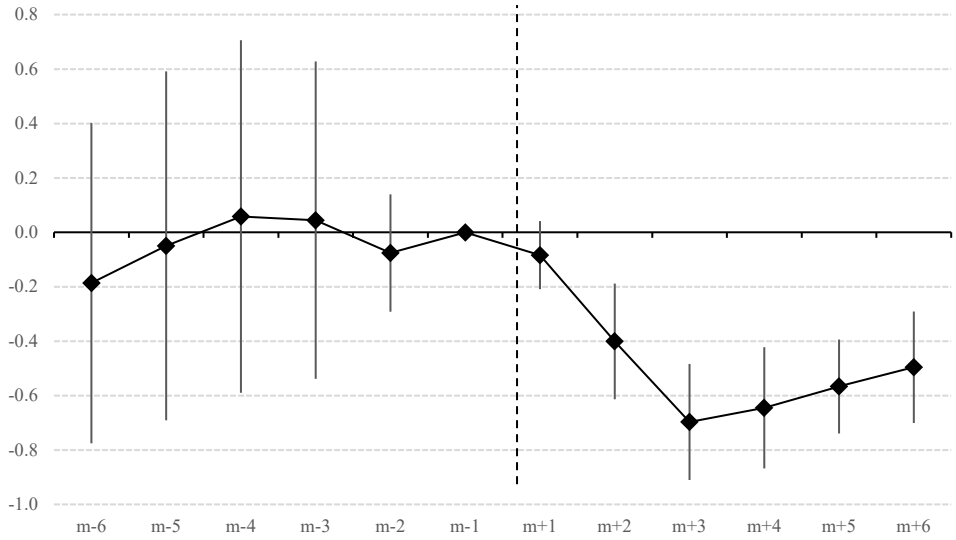
After the policy shock, yields of the green bonds are significantly reduced compared to non-green bonds. The policy reform therefore reversed a potential ongoing trend of homogenization of green and non-green bonds, clearly reducing yield of green bonds, all other things equal. The graphs show that the impact is almost immediate. The weekly analysis in Figure 4 shows that there might be around three weeks delay in the materialization of the impact. The effect is persistent throughout the timeframe analysed. Looking at Figure 1, it also looks there were no anticipation effects. The chart shows no movement before the reform.

Figure 2 – Dynamic effect, quarterly basis



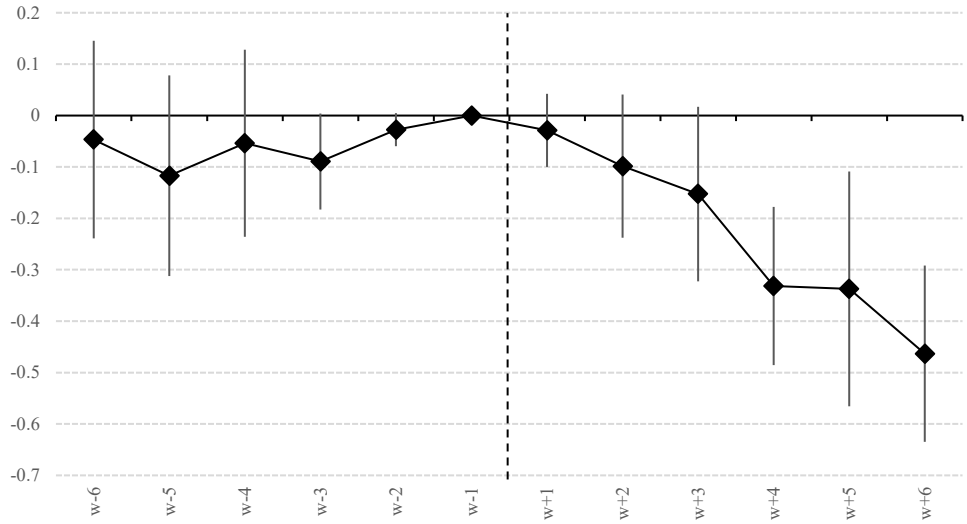
Note: The perpendicular dotted line shows the policy change on 1 June 2018. The graph covers the period 01/12/2017 to 30/11/2018, hence 4 quarters. The 01/06/2018 shocks occurs in the beginning of Q+1. Each point represents the coefficient of DID conducted between Q-1 and the specific quarter. The vertical whisk around the point is the 95% confidence interval.

Figure 3 – Dynamic effect, monthly basis



Note: The perpendicular dotted line shows the policy change on 1 June 2018. The graph covers the period 01/12/2017 to 30/11/2018, hence 12 months. The 01/06/2018 shocks occurs in the beginning of m+1. Each point represents the coefficient of DID conducted between m-1 and the specific month. The vertical whisk around the point is the 95% confidence interval.

Figure 4 – Dynamic effect, weekly basis



Note: The perpendicular dotted line shows the policy change on 1 June 2018. The graph covers the period 23/04/2018 to 13/07/2018, hence 12 weeks. The 01/06/2018 shocks occurs in in the beginning of w+1. Each point represents the coefficient of DID conducted between w-1 and the specific week. The vertical whisk around the point is the 95% confidence interval.

Our findings provide an insight into how central bank collateral policy can significantly influence specific financial assets and thus pursue targeted objectives. In particular, China has had a pioneering attitude towards green finance and our results show encouraging ways in which central banks can support this market segment. Yet, some caveats apply. First, green finance is only as good as the green taxonomy underlying it and in this paper we refrain from evaluating the green taxonomy in China and take it as a given. Since there is no standardized framework for identifying green assets globally, distinct definitions arose globally, which brings limitation to the study of one national market (Gilchrist, Yu, and Zhong 2021). Issues of greenwashing could make these policies less effective (Jones et al. 2020). Then, the reform forms part of a more comprehensive strategy to support green financing in the country, and its impact might have been amplified by a supportive environment.

Another shortcoming of our study is that it happened in the midst of a trade war between China and the US. It is unlikely that the trade war would have affected green over non green bonds at the exact time of the reform by this order of magnitude. Yet, it is not impossible that the trade war could have had heterogeneous effects affecting our results.

Lastly, improved financing of green bonds cannot mitigate the drastic effects of climate change, as green bonds only represent an extremely small proportion of outstanding bonds. Sure, measures as the one presented here can potentially favor green bonds emissions but, alone, they might not be sufficient to mitigate the devastating effects of climate change. Other measures by governments such as an international carbon tax are needed. Central banks can also undertake additional measures related to non-green assets, such as asset reallocation out of the most polluting assets (Naef 2020) or when possible more activism in asset ownership based on the example of the Norges Bank (van 't Klooster and Naef 2021).

Conclusion

In this paper, we show how the PBoC lowered yields of green-labelled financial bonds compared to similar non-green bonds by including them as favoured tools for collateral policy. Using a difference-in-differences approach, we find that the policy had significant and persistent effects over several months. Specifically, the reform lowered the yield differential between green and non-green financial bonds by 46 basis points after the policy when compared to before.

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Appendix

Data description: Main characteristics of observed bonds

Table 3 – bonds analysed

Issuer name	Green status	Local Credit Rating	Issue Date	Maturity	Coupon type	Curr.	Amount Issued kCNY	Exchange Market	Security Name
Bank of Qingdao	G	AAA	14/03/2016	14/03/2021	fixed	CNY	500	Interbank	QDBANK 3.4 03/14/21
Bank of Qingdao	NG	AA+	14/07/2017	14/07/2027	fixed	CNY	2 000	Interbank	QDBANK 5 07/14/27
Bank of Qingdao	G	AAA	24/11/2016	24/11/2021	fixed	CNY	1 000	Interbank	QDBANK 3.4 11/24/21
Jiangxi Bank	G	AAA	08/08/2016	08/08/2021	fixed	CNY	1 500	Interbank	NANCHB 3.48 08/08/21
Jiangxi Bank	NG	AA+	28/09/2017	28/09/2027	fixed	CNY	3 000	Interbank	NANCHB 5 09/28/27
Jiangxi Bank	G	AAA	17/07/2016	14/07/2021	fixed	CNY	1 500	Interbank	NANCHB 3.7 07/14/21
Jiangxi Bank	NG	AA+	07/06/2017	07/06/2027	fixed	CNY	3 000	Interbank	NANCHB 5 06/07/27
Sh. Pudong Dev. Bank	G	AAA	18/07/2016	18/07/2021	fixed	CNY	15 000	Interbank	SHANPU 3.4 07/18/21
Sh. Pudong Dev. Bank	NG	AAA	28/12/2012	28/12/2027	fixed	CNY	12 000	Interbank	SHANPU 5.2 12/28/27
Bank of Beijing	G	AAA	17/04/2017	17/04/2022	fixed	CNY	3 000	Interbank	BOBJ 4.5 04/19/22
Bank of Beijing	NG	AA+	18/01/2011	18/01/2026	fixed	CNY	3 500	Interbank	BOBJ 4.9 01/18/26
Bank of Nanjing	G	AAA	27/04/2017	27/04/2022	fixed	CNY	1 000	Interbank	NANJBK 4.6 04/27/22
Bank of Nanjing	NG	AAA	17/11/2016	17/11/2021	fixed	CNY	10 000	Interbank	NANJBK 3.45 11/17/21
Bank of Comm.	G	AAA	22/11/2016	22/11/2021	fixed	CNY	20 000	Interbank	BOCOM 3.25 11/22/21
Bank of Comm.	NG	AAA	22/12/2015	22/12/2022	fixed	CNY	30 000	Interbank	BOCOM 3.45 12/22/20
Industrial Bank	G	AAA	17/11/2006	17/11/2021	fixed	CNY	20 000	Interbank	INDUBK 3.4 11/17/2021
Industrial Bank	NG	AAA	13/04/2016	13/04/2026	fixed	CNY	30 000	Interbank	INDUBK 3.74 04/13/2026
Industrial Bank	G	AAA	18/07/2016	18/07/2019	fixed	CNY	20 000	Interbank	INDUBK 3.2 07/18/2019

Source: Bloomberg

Data limitations: bond selection process

Table 4

Restriction	**Number of bonds**
Chinese bonds issued in RMB	282'960
And with an issue date priori to June 2017	86'306
And a maturity date later than November 2019	17'538
And with a rating higher than AA	10'922
And which are financial bonds	368
And which are green bonds	26

The list of bonds presented here are an exhaustive list of bonds available within our selection criteria. The reform we study only concerns financial green bonds with at least a rating of AA. We selected only bonds issued before our period of interest and with enough remaining maturity. This is to avoid abnormal fluctuation. Loosening these last criteria by several months does not increase the number of bonds. Our sample is as exhaustive as can be, within the specifications of the paper. Out of the 26 green bonds available, only 10 offered exploitable market data. Some were not traded at all. Others offer only very infrequent market prices. Finally some were completely flat and offered no variation at all. They were all not exploitable.

Data description: Main characteristics of observed issuing institution

Table 5

Name	Bank type (main activity)	Ownership	Equity listing	Largest shareholder
Bank of Qingdao	Retail bank	Private and public	Listed in Mainland China and Hong Kong	Qingdao Conson Development group (9% of Mainland China shares)
Jiangxi Bank	Commercial bank	Private and public	Listed in Mainland China and Hong Kong	Huan Fund management and co LTD (17.06% of Hong Kong shares)
Shanghai Pudong Development Bank	Commercial bank	Private and public	Listed in Mainland China, Singapore and London	Shanghai International group (21.57% of Mainland China shares)
Bank of Beijing	Commercial bank	Private and public	Listed in Mainland China only	ING Groep NV (13.03% of Mainland China shares)
Bank of Nanjing	Commercial bank	Private and public	Listed in Mainland China only	BNP Paribas (13.92% of Mainland China shares)
Industrial Bank	Retail bank	Private and public	Listed in Mainland China and Hong Kong	Fujian Province Finance Bureau (18.78% of Mainland China shares)

Source: Bloomberg

Robustness check – regression on AAA bonds only

To verify whether the integration into the dataframe of AA+ bonds might include a significant biais, we conduct the same regression with groups of firms for which we have both green and non-green AAA bond yields series. Results are broadly similar.

Table 6

Dependent variable: Bond yields	
Intercept	4.86*** (0.025)
Treated dummy	-0.15*** (0.047)
Post dummy	-0.43*** (0.029)
Treated x Post	-0.48*** (0.047)
Company fixed effects	YES
Adjusted R^2	0.71
Observations	881

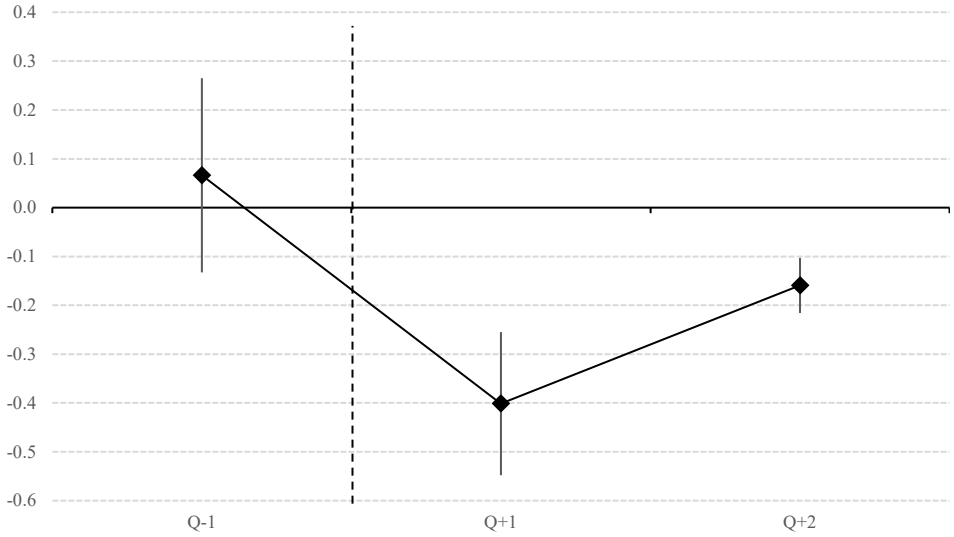
*** signifies statistically significant at the 1% level of significance; ** at the 5% level of significance; * at the 10% level of significance.

Robustness check – counterfactual reforms

We presented a difference-in-differences approach where we compared each period with the periods before the reform (or t-1). Here we compare each period with the previous one. This acts as a counterfactual, as if the reform occurred between each period. The ideal result would be to show that there is only a significant break before and after the reform, and in no other time period.

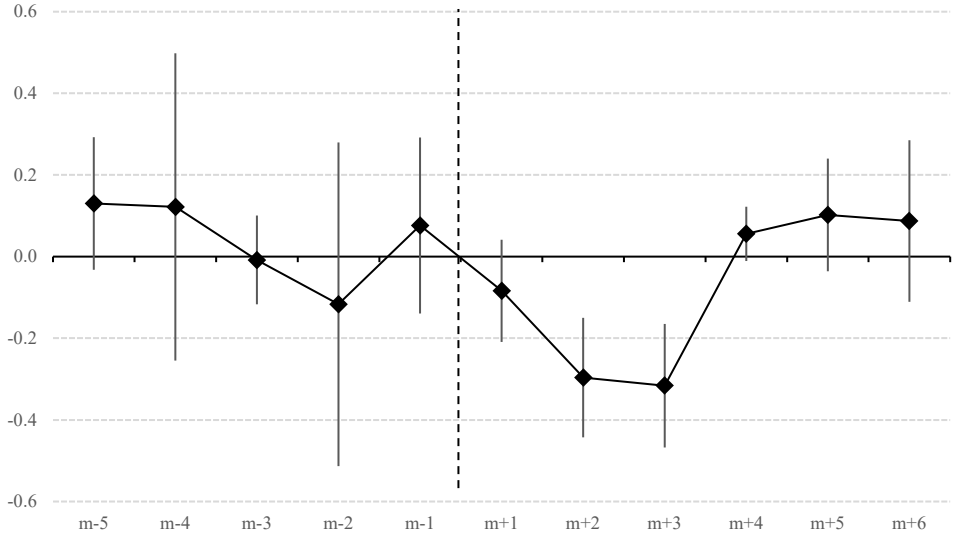
Figures 5 to 7 show the different coefficients over time. At the quarterly level in Figure 5, the largest drop is the period right after the reform, reinforcing our findings. At a monthly frequency (Figure 6), we can see the largest drops of the sample 2 and 3 month after the reform. At a weekly frequency (Figure 7), the data becomes noisier and shows less of a trend (when compared with Figure 4). What all three figures show is the clear absence of downward pre-trend, reinforcing that what happened in June 2018 at the time of the reform is not linked to previous trends in the data.

Figure 5 – Iterative effect, quarterly basis



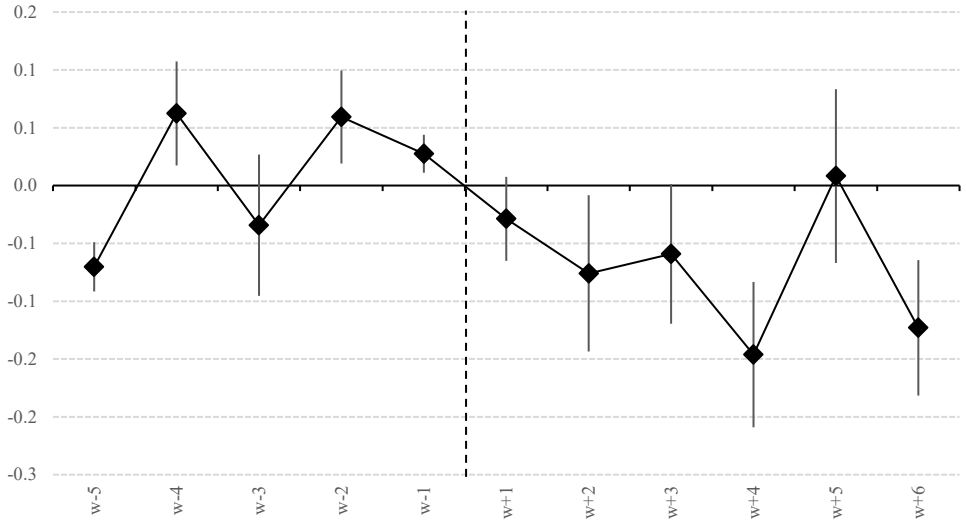
Note: The perpendicular dotted line shows the policy change on 1 June 2018. The graph covers the period 01/12/2017 to 30/11/2018, hence 4 quarters. The 01/06/2018 shocks occurs in the beginning of Q+1. Each point represents the coefficient of DID conducted between Q(t-1) and Q(t). The vertical whisk around the point is the 95% confidence interval.

Figure 6 – Iterative effect, monthly basis



Note: The perpendicular dotted line shows the policy change on 1 June 2018. The graph covers the period 01/12/2017 to 30/11/2018, hence 12 months. The 01/06/2018 shocks occurs in the beginning of m+1. Each point represents the coefficient of DID conducted between m(t-1) and m(t). The vertical whisk around the point is the 95% confidence interval.

Figure 7 – Iterative effect, weekly basis



Note: The perpendicular dotted line shows the policy change on 1 June 2018. The graph covers the period 23/04/2018 to 13/07/2018, hence 12 weeks. The 01/06/2018 shocks occurs in in the beginning of w0. Each point represents the coefficient of DID conducted between w(t-1) and w(t). The vertical whisk around the point is the 95% confidence interval.

Robustness check – Similar maturities and differential with government bonds

Because of the limited bonds to compare available, maturities and issues dates in Table 3 are not perfectly matched. This might introduce a bias in our results. To better match both the remaining maturity and issuance date, we run our exercise again. This time we match each bond with a government of equivalent maturity and with a similar issue date. Table 7 shows our matching as well as the difference of remaining maturity. We re-run the same regression than in Table 2. Table 8below shows the results. Using the difference with government bonds yields similar results. The point estimate is slightly lower.

Table 7

Matching bond identifier	Government bond issue date	Government bond maturity	Remaining maturity difference in days	Issue Date	Maturity	Bond analysed
JK712524	04/07/2016	04/07/2021	112	14/03/2016	14/03/2021	QDBANK 3.4 03/14/21
AO5171597	03/08/2017	03/08/2027	20	14/07/2017	14/07/2027	QDBANK 5 07/14/27
AL5500353	12/12/2016	12/12/2021	18	24/11/2016	24/11/2021	QDBANK 3.4 11/24/21
LW7656413	14/07/2016	14/07/2021	-25	08/08/2016	08/08/2021	NANCHB 3.48 08/08/21
AO5171597	03/08/2017	03/08/2027	-56	28/09/2017	28/09/2027	NANCHB 5 09/28/27
LW7656413	14/07/2016	14/07/2021	0	17/07/2016	14/07/2021	NANCHB 3.7 07/14/21
AN3476131	04/05/2017	04/05/2027	-34	07/06/2017	07/06/2027	NANCHB 5 06/07/27
LW7656413	14/07/2016	14/07/2021	-4	18/07/2016	18/07/2021	SHANPU 3.4 07/18/21
EJ713183	27/06/2013	27/06/2028	182	28/12/2012	28/12/2027	SHANPU 5.2 12/28/27
AN153582	13/04/2017	13/04/2022	-4	17/04/2017	17/04/2022	BOBJ 4.5 04/19/22
QJ892208	30/11/2015	30/11/2025	-49	18/01/2011	18/01/2026	BOBJ 4.9 01/18/26
AN153582	13/04/2017	13/04/2022	-14	27/04/2017	27/04/2022	NANJBK 4.6 04/27/22
AL5500353	12/12/2016	12/12/2021	25	17/11/2016	17/11/2021	NANJBK 3.45 11/17/21
AL5500353	12/12/2016	12/12/2021	20	22/11/2016	22/11/2021	BOCOM 3.25 11/22/21
QJ189862	22/10/2015	22/10/2022	-61	22/12/2015	22/12/2022	BOCOM 3.45 12/22/20
EF828393	15/11/2006	15/11/2021	-2	17/11/2006	17/11/2021	INDUBK 3.4 11/17/2021
JK9343183	05/05/2016	05/05/2026	22	13/04/2016	13/04/2026	INDUBK 3.74 04/13/2026
LW5458572	04/07/2016	04/07/2019	-14	18/07/2016	18/07/2019	INDUBK 3.2 07/18/2019

Table 8

Dependent variable: Bond yields (difference with matching government bonds)	
Intercept	0.51*** (0.023)
Treated dummy	-0.17*** (0.021)
Post dummy	-0.12*** (0.020)
Treated x Post	-0.31*** (0.026)
Company fixed effects	YES
Adjusted R^2	0.52
Observations	2615

*** signifies statistically significant at the 1% level of significance; ** at the 5% level of significance; * at the 10% level of significance.

Greening Monetary Policy: Evidence from the People's Bank of China

14-15 September 2021

International Conference on Statistics for Sustainable Finance

Camille Macaire
Alain Naef

The views expressed in this paper do not represent the opinion of the Banque de France or the Eurosystem.

Questions of "Green" Monetary Policy

- There are debates on the relevance of market neutrality when it comes to address "market failures" such as climate change (Schnabel, 2020)

- Christine Lagarde (2020):

  "In the face of what I call the market failures, it is a question that we have to ask ourselves as to whether market neutrality should be the actual principle that drives our monetary policy portfolio management."

- Literature shows that the ECB verbal interventions have an impact on green bond yields (Giovanardi, Kaldorf, Radke and Wicking 2021) and that the current portfolio of the ECB is probably not aligned with the European Union's targets (Oustry, Erkan, Svartzman and Weber 2020).

Why should we care about China?

China has a pioneering attitude when it comes to green finance

- China is the world's biggest producer of greenhouse gases (28% of world total in 2020); **carbon neutrality in 2060** will require a dramatic reshaping of the energy consumption model

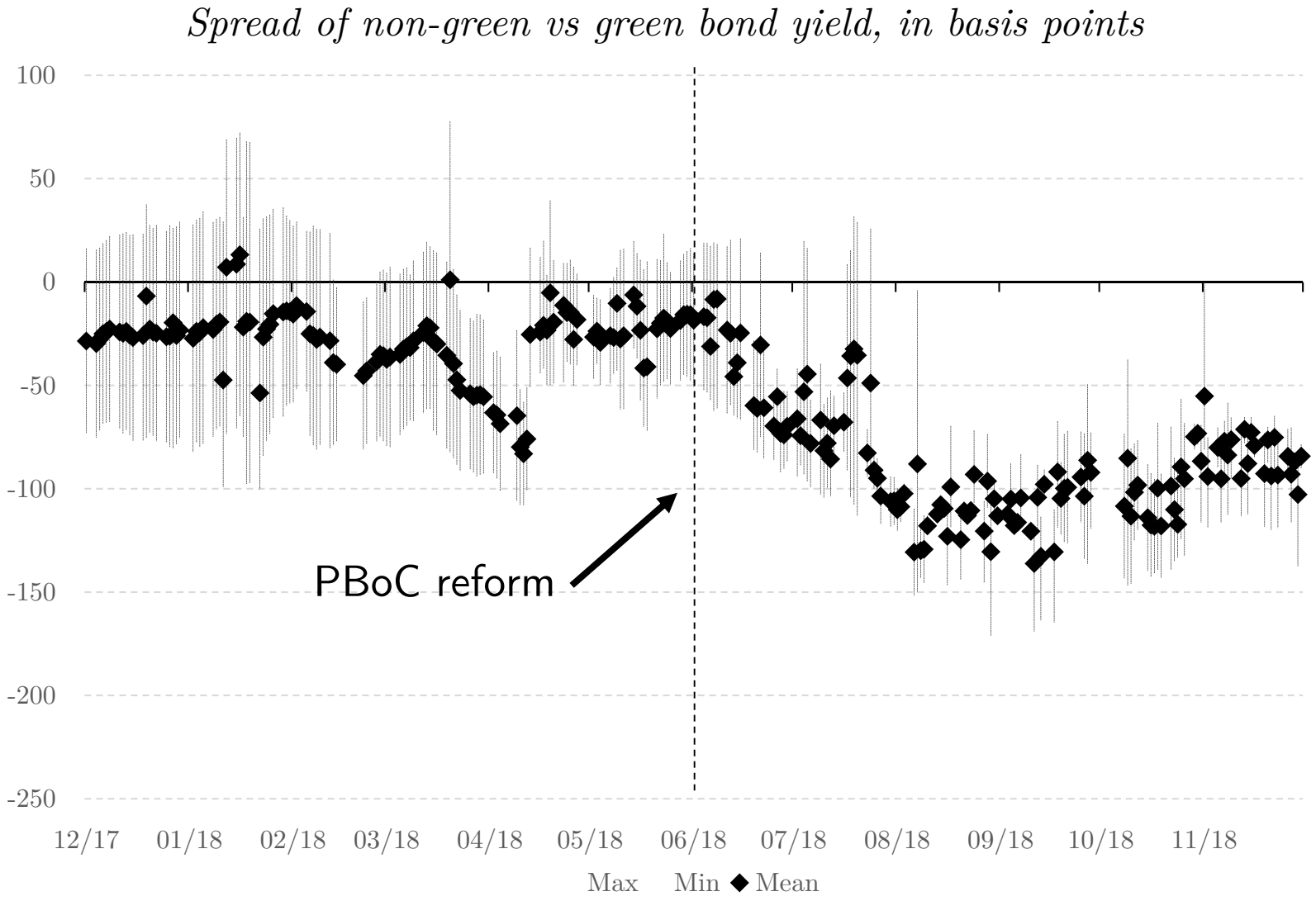
- Concrete action in supporting the development of green finance through official guidelines dates back a decade
  - Main breakthrough : **publication of Taxonomies in 2015** → led to more green bond emissions (China accounted for **12% of the global green bond emissions in 2019**, ranking second).

- **On 1st June 2018, the PBoC** changed its collateral policy and **started to accept green financial bonds** (bonds issued by banks)

Data overview

- Data for 10 green and 10 non-green bonds, for the 01/12/2017 to 30/11/2018 timeframe (retrieved from Bloomberg)
- 7 issuing firms, with both green and non green bonds for each firm, allowing to control for fixed firm effects
- The main difference is the green status (and to some extent maturities)

Raw data – green vs non-green yield differential 2017-18 (daily data)



Results over the whole sample

Dependent variable: Bond yields	
Intercept	4.45*** (0.024)
Treated dummy	-0.32** (0.11)
Post dummy	-0.41** (0.19)
Treated x Post	-0.46** (0.19)
Company fixed effects	YES
Adjusted R^2	0.69
Observations	2609

Standard errors rare clustered at the bond level. *** signifies statistically significant at the 1% level of significance; ** at the 5% level of significance; * at the 10% level of significance.

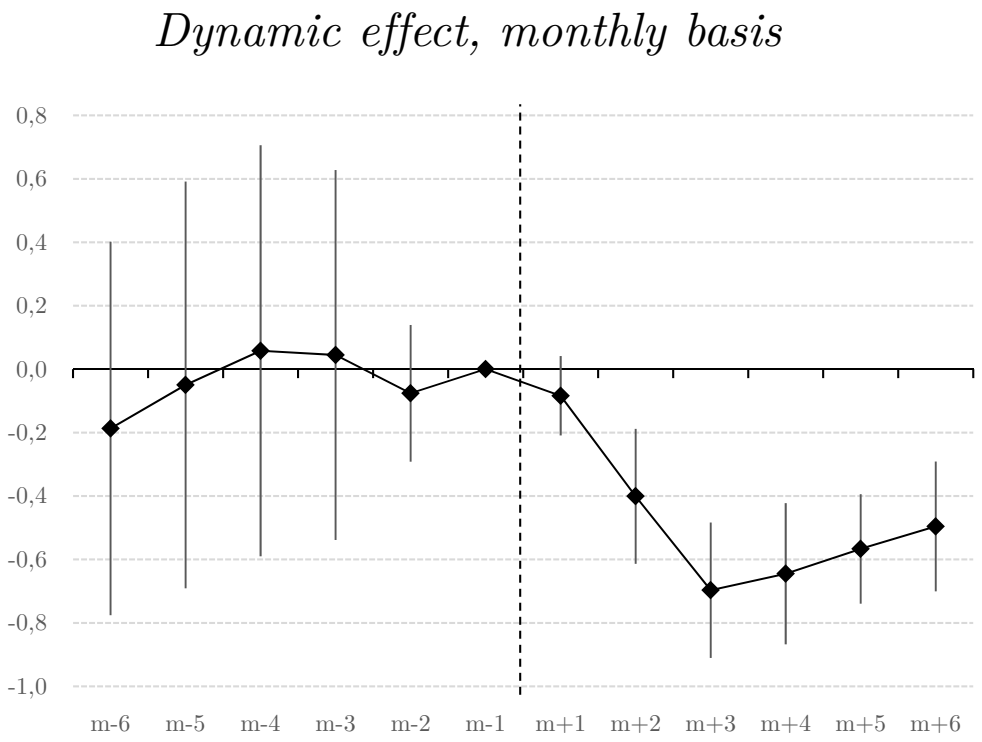
Using longer pre-trends in time series

- The part above showed that there is evidence that the reform implemented on June 1 2018 had a significant impact on the treated green bonds, compared to non-treated non-green bonds.
- Now, we use multiple time periods to generate a counterfactual policy change
- For periods prior to the policy change, the check act as a placebo test and allows us to examine the parallel trend assumption. For each periods after the policy change, it gives a view of the timeliness and persistency of the shock.

Previous DID $$Y_{it} = \alpha + \beta_1 T_i + \beta_2 P_t + \beta_3 (T_i \times P_t) + \gamma FE + \varepsilon_{it}$$

Counterfactual $$Y_{it} = \alpha + \beta'_1 T_i + \beta'_2 Test_{t'} + \beta'_3 (T_i \times Test_{t'}) + \gamma' FE + \varepsilon_{it'}$$

Monthly effect



Note: The perpendicular dotted line shows the policy change on 1 June 2018. The graph covers the period 01/12/2017 to 30/11/2018, hence 12 months. The 01/06/2018 shocks occurs in the beginning of m+1. Each point represents the coefficient of DID conducted between m-1 and the specific month. The vertical whisk around the point is the 95% confidence interval.

Policy implications and limitations

Policy Implications

- The PBoC was one of the first central banks to have a policy specifically targeting green bonds in 2018. Investigating the impact of the reform is an interesting case study for other central banks considering similar policies
- The reform happened in China as the green bond market was still nascent
  - Implications in terms of *Developmental Central Banking*
  - Also relevant for emerging countries

Limitations

- ECB already accepts green bonds so not applicable
- No measure of the effect on the real economy but see Giovanardi, Kaldorf, Radke and Wicking (2021) for a model on how this could impact the real economy

Conclusion

- We show that the policy by the PBoC reduced the spread between green bond and non green bond yields by **46 basis points on average**
- These findings can be interesting for other central banks considering similar policies, especially in emerging markets
- More research is needed to see if this impact on the secondary market also has an impact on the primary market, and on new green projects financed