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The impact of liquidity risk in the Chinese banking system on the global commodity markets[☆]

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ABSTRACT

We show that liquidity risk in the Chinese banking system, via the demand of commodities as collateral, affects commodity markets. Investors in China, to circumvent capital controls, import commodities, collateralize them, and use the loan proceeds to invest in domestic banking products. The Chinese banking system plays a crucial role in every step of this process. Thus, liquidity risk in the Chinese banking system may impact the demand of commodities as collateral. We find empirically that the liquidity risk affects excess returns and risk premium in commodity futures in Chinese and global markets. Our findings give new insights into commodity markets by unraveling their risk exposure to the Chinese interbank market due to the financialization of commodities.

1. Introduction

Commodity markets have become more financialized over the last two decades (Tang and Xiong, 2012; Singleton, 2013; Cheng et al., 2015; Henderson et al., 2014; Sockin and Xiong, 2015; Basak and Pavlova, 2016). In China, the financialization of commodities has been spurred by the collateral use of commodities, mostly via Chinese commodity financing deals (CCFDs). CCFDs are constructed by a series of financial transactions, including purchasing commodities offshore, obtaining a loan using the commodities as collateral, and investing the loan proceeds in domestic assets with relatively short duration such as CNY deposits and wealth management products (WMPs) (Yuan et al., 2014b). CCFDs can be highly attractive to Chinese investors because the deals enable them to take advantage of interest rate differentials between domestic and foreign markets while circumventing capital controls.

CCFDs create additional demand for commodities — demand for commodities as collateral, on top of the fundamental demand for production purposes. This additional demand from financing purposes is quite sizable. For example, the demand for copper as collateral is estimated to be approximately 5.7% of China's annual copper consumption (or 2.4% of the world's consumption) in

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2012 (Tang and Zhu, 2016). The magnitude of the collateral demand depends on the risk and return of CCFDs, which may end up impacting global commodity markets. Focusing on the return of CCFDs, Tang and Zhu (2016) show, theoretically and empirically, that CCFDs affected commodity spot prices. In this paper, we look at the risk affecting the CCFD demand, namely, the liquidity risk of the Chinese banking system.

We focus on the liquidity risk of the Chinese interbank market to show the impact of CCFDs on global commodity markets because liquidity in the Chinese banking system plays a crucial role in several steps of CCFDs. First, liquidity affects the extent to which commercial banks can issue loans to CCFD investors as liquidity shocks lead to credit crunches (Diamond and Rajan (2005), Ivashina and Scharfstein (2010), and Cornett et al. (2011), among others). Second, liquidity affects CNY loan and deposit rates, which in turn may impact the interest rate differential that CCFD investors try to exploit. Third, liquidity also affects the risk involved in WMPs, a popular domestic investment choice for CCFD investors who want to pursue higher returns (Elliott et al. (2015), Perry and Weltewitz (2015), Sun (2019), Chen et al. (2020), and Acharya et al. (2021)). WMPs face maturity mismatch problems because WMPs mature before their underlying assets. As main issuers of WMPs, commercial banks resolve these problems relying on the liquidity in the interbank money market. Hence, the interbank liquidity risk spills over to WMPs and then to CCFDs. Thus, for all these reasons, we hypothesize that liquidity conditions in the Chinese interbank market may affect the collateral demand for commodities and, consequently, global commodity markets.

To measure the liquidity risk, we use the spread between the 3-month and the overnight rates in the Chinese interbank money market. In turbulent markets, the overnight rate increases relative to the 3-month rate, narrowing the short-term spread (Acharya and Skeie (2011) and Acharya and Merrouche (2013)). Thus, a short-term spread can identify periods when liquidity is an issue and, thus, CCFDs become less attractive due to their increased risk.

Having constructed a measure for the interbank liquidity risk, we investigate the impact of the risk on commodity futures markets. Following the literature, we focus on futures markets over spot markets to avoid concerns about spot price availability, or spot markets' illiquidity (see Fama and French (1987), Tang and Xiong (2012), and Szymanowska et al. (2014)). More importantly, futures markets are essential to CCFDs, as investors need to hedge their commodity positions — hedging demand. Given that CCFD investors hold the commodities that are used as collateral, they hedge their positions by selling futures.[1] Hence, an increased amount of CCFDs should result in an increase in the hedging demand, ultimately affecting futures prices. Because the interbank liquidity risk can affect the attractiveness of CCFDs, we predict a relationship between this risk and futures prices.

We expect that when the interbank liquidity risk goes up, measured by a low spread in the interbank rates, CCFDs become less attractive due to their heightened risk. This leads to a decrease in the hedging demand, which translates to less short positions related to CCFDs in the futures market, resulting in higher futures prices. Hence, an increase in the Chinese interbank liquidity risk (a decrease in the interbank spread), everything else constant, should lead to an increase in contemporaneous commodity futures excess returns.

We empirically test the relationship between liquidity risk in the Chinese banking system and commodity futures excess returns for the period starting in October 2006 and ending in March 2016. We compute weekly futures excess returns for sixteen commodities that have active futures contracts in both developed countries (e.g., the United States, the United Kingdom, and Japan) and China. We then investigate how our measure of liquidity risk relates to the commodity futures excess returns in developed futures markets as well as in China.

We find strong supportive evidence that interbank liquidity risk affects commodity markets. First, we find that the weekly spread between the 3-month SHIBOR and the overnight SHIBOR is negatively correlated with the contemporaneous commodity futures excess returns in both developed and Chinese commodity markets as we expected. The effects are economically significant as an increase of one standard deviation of the weekly spread is associated, in the same week, with 0.25 percentage points lower excess returns in developed markets. Annually this corresponds to a decrease of 13.2 percentage points. For Chinese markets, the effect is 0.16 and 8.5 percentage points per week and per year, respectively. Our results hold when we control for macroeconomic conditions and the collateral demand proxy used in Tang and Zhu (2016). Interestingly, we discover interaction effects between our spread and the carry trade return used as a collateral demand proxy in Tang and Zhu (2016). We find that the Chinese banking risk impacts contemporaneous commodity futures excess returns more severely when the gains from trading CCFDs, as measured by the carry trade return, are low. Whereas in times when the potential gains are high, the impact of interbank liquidity risk disappears.

Following Tang and Zhu (2016), we distinguish between metal and nonmetal commodities. If liquidity in the Chinese banking system is affecting commodity markets through CCFDs, we should see a stronger effect on metal commodities because their physical characteristics are better suited to be collateral. For commodity markets in developed countries, we find a much stronger effect of our measure of risk on commodity futures excess returns for metal commodities than for nonmetal commodities.

Having provided supporting evidence of a contemporaneous relationship between interbank liquidity risk and commodity markets, we next investigate if there is also a predictive relationship. To be precise, we test if the weekly spread between the 3-month SHIBOR and the overnight SHIBOR in week t predicts excess returns in commodity futures markets for week $t + 1$. We indeed find that this spread predicts risk premium both in developed and Chinese futures commodity markets. We observe a lower risk premium following weeks of low risk. Moreover, as in the contemporaneous relation, we find that the impact of liquidity risk is paramount in weeks when the gains from trading CCFDs, as measured by the carry trade return, are low.

We conduct a series of robustness tests. First, we modify how we measure interbank liquidity risk in a way that allows us to disentangle the effect of risk and potential gains of CCFDs. Instead of using the spread between the 3-month SHIBOR and the

[1] As described with more detail in Section 3.1, CCFD investors might sell the commodities to the bank with an obligation to buy them back at a later stage instead of using commodities as standard collateral. In both cases, investors face commodity price risk and may want to hedge their positions in the futures market.

overnight SHIBOR as our risk measure, we regress this spread onto the carry trade return. We then measure liquidity risk as the sum of the regression intercept and residuals. Redoing the analysis with the new measure of liquidity risk leads to nearly identical results for both the contemporaneous and predictive relationships.

In our second robustness test, we again modify the way we measure the liquidity risk. We still use a spread of SHIBOR rate, but instead of benchmarking the overnight rate with the 3-month rate, we use the 6-month rate. We repeat the analysis with this new spread and the results for both the contemporaneous and predictive relations are consistent with our main analysis.

In our third robustness test, we modify the way we compute our dependent variable: commodity excess returns. In our main analysis, we compute futures excess returns using the nearest contract available. However, we do not know which contracts are being used to hedge commodity positions. Thus, as a robustness test, we repeat the analysis using the second nearest contract instead of the nearest one. We again do not find any significant differences from the main analysis and, thus, the results do not seem to be specific to the maturity of the contract used.

In our fourth robustness test, we change our regression specification for the predictive relation. In the main analysis, we regress excess returns onto our spread. However, if excess returns are persistent then the predictive results are just an extension of the contemporaneous relation. To address this concern, we perform a changes-on-changes regression and find that changes in our slope measure still predict changes in excess returns.

In our fifth and last robustness test, we show that the impact of our liquidity risk measure on the commodity futures risk premium is robust to various types of funding liquidity measures. We add an additional measure of general funding liquidity risk in the U.S., a longer-term Chinese interbank liquidity risk measure, and a general funding liquidity risk measure in China. Adding these extra liquidity proxies does not affect our main results for both the contemporaneous and predictive results in China and global commodity markets. Our risk measure seems to capture an impact on commodity markets that is orthogonal to known liquidity measures.

The rest of the paper is organized as follows. Section 2 reviews the related literature. Section 3 describes CCFDs and the connection to the Chinese banking system. Section 4 provides the details on our data — commodity futures excess returns, the risk measure, and our set of covariates. Section 5 then presents our main empirical results and robustness tests. Section 6 concludes the paper.

2. Related literature

Our paper relates to the recent literature on the financialization of commodities. Several papers have shown that the financialization of commodities has impacted commodity markets. For example, Tang and Xiong (2012) find that commodity markets have become less segmented as the popularity of investments in commodities indexes such as S&P GSCI and DJ-UBSCI have risen since 2004. Singleton (2013) provides evidence that changes in index investors' positions and managed-money spread positions are able to predict excess returns of crude oil futures. Henderson et al. (2014), using commodity-linked notes (CLNs) data, document that there are two channels by which CLNs affect the commodity futures returns: (i) the issuers' hedging demand for their commodity exposures, (ii) the extent to which they unwind positions at the end of their contracts. Theoretically, Basak and Pavlova (2016) provide a theoretical framework for the relationship between institutional investment flows into commodity indices and commodity futures markets. We add to this literature by providing evidence of another channel by which global commodity markets are affected by the financialization of commodities.

Closely related to our paper is Tang and Zhu (2016). Their paper is the first to study how CCFDs impact Chinese and global commodity markets. Due to capital controls and scarcity of high-quality collaterals, commodities are imported into China and used as collateral. Tang and Zhu (2016) show theoretically and empirically that this demand for commodities as collateral increases commodity spot prices. We add to the discussion by adding three important contributions. First, we consider the risk involved in CCFDs, which is absent in the theory of commodities as collateral in Tang and Zhu (2016). We look at the liquidity risk in the Chinese banking system as a new channel that affects the collateral and hedging demand for commodities. More importantly, we empirically show that this risk has a first-order impact on commodity markets. A second major contribution of our paper relative to Tang and Zhu (2016) is that we find both contemporaneous and predictive relationships between risk and commodity futures excess returns. Tang and Zhu (2016) provide evidence for a contemporaneous relation between demand for commodities as collateral and spot prices. Analogously, we show that there is a contemporaneous relationship between liquidity risk of the Chinese banking system and commodity futures excess returns. We then further show that the risk can predict commodity futures risk premia. As the third contribution, we provide new evidence that CCFDs connect the Chinese commercial banking sector and global/Chinese commodity futures markets. Our findings provide stronger evidence on the collateral use of commodities as a new channel for the financialization of commodity markets.

The liquidity risk of the Chinese banking system is relevant for CCFDs partly due to the WMP's maturity mismatch nature. Thus, our paper is also related to the strand of literature that looks into the impact of maturity mismatch problems in financial markets. Several previous studies about the 2007–2008 financial crisis suggest that the pervasive maturity mismatch in financial intermediaries' banking securities such as asset-backed commercial papers (ABCPs) was one of the main catalysts for the crisis (see Brunnermeier (2009), Kacperczyk and Schnabl (2010) and Covitz et al. (2013)). Acharya et al. (2011) and He and Xiong (2012) model how a small change in the asset value, when the debt market is made up of sequentially rolled over short-term debts, can originate a crisis. Interestingly, Brunnermeier and Oehmke (2013) focus on why financial institutions cling to the maturity structure of short-term financing and long-term investing in spite of maturity mismatch risk. Closer to our paper is Acharya et al. (2021) that studies the rollover risk in the Chinese banking sector and shows a relationship between rollover risk and interbank money market rates. Furthermore, they provide evidence that investors price the rollover risk in the stock price of commercial banks in China.

Our study extends greatly the scope of the impact of Chinese banking risk on financial markets by documenting an effect on global commodity markets.[2]

Our paper also provides new evidence for the relation between hedging demand and commodity futures risk premia. There is no consensus on the direction of the relationship. The theory of normal backwardation (see Keynes (1930), Hicks (1946), Stoll (1979), Carter et al. (1983), Chang (1985), Hirshleifer (1988, 1990), Bessembinder (1992), De Roon et al. (2000), Dewally et al. (2013), and Cheng et al. (2015), among others) argues that as the hedging demand from commodity producers increases so does the risk premium. The idea behind this is that speculative capital enables risk-sharing for hedgers who seek insurance against future price fluctuations. Under the assumption that the hedging demand for futures is net short, speculators demand a risk premium as they are exposed to price fluctuations. The empirical support for this Keynesian view is rather weak (see Rouwenhorst and Tang (2012) for a literature review), which sprouted other theories for the relationship between hedging demand and commodity futures risk premium. Cheng et al. (2015) and Kang et al. (2020) emphasize the importance of motives to trade that are distinct from insurance provision and argue that the relationship between hedging demand and futures risk premium does not need to be negative. The idea behind this is that in the short run, most of the hedging pressure can come from the liquidity needs of non-commercial traders instead of price insurance from commercial traders. This results in non-commercial traders' paying a liquidity provision premium to commercial traders instead of receiving a premium for providing insurance. In terms of futures risk premium, this then might result in lower premia compared to the theory of normal backwardation.

Ultimately, the sign of the relationship between hedging demand from CCFDs players and commodity futures risk premium is an open question. Hence, we use our setting to explore the question. When Chinese banking risk goes down, the amount of CCFD goes up and there is a higher need to hedge commodity positions. Under the theory of normal backwardation, higher hedging pressure should lead to higher commodity futures risk premia. However, in our setting, it is not commodity producers that are hedging, but CCFD players. Commodity producers have longer-term hedging demand schedules than CCFDs players. This is important as Kang et al. (2020) show that in the short-term period, the liquidity provision to commodity speculators dilutes the risk premium in the futures markets. Moreover, Cheng et al. (2015) and Kang et al. (2020) show that short-term high hedging pressure from commodity speculators leads to low commodity futures risk premium. The closest paper to ours, Tang and Zhu (2016) also explored the question and found no empirical relation between hedging demand from CCFDs players and futures risk premium. We do find that there is a negative relation and, thus, join the list of papers that fail to find empirical support for the Keynesian view.

3. Chinese Commodity financing deals and Chinese banking system

In this section, we discuss how changes in the conditions of the Chinese banking system can affect the global commodity markets. We first describe the institutional details of CCFDs to show how the Chinese banking system is involved in the making of CCFDs. Next, we elaborate on how liquidity risk of the Chinese banking system can affect the commodity demand for CCFDs and, more importantly, the demand for hedging against commodity price risk. This, in turn, impacts commodity futures prices in both Chinese and developed markets.

3.1. Chinese commodity financing deals (CCFDs)

There are many variations of CCFDs,[3] but for simplicity, we describe the standard conditions of such deals (for more details on CCFDs, see Layton et al. (2013) and Garvey and Shaw (2014)). The standard deal is sufficient to illustrate the financial attractiveness and risks of CCFDs as well as their connection to the Chinese banking system. Fig. 1 depicts the multiple transaction steps required for a typical CCFD, of which we give the details in the following.

A deal is initiated by an investor, usually a commodity importer in China, who contracts to import a commodity into China with an offshore commodity exporter. To guarantee the payment, the investor opens a letter of credit (LC) in US dollars at LIBOR plus spread for a 3–6 month period with an onshore bank. This letter is then issued to the offshore commodity exporter (Step 1). The offshore commodity exporter then sells the commodity by sending a commodity warrant to the investor (Step 2). This gives the owner the right to hold the commodity in a bonded warehouse. Note that this bonded warehouse is outside of the Chinese customs territory. In the standard case, the investor exploits the interest rate differential between the US dollars and the Chinese Yuan Renminbi (CNY) by taking the following steps.[4] In Steps 3 and 4, the investor approaches another onshore bank and using the commodity warrant as collateral, obtains CNY loan. This is possible because of the new property rights law that went into effect in China on October 1, 2007, which allows commodity inventory to be used as loan collateral.[5] In the typical CCFD, the CNY loan is a form of a repurchase agreement (repo) where the investor sells the commodity warrant to the bank and then repurchases it when the CNY loan expires. The size of the repo CNY loan is the risk-adjusted market value of the pledged commodity.[6]

One important feature of this typical CCFD is the need to hedge commodity positions. Given that the loan in Step 4 is a repo loan, the investor needs to buy back the warrant from the bank. Thus, the investor still bears the risk that commodity prices change

[2] See Dang et al. (2014), Chen et al. (2020), and Allen et al. (2019) for previous studies on the Chinese banking system.

[3] Garvey and Shaw (2014) and Lewis et al. (2014) describe various ways in which investors construct CCFDs in practice.

[4] Yuan et al. (2014a) argue that there are bidirectional trading incentives to capture the spread between the London Metal Exchange (LME) and the Shanghai Futures Exchange (SHFE). If the investor wants to take advantage of just the price spread between foreign commodity markets and domestic commodity markets, the investor can import the commodity and sell it in the domestic market. This, however, is uncommon and not a typical CCFD.

[5] For additional information on the China's property rights law reform, see Marechal et al. (2009).

[6] The risk-adjusted market value is obtained by taking the difference between the market value of the pledged commodity and the repo margin (haircut).

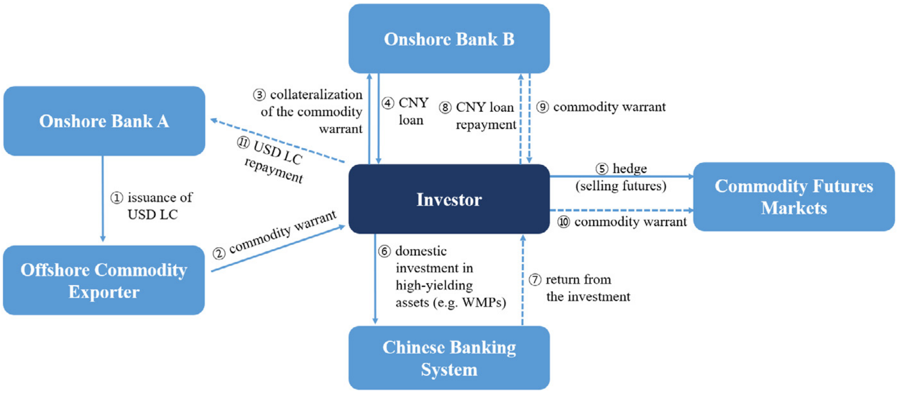

Fig. 1. A typical Chinese commodity financing deal (CCFD).
This figure illustrates a series of transactions that completes one cycle of the standard Chinese commodity financing deals. It is reported that this one cycle is repeated many times in practice. Note that Steps 6–9, shown in the dashed blue line, take place about 3–6 months after the previous transactions.

during the duration of the loan. To hedge this risk, investors trade in the futures markets by taking short positions (Step 5). Thus, as the CCFD demand increases so does the hedging demand — the number of short positions in the futures market increases. This is not exclusive to standard CCFDs since even in other variations of CCFDs, it is still the case that when the CCFD demand increases, the hedging pressure increases. Note that the hedging can be done in either foreign or domestic markets. For example, Tang and Zhu (2016) assume that the CCFD investor imports commodities into China. Hence, in their setting, hedging in domestic markets is natural. However, according to Layton et al. (2013) and Garvey and Shaw (2014), importing commodities into China is not common. The decision to import commodities into China depends on their domestic and foreign prices but also on importing costs such as shipping and customs duties. These costs can be large, which suggests that investors may prefer to keep their commodities in an offshore bonded warehouse. This, in turn, makes it more likely that foreign markets are being used for hedging.

In Step 6, the proceeds from the repo loan are invested with the goal of earning high returns from the CCFD. Specifically, the funds from the CNY repo loan are invested domestically, especially in short-term duration assets such as CNY deposits, trust products, or other WMPs (Yuan et al., 2014b). Among these short-term domestic investment options, WMPs have been quite popular because higher returns of WMPs (over 5% on average in 2014) than capped deposit interest rates (ranged 2%–3% in 2014) attract investors to WMPs (Perry and Weltewitz, 2015). WMPs are composed of pooled time-deposit accounts to be invested in a variety of assets, such as bonds, trust products, repurchase agreements, real estate loans, private equity funds, and local government financing vehicles (LGFVs) loans. These provide the main source of credit to nonbank credit intermediaries such as trust companies, brokerage firms, guarantee companies, and unofficial lenders.

To complete the CCFD, the investor needs to unwind the previous transactions, at which point, Steps 7–11 occur. In Step 7, the investor receives the proceeds from the investments. With these, the CNY loan is repaid and the investor buys back the commodity warrant, Steps 8 and 9, respectively. Next, in Step 10, the investor settles the futures position by delivering the commodity warrant. Finally, the initial letter of credit is repaid (Step 11). This series of transactions can be adapted such that they can be repeated many times. Layton et al. (2013) argue that investors repeat a cycle of transactions 10–30 times during a 6-month period. This is commonly known as a rolling CCFD and is achieved by keeping the commodity in the same bonded warehouse while the warrant for ownership gets passed around. Garvey and Shaw (2014) also document that the rolling CCFDs are popular and multiple parties can work in concert to facilitate them.

The financial attractiveness of CCFDs is twofold. First, CCFDs can provide high returns because CCFDs provide a channel for investors to take advantage of the difference in interest rates between the domestic market (high) and foreign market (low) even under the capital controls in China. According to Garvey and Shaw (2014), the investor can earn about an 11% return over a 6-month period with CCFDs. Layton et al. (2013) estimate that the interest rate arbitrage from trading LME copper using CCFDs is at least 3.5% over six months. This is a conservative estimate given that they do not consider investing in high-yielding unsecured assets in China. The second advantage of CCFDs is access to cheaper financing. Chinese companies that cannot access formal lending channels due to poor collateral quality can engage in CCFDs to get better financing conditions. For instance, Zhang (2012) reports that the lending rate of informal financing for small and medium enterprises in the city of Wenzhou was 24.4% in mid-2011. Ping (2013) notes that the average lending rates of banks for micro and small enterprises in 2012 were 20–40 percentage points higher than the interbank benchmark lending rates. Furthermore, CCFDs not only provide cheaper financing but also resolve urgent liquidity needs. In sum, the seemingly profitable returns of the CCFDs, as well as the demand for extra liquidity circumventing capital controls, drive the collateral and hedging demand for commodities.

One potential concern is whether CCFDs are prevalent enough to have a sizable impact on commodity markets. Yuan et al. (2014b) estimate that, in 2013, about 31% of China's total FX short-term debts are related to CCFDs (the LC in Step 1). Tang and Zhu (2016) estimate that, in 2012, 5.7% of China's annual copper demand (or, equivalently, 2.4% of the world's copper demand) is linked to CCFDs. These are conservative estimates since the studies do not take into account the cases of multiple CCFDs that can be initiated with the same commodity warrant. More importantly, the empirical analysis in Tang and Zhu (2016) show that the collateral demand for commodities has indeed affected the commodity prices in developed markets and China.

There is also some anecdotal evidence suggesting the impact of CCFDs on commodity markets. Several events showed that the Chinese regulators and banks were concerned about the ramifications of CCFDs on the financial markets. For example, in May 2013, the State Administration of Foreign Exchange in China announced that they would start to limit banks' dollar short positions (which interrupts the Steps 1 and 11), while thoroughly monitoring the details of the commodity transactions of the importing and exporting companies.[7] The culminating event was the Qingdao port probe in 2014 and the following crackdown on commodity financing by Chinese authorities, which investigated fake copper warehouse receipts made for multiple loans. These fraudulent practices hit many global banks such as HSBC, Standard Chartered, Citi, and others. More importantly, this led to a fall in copper prices in London for a few weeks after the report of the probe.[8] As a result, banks largely exposed to CCFDs in terms of CNY loans pledged by commodities saw the quality of their collateral deteriorate due to the plunging of commodity prices.[9]

3.2. Liquidity risk in the Chinese banking system and its impact on commodity futures markets via CCFDs

As described above, in one cycle of the typical CCFD, an investor goes through two loan processes via Chinese banks: issuance of LC (a USD loan) and a collateralized loan (a CNY loan). Liquidity in the Chinese banking system will affect the ease and conditions of these loans. A large literature has shown that increased liquidity risk in the banking system adversely affects the lending process (see for example Diamond and Rajan (2005), Ivashina and Scharfstein (2010) and Cornett et al. (2011)). More specifically, Li (2009), Gunji and Yuan (2010), Fungáčová and Korhonen (2011), Nguyen and Boateng (2013), and Chen et al. (2015) show the same relationship between liquidity risk and lending activity in the Chinese banking system. Thus, liquidity risk in the banking system may have an impact on CCFDs through Steps 1, 3 and 4.

Arguably, the most important link connecting the liquidity in the interbank market to CCFDs are in Steps 6 and 7, when the investor tries to reap high returns through investments in short duration assets. If the domestic investment is made in assets such as bank deposits, the return will naturally be affected by banking liquidity conditions. However, investors in China including CCFD investors usually look for higher return opportunities. Among them, WMPs have been the most popular as the size of total investment in these was estimated to be more than 26% of GDP as of June 2014 and to continue increasing (Sun, 2019). WMPs are usually issued by commercial banks. According to Perry and Weltewitz (2015), 81% of the outstanding WMPs in 2014 were directly or indirectly linked to commercial banks. More importantly, WMPs carry rollover risk which stems from maturity mismatch problems as WMPs typically expire ahead of the underlying assets (Li, 2014), Elliott et al. (2015), and Acharya et al. (2021). This is because WMPs are short-term pooled time-deposit accounts invested in medium to long-term assets.[10] Given the magnitude of this problem, commercial banks have to frequently roll over WMPs to resolve the maturity mismatch. This, naturally, introduces rollover risk in WMPs.[11] The liquidity in the banking system plays a crucial role in the ability to manage this rollover risk.[12]

Consistent with this, Acharya et al. (2021) empirically find a relationship between rollover risk in WMPs and interbank market rates. They show that Chinese commercial banks bid for higher short-term interbank rates when they have more WMPs near maturity. Thus, conditions in the interbank money market and the way commercial banks manage the rollover risk in WMPs go hand in hand. In periods of low interbank liquidity, banks will have a harder time managing rollover risk and they will limit their credit exposure affecting the ease and attractiveness of CCFDs.

In sum, due to the impact of liquidity on Steps 1, 3, 4, 6 and 7 of a typical CCFD, the demand for CCFDs goes down when short-term borrowing becomes difficult in the interbank market. This in turn implies that the demand for commodities as collateral goes down and so does the hedging demand. We should then observe that when the liquidity risk increases, commodity futures prices go down since there are fewer commodity positions to hedge. This decline in futures prices may be observed both in China and global markets as the investors can hedge in either market depending on the location of their warranted commodities. Investors are likely to hedge in global markets if they do the standard CCFDs, while they are likely to hedge in the Chinese futures market if they do some variations of CCFDs that use commodities stocked in China.

[7] S. Rabinovitch, "China to crack down on faked export deals", Financial Times, May 6, 2013.

[8] L. Hornby, "China probe sparks metals stocks scramble", Financial Times, June 10, 2014. X. Rice and L. Hornby, "Ripples spread from China metals probe", June 12, 2014.

[9] C. Sau-wai, "Commodity financing exposure in Asia-Pacific hits banks hard", South China Morning Post, January 25, 2015.

[10] According to Li (2014), in 2012, about 80% of bank-issued WMPs had their maturity shorter than 6-month. The magnitude of this maturity mismatch should not be undervalued as it was reported by the local press that about 27–29 trillion yuan, approximately 55% of GDP.

[11] It may be helpful to note that WMPs and asset-backed commercial paper (ABCP) conduits are similar in their asset compositions: the ABCP conduits are composed of medium-to-long-term assets funded by short-term asset-backed commercial papers, and WMPs are composed of medium-to-long-term assets funded by pooled time deposit accounts. Due to their composition structures with short-term debts, both ABCP and WMP bear rollover risk.

[12] "China's banks: Ten days in June", July 6, 2013, The Economist, reports "...Wealth-management products raise money, mostly from better-off individuals, for fixed periods (often less than six months). The cash is invested in a variety of assets, some of them riskier than others. These products added to the cash crunch because they often matured before the underlying assets did. The banks grew used to borrowing money in the interbank market to redeem maturing products until they could sell new ones..."

4. Data

4.1. A proxy for the Chinese interbank liquidity risk

We use the spread between the 3-month SHIBOR and the overnight SHIBOR as the main proxy for the Chinese interbank liquidity risk. We denote this spread as the variable *Slope*. If *Slope* decreases, it indicates that overnight borrowing between banks becomes relatively more difficult compared with the longer-term interbank reference rates (see Nagel (2012)). In other words, a low spread between the 3-month and overnight SHIBOR corresponds to high liquidity risk in the Chinese banking system.[13] The main reason why we benchmark the overnight SHIBOR with the 3-month SHIBOR is that the spread can identify moments where liquidity evaporates and the ability to manage rollover risk is compromised. This is in line with Acharya and Skeie (2011) that describes a market failure as "the inability to borrow overnight against high quality but long-term assets." Moreover, the use of a spread to measure liquidity risk is well established in the literature (see Brunnermeier et al. (2008), Asness et al. (2013), and Gârleanu and Pedersen (2013)).[14]

We compute *Slope* for the period from October 2006 to March 2016. Table 1 shows that the mean value of *Slope* is 1.36%, the standard deviation is 0.91%, the maximum is 3.81%, and the minimum is −4.52%. Fig. 2 plots *Slope* and we can see that the minimum *Slope* is observed during the Great Recession at the end of 2007. We can also see that in June 2013 the *Slope* is highly negative. This was due to the overnight loan default of the China Everbright Bank. The China Everbright Bank Co. Ltd., China's 11th largest bank by assets, announced that they defaulted on the 6.5 billion yuan overnight loan from China Industrial Bank Co. Ltd. on June 5th, 2013. At the end of the week, the spread between the 3-month SHIBOR and the overnight SHIBOR was −3.72%.[15] This shows that a sudden freeze in the short term interbank money market correlates with a moment of market failure. There was also a view that the Chinese government intentionally intervened in the interbank money market to raise the alarm over the moral hazard of the commercial banks.[16]

As explained in the previous section, high liquidity risk in the Chinese interbank market leads to banks having more difficulty managing rollover risk. Naturally, banks may react by scaling down the issuance of WMPs. Hence, we perform a correlation test between *Slope* and changes in the total amount of WMPs as constructed by Sun (2019). To compute correlations, we construct *Slope* at the quarterly level to match the frequency of Sun (2019)'s measures. We find that *Slope* is statistically and positively correlated with changes in the total amount of WMPs by banks. The Pearson's and the Spearman's rank correlation coefficients for the entire sample period are 0.30 and 0.49, respectively. These correlations are higher after the US financial crisis, when CCFDs are allegedly more popular (Layton et al., 2013) and Garvey and Shaw (2014). Specifically, the Pearson's and Spearman's rank correlation coefficients increase to 0.35 and 0.58, respectively. These results indicate that, as expected, banks issue fewer WMPs as *Slope* narrows down.

When using a spread of the yield curve as we do in the construction of *Slope*, one might be concerned that we pick up more than liquidity risk. For example, the spread may change due to expectations about future economic growth, inflation, or fiscal policy, as shown in the yield curve literature. However, not a short-term spread like our *Slope* but longer term spreads such as a spread between the 10-year and 3-month rates are typically used in such literature (Estrella and Trubin, 2006). Moreover, Acharya and Skeie (2011), Acharya and Merrouche (2013) show how the liquidity risk and interbank overnight rates are linked.

4.2. Commodity futures excess returns, basis, and aggregate controls

We look at excess returns on commodity futures in developed markets and China to see the impact of the Chinese banking risk on global commodity markets. We use futures prices because they are readily available and because we are interested in the hedging demand originated from CCFDs. Tang and Zhu (2016) use spot prices as they focus on the collateral demand for commodities. However, using spot prices can be problematic since they are often unavailable and, thus, need to be estimated from the futures prices.

We obtain commodity futures end-of-week prices from October 9th, 2006 to March 25th, 2016 from Datastream.[17] To build comparable sets of commodities across markets and to follow Tang and Zhu (2016) we only keep commodities that have active futures contracts in both developed countries (e.g., the United States, the United Kingdom, and Japan) and China.[18] We end up with sixteen commodities, which we divide into the metal group (aluminum, copper, lead, zinc, gold, and silver) and the nonmetal group (corn, soybeans, soybean meal, soybean oil, wheat, cotton, palm oil, rubber, sugar, and fuel oil).

Using the futures prices we then compute futures excess returns following Gorton and Rouwenhorst (2006) and Gorton et al. (2013). To be precise, the excess return of commodity futures i over week t to week $t+1$, $Excess\ Return^i_{t+1}$, is given as follows:

$$Excess\ Return^i_{t+1} = \frac{F^i_{t+1,T_1} - F^i_{t,T_1}}{F^i_{t,T_1}}, \tag{1}$$

[13] The true risk may not be monotonic if there are certain high-risk events that *Slope* misses. For example, times in which the 3-month SHIBOR increases relative to the overnight. This may work opposite the sign of the impact assumed in our hypothesis, indicating that our results actually underestimate the effect of the interbank liquidity risk on the commodity markets.

[14] We recognize that the choice of the 3-month SHIBOR in constructing *Slope* is debatable. Thus, to address any concerns, we provide further results in the robustness section using the spread between the 6-month SHIBOR and the overnight SHIBOR.

[15] D. McMahon, "China Everbright Admits to Interbank-Loan Default", The Wall Street Journal, December 16, 2013. M. Zhang. "China Everbright Bank Co. Ltd (SHA:601818) 'Admits' To 6.5 Billion Yuan Interbank Loan Default", International Business Times, December 16, 2013

[16] "Re-education through SHIBOR", June 29th, 2013, The Economist and Farhi and Tirole (2012).

[17] The beginning of our sample period is restricted by the availability of SHIBOR data.

[18] One exception is fuel oil futures that are available only in China. We do not drop this commodity as we use CME heating oil futures to proxy the fuel oil futures in developed markets. This seems reasonable as fuel oil is one type of heating oil.

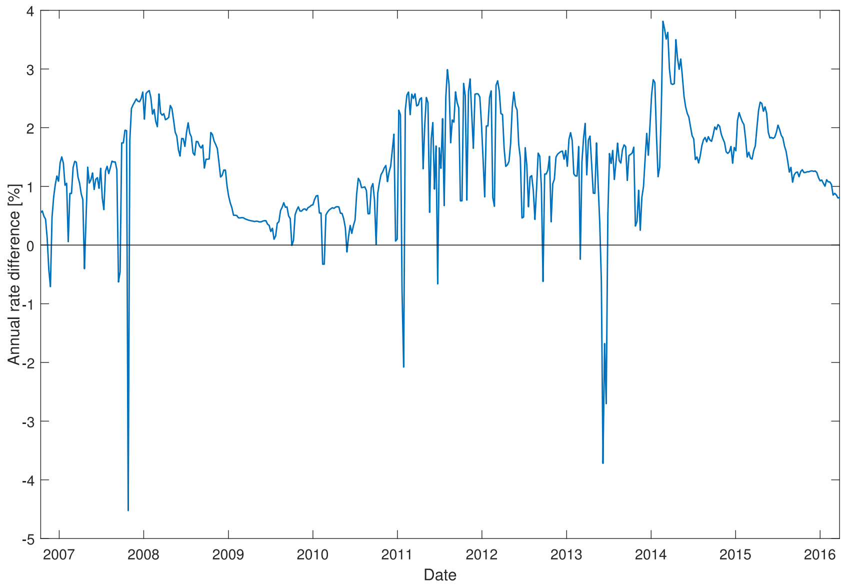

Fig. 2. The spread between the 3-month SHIBOR and the overnight SHIBOR (*Slope*). The blue line indicates the spread between the 3-month SHIBOR and the overnight SHIBOR.

Table 1
Summary statistics. All variables are calculated from Oct. 13th, 2006 to Mar. 25th, 2016. The table shows the average (mean), standard deviations (SD), maximum (Max), minimum (Min) of the variables and sample mean test of the null hypothesis that each variable is zero.

Variable	Description	Mean	Std. dev	Max	Min
Excess Returns	Weekly excess returns of all commodities in developed markets [%]	0.05	4.13	28.02	−27.39
	Weekly excess returns of all commodities in China [%]	−0.04	2.77	16.91	−20.60
	Weekly excess returns of metals in developed markets [%]	0.03	4.20	28.02	−27.39
	Weekly excess returns of metals in China [%]	−0.08	2.90	15.34	−17.73
	Weekly excess returns of nonmetals in developed markets [%]	0.07	4.10	24.20	−21.83
	Weekly excess returns of nonmetals in China [%]	−0.01	2.71	16.91	−20.60
Slope	3-month SHIBOR - Overnight SHIBOR (CNY) [%]	1.36**	0.91	3.81	−4.52
Basis	Annual Basis of all commodities in developed markets [%]	−1.61**	14.78	272.77	−39.45
	Annual basis of all commodities in China [%]	−2.32**	23.27	469.82	−499.26
	Annual basis of metals in developed markets [%]	−1.95**	7.40	89.43	−35.04
	Annual basis of metals in China [%]	−1.46**	7.08	47.01	−62.51
	Annual basis of nonmetals in developed markets [%]	−1.38**	18.49	272.77	−39.45
	Annual basis of nonmetals in China [%]	−2.73**	27.88	469.82	−499.26
$i_t^* - i_t$	3-month SHIBOR (CNY) - 3-month LIBOR ($) at date t [%]	0.60	0.56	1.50	−0.66
s_t	$s_t = \log(Spot(CNY/\$)_t) - \log(3-monthNDF(CNY/\$)_t)$ [%]	0.12*	1.02	4.37	−2.64
TZ	$TZ = i_t^* - i_t + s_t$; 3-month currency-hedged carry trade returns [%]	0.72**	0.90	4.79	−2.04
MSCI EM	Weekly excess returns of the MSCI emerging markets Asia index over one week LIBOR ($) [%]	0.02	3.26	13.90	−18.87
MSCI China	Weekly excess returns of the MSCI China index over one week SHIBOR (CNY) [%]	0.01	3.98	17.72	−22.34
SPX	Weekly excess returns of the S&P 500 index over one week LIBOR ($) [%]	0.06	2.66	11.34	−20.16
DXY	Weekly log changes in the dollar index [%]	0.02	1.17	4.77	−4.14
BDI	Weekly log changes in the Baltic dry index [%]	−0.47	9.25	42.83	−43.47
TED spread	Spread between 3-month Eurodollars and 3-month Treasury Bill ($) [%]	0.47**	0.41	2.61	0.02
LIBOR-Repo spread	Spread between 3-month LIBOR and 3-month Repo ($) [%]	0.37**	0.45	4.07	−0.05
Swap-Tbill spread	Spread between interest rate swaps and 3-month Treasury Bill ($) [%]	0.55**	0.40	2.54	0.15
SHIBOR-Repo spread	Spread between 3-month SHIBOR and 3-month Repo (CNY) [%]	−0.10**	0.55	1.16	−4.00
SHIBOR spread	Spread between 3-month SHIBOR and 1-month SHIBOR (CNY) [%]	0.13**	0.72	1.63	−4.82

* $p < 0.05$, ** $p < 0.01$.

where F^i_{t+1,T_1} is the futures price of the commodity i at the end of week $t+1$ on the nearest contract whose expiration date is T_1. We require that the expiration date T_1 to be at least in month $M+2$, where M is the month which the week $t+1$ is in.

We include the basis as a commodity-specific control. Fama and French (1987), Gorton and Rouwenhorst (2006), Hong and Yogo (2012), and Singleton (2013) use the basis as a proxy for convenience yield or as a control for the effect of the commodity-specific hedging pressure hypothesis. Note that we posit Chinese interbank liquidity risk is a common factor affecting the hedging demand of various commodities used in CCFDs. Furthermore, Yang (2013), Szymanowska et al. (2014), and Bakshi et al. (2019) among

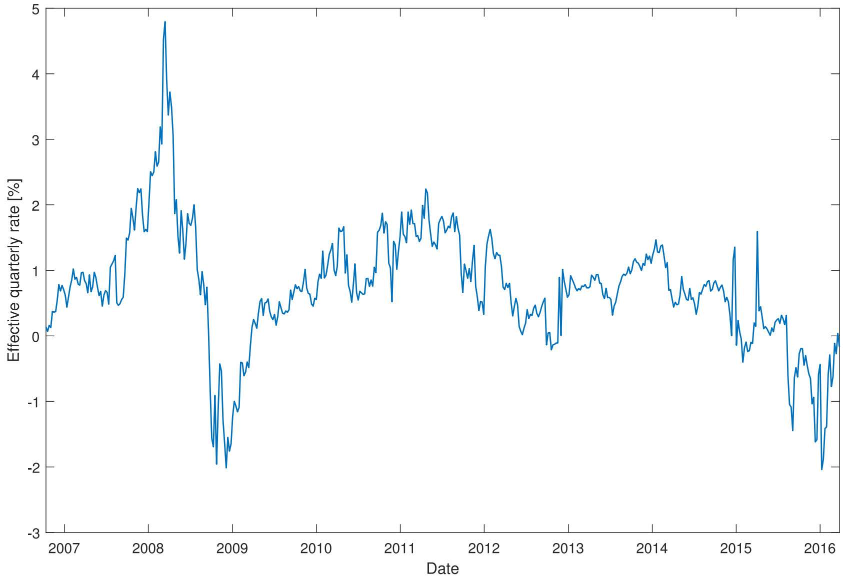

Fig. 3. The 3-month currency-hedged carry trade returns (*TZ*) by Tang and Zhu (2016). The currency-hedged carry trade returns are calculated as the sum of (1) the interest rate difference between the 3-month SHIBOR and 3-month LIBOR and (2) the hedged currency returns from the official USD-CNY spot exchange rate and the USD-CNY 3-month nondeliverable forward (NDF) exchange rate.

others show that the basis has predictive power for commodity futures risk premia. We construct the annual basis for commodity i in week t, $Basis_t^i$, as

$$Basis_t^i = \frac{F_{t,T_1}^i - F_{t,T_2}^i}{F_{t,T_2}^i} \times \frac{365}{D_{t,T_2}^i - D_{t,T_1}^i}, \tag{2}$$

where F_{t,T_2}^i is the futures price of the commodity i at the end of week $t+1$ in month M, on the second nearest contract whose expiration date is T_2. We require that the expiration date T_2 to be at least in month $M+2$. D_{t,T_1}^i and D_{t,T_2}^i are the remaining days of each futures until the last trading date.

We also control for the currency-hedged carry trade returns which Tang and Zhu (2016) used as a proxy for the collateral demand for commodities. The currency-hedged carry trade returns are calculated as the sum of (1) the interest rate difference between the 3-month SHIBOR and 3-month LIBOR and (2) the hedged currency returns from the official USD-CNY spot exchange rate and the USD-CNY 3-month nondeliverable forward (NDF) exchange rate. We call the currency-hedged carry trade returns as *TZ*. Fig. 3 shows the evolution of *TZ* during our sample period.

We include macroeconomic fundamentals as control variables to ensure that the effect of our interbank risk measure is not driven from macroeconomic conditions. General economic conditions affect both commodity producers' and speculators' fundamental hedging demand, thereby affecting the commodity futures market.[19] Following Tang and Xiong (2012), Acharya et al. (2013), Singleton (2013), and Henderson et al. (2014), we include *MSCI EM* – the difference between MSCI Emerging Markets Asia Index weekly return and the weekly USD LIBOR. This captures the growth of emerging Asian economies. In the same spirit, we control for the Chinese growth using *MSCI China*. We also control for the excess returns of the U.S. market with *SPX* – the difference between the weekly return of the S&P 500 index and the weekly USD LIBOR. We use the stock market indexes to control for macroeconomic fundamentals because common economic indicators such as GDP growth rate, consumer price index (CPI), or purchasing managers index (PMI) are not available at the weekly frequency. As in Tang and Xiong (2012), we add the log changes in the U.S. Dollar Index futures *DXY* to control for exchange rate risks. Following Bakshi et al. (2011), we also use the log changes in the Baltic Dry Index (*BDI*) to proxy for the aggregated commodity demand. We use two common liquidity risk measures in the literature: (i) the TED spread, which is the difference between the 3-month Eurodollars and the 3-month Treasury Bill; (ii) the LIBOR-Repo spread, which is the spread between the 3-month USD LIBOR and the 3-month USD term repurchase agreement rate. In the robustness section, we add controls for general funding liquidity shocks from global markets as these can have an impact on assets' risk premium (Brunnermeier et al. (2008), Asness et al. (2013), and Gârleanu and Pedersen (2013)).

Table 1 shows the summary statistics for weekly excess returns, *Slope*, annual basis of aggregate commodities (all, metals, and nonmetals), and the other control variables.[20] During the sample period, the excess returns of all of the commodities, *MSCI EM*,

[19] Concerning the speculators' reactions to macroeconomic fundamentals, Acharya et al. (2013) note that the commodity risk premium is related to equity holders' marginal rate of intertemporal substitution. Singleton (2013) considers cross-market trading strategies between equity and commodity markets.

[20] The summary statistics for each individual commodity are shown in Table A.1. Quite extreme values for the maximum (469.82) and minimum (−499.26) of annual basis in China belong to palm oil, notably during the US financial crisis. For example, the annual basis of palm oil in China is −499.26 on September 19th, 2008 and 469.82 on October 10th, 2008. Other commodities also experienced their maximum and minimum during the financial crisis.

Table 2
Contemporaneous commodity futures excess returns. This table presents the panel regression results for contemporaneous commodity futures excess returns ($Excess\ Returns_t^i = \beta_0 + \beta_1 Slope_t + \beta_2 Basis_t^i + \beta_3 TZ_t + \beta_4 Slope \times Low\ TZ_t + \beta_5 Slope \times High\ TZ_t + \gamma X_t + \epsilon_t^i$ where X_t is a vector of aggregate control variables and ϵ_t^i is an error term at week t for commodity i) with fixed effects at the individual commodity level. Panel A including columns (1) to (4) reports results in developed markets (aluminum, copper, lead, zinc, gold, silver, corn, soybeans, soybean meal, soybean oil, wheat, cotton, palm oil, rubber, sugar, and heating oil). Panel B reports results in Chinese commodity futures markets (aluminum, copper, lead, zinc, gold, silver, corn, soybeans, soybean meal, soybean oil, wheat, cotton, palm oil, rubber, sugar, and fuel oil).

Variables	*A. Developed markets*				*B. China*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Slope	−0.28**	−0.36**	−0.38**	−0.18**	−0.18**	−0.22**	−0.26**	−0.17**
	(0.05)	(0.05)	(0.06)	(0.06)	(0.04)	(0.04)	(0.04)	(0.04)
Basis	1.26**	1.16**	1.17**	1.12**	0.41**	0.43**	0.43**	0.46**
	(0.17)	(0.17)	(0.17)	(0.16)	(0.07)	(0.08)	(0.07)	(0.07)
TZ		0.38**	0.28**	−0.08		0.16**	−0.03	−0.22**
		(0.05)	(0.08)	(0.08)		(0.04)	(0.06)	(0.06)
Slope × Low TZ			−0.14	−0.13			−0.22**	−0.19**
			(0.10)	(0.09)			(0.07)	(0.07)
Slope × High TZ			0.09	0.27**			0.18**	0.33**
			(0.07)	(0.07)			(0.05)	(0.05)
MSCI EM				0.21**				0.15**
				(0.04)				(0.03)
MSCI China				0.02				0.06**
				(0.03)				(0.02)
SPX				0.13**				−0.02
				(0.02)				(0.02)
DXY				−0.74**				−0.24**
				(0.04)				(0.03)
BDI				0.00				0.01*
				(0.00)				(0.00)
TED spread				−0.26				0.14
				(0.25)				(0.18)
LIBOR-Repo spread				−0.12				−0.63**
				(0.23)				(0.17)
Constant	0.47**	0.31**	0.41**	0.48**	0.23**	0.17**	0.36**	0.47**
	(0.08)	(0.09)	(0.10)	(0.11)	(0.06)	(0.06)	(0.07)	(0.08)
Observations	7888	7888	7888	7888	7221	7221	7221	7221
Adjusted R^2	0.008	0.015	0.015	0.158	0.005	0.008	0.010	0.107

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$.

MSCI China, *SPX*, *DXY*, and *BDI* are statistically indifferent from 0, and most of the commodities are in contango, as they have a negative basis on average. Consistent with the theory of storage and Fama and French (1987) and Gorton et al. (2013), the standard deviation of basis is lower for more storable commodities such as metals than nonmetals. It is also noteworthy that the 3-month currency-hedged carry trade returns (*TZ*) show 0.72% quarterly excess returns on average. This is fairly high, and given that the carry trade return is a conservative estimate of the returns from CCFDs, it suggests that CCFDs have been quite lucrative.

5. Empirical analysis

In this section, we test if our proxy for the liquidity risk in the Chinese banking system, *Slope*, has an impact on commodity futures markets in developed countries and China. First, we look at the contemporaneous relationship between risk and commodity futures excess returns. Then, we run a separate analysis for metal and nonmetal commodities, as we expect the short-term interbank spread to have a stronger impact on metals. Next, we test if our measure of risk can also predict next week's commodity futures excess returns, following Hong and Yogo (2012), Acharya et al. (2013), and Singleton (2013).

5.1. Contemporaneous relationship between risk and futures markets

We start our empirical analysis by looking at commodity futures excess returns for all commodities in developed markets and China. To be specific, we look at the following commodities: aluminum, copper, lead, zinc, gold, silver, corn, soybeans, soybean meal, soybean oil, wheat, cotton, palm oil, rubber, sugar, and heating oil (fuel oil in China).

We regress commodity futures excess returns onto our variable of interest, *Slope*, while controlling for *Basis* of individual commodities.

$$Excess\ Returns_t^i = \beta_0 + \beta_1 Slope_t + \beta_2 Basis_t^i + \gamma X_t + \epsilon_t^i, \tag{3}$$

where X_t is a vector of aggregate control variables and ϵ_t^i is an error term at week t for commodity i. We perform a panel regression including individual commodity fixed effects.[21] Table 2, Panels A and B present, respectively, the results for developed markets and China.

We expect that in weeks when risk is low, as measured by high *Slope*, investors are more likely to engage in CCFDs. This increased demand for CCFDs enhances the need to hedge the commodities positions by selling futures. This leads to a decrease in futures prices, yielding lower excess returns. In columns (1) and (5) of Table 2, where we do not have any aggregate controls, we see that the estimate on *Slope* is, as expected, negative and statistically significant both for developed markets and the Chinese market. An increase of one standard deviation of *Slope*, 91 basis points, is associated, in the same week, with 0.25 percentage points (0.91×0.28) lower excess returns in developed markets. This translates to an annual decrease of 13.2 percentage points. For the Chinese market, the magnitude of the effect is smaller, but still significant: 0.16 and 8.5 percentage points per week and year, respectively.

To check that our measure does not contain the same information as Tang and Zhu (2016)'s measure, which we dub as *TZ*, we add it to our initial panel regressions. Columns (2) and (6) show that the estimates on *Slope* are still significant, and the effect is even slightly stronger in magnitude. Moreover, we find that the estimates on *TZ* are positive for developed markets and China. This is a surprising result because *TZ* attempts to measure the demand for CCFDs. As this demand increases, so does the demand for hedging the commodity positions, which should result in lower futures excess returns.

To shed more light on the surprising result, we investigate whether the effect of *Slope* differs when potential gains from CCFDs are low or high. To be precise, we add *Slope* × *Low TZ* and *Slope* × *High TZ*. *Low TZ* and *High TZ* are dummy variables equal to 1 if *TZ* in that particular week is in the bottom or top quartile of the *TZ* distribution, respectively. Results are shown in columns (3) and (7). For developed markets, the inclusion of the interaction terms does not change the previous results — high *Slope* correlates with lower excess returns, while high *TZ* correlates with higher excess returns. For China, interesting results emerge. *Slope* continues significant and negative as expected, while *TZ* is now not significant. Moreover, we find a negative estimate for *Slope* × *Low TZ* and a positive one for *Slope* × *High TZ*. If we interpret *TZ* as the potential gains from trading CCFDs, we see that when potential gains are high the interbank liquidity risk in China has a negligible impact ($-0.26 + 0.18$) in contemporaneous futures excess returns in the Chinese market. However, in weeks where *TZ* is low, the impact of *Slope* on futures excess returns almost doubles ($-0.26 - 0.22$).

One concern about the previous regressions is that our measure is correlated with fundamental macroeconomic variables that affect commodity markets. To alleviate this concern, we add the set of control variables as described in Section 4.2: *MSCI EM*, *MSCI China*, *SPX*, *DXY*, *BDI*, *TED spread* and *LIBOR-Repo spread* (see Table 1 for descriptions). Column (4) shows that once we include the macro controls, the impact of *Slope* in futures excess returns in developed markets is lower but, more importantly, still significant. Moreover, *TZ* is no longer relevant, which suggests that the results from columns (2) and (3) were due to *TZ* and the state of the economy being correlated. Lastly, from column (4), we observe from *Slope* × *High TZ* that when potential gains from engaging in CCFDs are high, the liquidity risk in the Chinese banking system does not negatively impact futures prices in developed markets ($-0.18 + 0.27$). Column (8) repeats the exercise for the Chinese market. We find that the magnitude of the effect of *Slope* decreases but is still significant, whereas the estimate on *TZ* is now, as expected, negative. Looking at the interaction between potential gains (*TZ*) and risk (*Slope*) of CCFDs, we see that the risk is paramount in weeks where gains are low ($-0.17 - 0.19$). In weeks when *TZ* is high, there is no negative impact of *Slope* on future excess returns in China ($-0.17 + 0.33$).

Next, we analyze the effect of the interbank spread on metal and nonmetal commodities separately. Metal commodities are a better suit as the medium for CCFDs in terms of volume per value and storability than nonmetals. Hence, the liquidity risk in the Chinese banking system should affect excess returns for metal commodities futures more severely. To test this, we first separate commodities into metals including aluminum, copper, lead, zinc, gold, and silver, and nonmetals including corn, soybeans, soybean meal, soybean oil, wheat, cotton, palm oil, rubber, sugar, and fuel oil (heating oil in developed markets). As before, regressions include fixed effects at the individual commodity level.

Table 3 presents the results for developed markets. Columns (1)–(4) present the regression estimates for metals, and (5)–(8) for nonmetals. Column (9) includes a full set of controls, both types of commodities, and a dummy for metal commodities interacted with *Slope*.

First, consistent with our previous results, for seven out of nine specifications, the estimate on *Slope* is negative and significant. More importantly, as expected, we find evidence that our measure of the liquidity risk impacts more severely future excess returns of metal commodities than of nonmetal commodities. Comparing the coefficients of *Slope* in metals and nonmetals, we find that these are more negative for metal commodities. For example, once we control for all macro variables, we see in column (4) that the coefficient of *Slope* is still negative and significant. This means that for metals, in developed markets, an increase of 91 basis points of *Slope* (one standard deviation) is associated with lower weekly excess returns of 0.28 percentage points (0.91×0.31). For nonmetals, we see in column (8) that there is no significant effect of *Slope*. More importantly, in column (9) we see that the coefficient on the interaction term *Metal* × *Slope* is -0.21 and statistically significant. Economically, this is a large effect given that the estimate on *Slope* is -0.10 and even statistically insignificant. In other words, the impact of the liquidity risk in the Chinese banking system is at least triple for metal commodities than for nonmetals.

Table 4 repeats the exercise for the Chinese market. Contrary to the results in Table 3 for developed markets, we do not find significant differences between metals and nonmetals in the Chinese market. Looking at column (9), we find that the estimate on *Slope* is negative, but the estimate on the interaction term *Metal* × *Slope* is not. There are two possible interpretations of this result. The first is that in China, nonmetal commodities may still be used as collateral, and thus no significant differences are observed regarding the effect of *Slope*. This is unlikely to be the case due to the poor characteristics of nonmetals as collateral. The more natural interpretation is that CCFDs investors hedge more of their commodity positions in developed markets. This would not be surprising if the commodities used as collateral do not effectively enter China, as many have suggested being the case when engaging in CCFDs (Layton et al. (2013) and Garvey and Shaw (2014)).

[21] Including an AR(1) disturbance does not change our results.

Table 3

Metals vs. nonmetals for contemporaneous commodity futures excess returns in developed markets. This table presents the panel regression results for contemporaneous commodity futures excess returns ($Excess\ Returns_t^i = \beta_0 + \beta_1 Slope_t + \beta_2 Basis_t^i + \beta_3 TZ_t + \beta_4 Slope \times Low\ TZ_t + \beta_5 Slope \times High\ TZ_t + \gamma X_t + \epsilon_t^i$ where X_t is a vector of aggregate control variables and ϵ_t^i is an error term at week t for commodity i) with fixed effects at the individual commodity level. Panel A including columns (1) to (4) reports results for aluminum, copper, lead, zinc, gold, and silver. Panel B including columns (5) to (8) reports results for corn, soybeans, soybean meal, soybean oil, wheat, cotton, palm oil, rubber, sugar, and heating oil. Panel C reports results for both metals and nonmetals with the metals dummy variable.

Variables	*A. Metals*				*B. Nonmetals*				*C. All*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
Slope	−0.43**	−0.51**	−0.57**	−0.31**	−0.20**	−0.28**	−0.28**	−0.11	−0.10
	(0.08)	(0.09)	(0.10)	(0.09)	(0.06)	(0.07)	(0.08)	(0.07)	(0.07)
Basis	7.33**	7.14**	7.19**	5.41**	1.15**	1.06**	1.05**	1.03**	1.12**
	(1.34)	(1.34)	(1.34)	(1.21)	(0.17)	(0.17)	(0.17)	(0.16)	(0.16)
TZ		0.37**	0.29*	−0.08		0.39**	0.25*	−0.08	−0.08
		(0.09)	(0.13)	(0.12)		(0.07)	(0.10)	(0.10)	(0.08)
Slope × Low TZ			−0.02	0.03			−0.22	−0.23	−0.13
			(0.17)	(0.15)			(0.13)	(0.12)	(0.09)
Slope × High TZ			0.14	0.34**			0.07	0.23*	0.27**
			(0.12)	(0.11)			(0.09)	(0.09)	(0.07)
MSCI EM				0.22**				0.20**	0.21**
				(0.06)				(0.05)	(0.04)
MSCI China				0.13**				−0.04	0.02
				(0.04)				(0.03)	(0.03)
SPX				0.07				0.17**	0.13**
				(0.04)				(0.03)	(0.02)
DXY				−0.86**				−0.67**	−0.74**
				(0.06)				(0.05)	(0.04)
BDI				−0.00				0.01	0.00
				(0.01)				(0.01)	(0.00)
TED spread				−0.61				−0.10	−0.26
				(0.39)				(0.32)	(0.25)
LIBOR-Repo spread				0.13				−0.17	−0.12
				(0.36)				(0.29)	(0.23)
Metals × Slope									−0.21*
									(0.10)
Constant	0.90**	0.74**	0.82**	0.81**	0.37**	0.21	0.33*	0.39**	0.48**
	(0.15)	(0.15)	(0.18)	(0.18)	(0.10)	(0.11)	(0.13)	(0.14)	(0.11)
Observations	2958	2958	2958	2958	4930	4930	4930	4930	7888
Adjusted R^2	0.015	0.021	0.021	0.227	0.008	0.015	0.015	0.127	0.158

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$.

Table 4

Metals vs. nonmetals for contemporaneous commodity futures excess returns in China. This table presents the panel regression results for contemporaneous commodity futures excess returns ($Excess\ Returns_t^i = \beta_0 + \beta_1 Slope_t + \beta_2 Basis_t^i + \beta_3 TZ_t + \beta_4 Slope \times Low\ TZ_t + \beta_5 Slope \times High\ TZ_t + \gamma X_t + \epsilon_t^i$ where X_t is a vector of aggregate control variables and ϵ_t^i is an error term at week t for commodity i) with fixed effects at the individual commodity level. Panel A including columns (1) to (4) reports results for aluminum, copper, lead, zinc, gold, and silver. Panel B including columns (5) to (8) reports results for corn, soybeans, soybean meal, soybean oil, wheat, cotton, palm oil, rubber, sugar, and fuel oil. Panel C reports results for both metals and nonmetals with the metals dummy variable.

Variables	*A. Metals*				*B. Nonmetals*				*C. All*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
Slope	−0.17*	−0.19**	−0.21**	−0.10	−0.19**	−0.23**	−0.28**	−0.21**	−0.17**
	(0.07)	(0.07)	(0.08)	(0.07)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)
Basis	0.14	0.29	0.30	0.46	0.41**	0.43**	0.43**	0.46**	0.46**
	(0.47)	(0.48)	(0.48)	(0.45)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
TZ		0.10	−0.03	−0.29**		0.19**	−0.04	−0.20**	−0.22**
		(0.07)	(0.11)	(0.10)		(0.04)	(0.07)	(0.07)	(0.06)
Slope × Low TZ			−0.15	−0.12			−0.27**	−0.23**	−0.19**
			(0.12)	(0.11)			(0.08)	(0.08)	(0.07)
Slope × High TZ			0.12	0.31**			0.21**	0.35**	0.33**
			(0.10)	(0.09)			(0.06)	(0.06)	(0.05)
MSCI EM				0.27**				0.10**	0.15**
				(0.05)				(0.03)	(0.03)
MSCI China				0.05				0.07**	0.06**
				(0.04)				(0.02)	(0.02)
SPX				−0.05				−0.01	−0.02
				(0.03)				(0.02)	(0.02)
DXY				−0.37**				−0.19**	−0.24**
				(0.05)				(0.03)	(0.03)
BDI				0.01				0.01*	0.01*
				(0.01)				(0.00)	(0.00)
TED spread				−0.05				0.21	0.14
				(0.35)				(0.22)	(0.18)
LIBOR-Repo spread				−0.59				−0.64**	−0.63**
				(0.32)				(0.20)	(0.17)
Metals × Slope									0.01
									(0.07)
Constant	0.16	0.13	0.26	0.43**	0.27**	0.19**	0.41**	0.51**	0.47**
	(0.11)	(0.12)	(0.14)	(0.15)	(0.07)	(0.07)	(0.09)	(0.10)	(0.08)
Observations	2346	2346	2346	2346	4875	4875	4875	4875	7221
Adjusted R^2	−0.000	0.000	0.001	0.165	0.008	0.012	0.015	0.086	0.107

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$.

Table 5
Commodity futures risk premia. This table presents the panel regression results for predicting commodity futures excess returns ($Excess\ Returns^i_{t+1} = \beta_0 + \beta_1 Slope_t + \beta_2 Basis^i_t + \beta_3 TZ_t + \beta_4 Slope \times Low\ TZ_t + \beta_5 Slope \times High\ TZ_t + \gamma X_t + \epsilon^i_{t+1}$ where X_t is a vector of aggregate control variables and ϵ^i_{t+1} is an error term at week $t+1$ for commodity i) with fixed effects at the individual commodity level. The description of each panel is the same as in Table 2.

Variables	*A. Developed markets*				*B. China*			
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Slope	−0.31**	−0.34**	−0.31**	−0.33**	−0.22**	−0.22**	−0.20**	−0.19**
	(0.05)	(0.05)	(0.06)	(0.06)	(0.04)	(0.04)	(0.04)	(0.04)
Basis	−0.05	−0.08	−0.11	−0.20	−0.37**	−0.37**	−0.37**	−0.34**
	(0.17)	(0.17)	(0.17)	(0.17)	(0.07)	(0.08)	(0.07)	(0.07)
TZ		0.13*	−0.16	−0.27**		0.01	−0.19**	−0.31**
		(0.05)	(0.08)	(0.08)		(0.04)	(0.06)	(0.06)
Slope × Low TZ			−0.50**	−0.46**			−0.35**	−0.36**
			(0.10)	(0.10)			(0.07)	(0.07)
Slope × High TZ			0.12	0.25**			0.08	0.18**
			(0.07)	(0.08)			(0.05)	(0.05)
MSCI EM				0.04				−0.00
				(0.04)				(0.03)
MSCI China				−0.07*				−0.00
				(0.03)				(0.02)
SPX				0.06*				0.08**
				(0.02)				(0.02)
DXY				−0.02				−0.13**
				(0.04)				(0.03)
BDI				0.01				0.00
				(0.01)				(0.00)
TED spread				−0.78**				0.04
				(0.27)				(0.19)
LIBOR-Repo spread				0.12				−0.48**
				(0.25)				(0.18)
Constant	0.47**	0.42**	0.70**	1.04**	0.25**	0.25**	0.44**	0.62**
	(0.08)	(0.09)	(0.10)	(0.12)	(0.06)	(0.06)	(0.07)	(0.08)
Observations	7904	7904	7904	7888	7237	7237	7237	7226
Adjusted R^2	0.003	0.003	0.006	0.012	0.006	0.006	0.010	0.024

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$.

5.2. Predictive relationship between risk and futures markets

In the previous subsection, we have provided evidence of a contemporaneous relationship between the liquidity risk in the Chinese banking system and commodity markets. We had a clear expectation for the sign of the contemporaneous relationship. In weeks when risk is low (high *Slope*), CCFDs activity is high which increases the hedging pressure and depresses futures prices, leading to lower excess returns in those weeks.

In this subsection, we investigate if there is also a predictive relationship between the liquidity risk in the Chinese banking system and commodity markets. To be precise, we study if the short-term spread in week t predicts excess returns in commodity futures markets for week $t+1$. Contrary to the contemporaneous relationship, we do not have a clear expectation for the sign of the potential predictive relationship. The theory of normal backwardation argues that as the hedging demand from commodity producers increases, hedgers require a higher risk premium. Hence, when risk is low (high *Slope*), hedging demand increases, and, according to this theory, we should observe a higher risk premium. In other words, this theory would predict a positive effect of *Slope* on futures risk premium. However, in our setting, it is not the commodity producers that hedge but the CCFD players. Moreover, the theory has received low empirical support in the short-term and has motivated the development of other theories. For example, Cheng et al. (2015) and Kang et al. (2020) emphasize the importance of motives to trade that are distinct from insurance provision and argue for the possibility of a negative relationship between hedging demand and futures risk-premium in the short-term.

The sign of the relationship between hedging demand and commodity futures risk premium is still an unanswered question. Hence, we use our setting to shed some light on the issue. The closest paper to ours, Tang and Zhu (2016) also explored the question and found no empirical relationship between hedging demand and futures risk premium. However, their proxy of hedging demand only caters to the potential gains of CCFDs ignoring their risk.

Table 5 presents the main results for the predictive relationship. This table is the equivalent to Table 2, but where the dependent variable is the futures excess return in week $t+1$. The results contradict the theory of normal backwardation. For developed markets, columns (1)–(4) show a negative effect of *Slope* in week t on commodity futures excess returns in week $t+1$. Columns (5)–(8) show the same negative relationship, although slightly weaker for the Chinese market.

It is interesting that the regression results of the predictive relationship are quite similar to the contemporaneous ones. Nonetheless, some differences are worth noting. First, once we control for macro conditions, both *Slope* and *TZ* predict negative excess returns for both developed markets (column (4)) and the Chinese market (column (8)). This was not the case for *TZ* in the contemporaneous relationship for developed markets (Table 2, column (4)).

Table 6

Metals vs. nonmetals for commodity futures risk premia in developed markets. This table presents the panel regression results for predicting commodity futures excess returns ($Excess\ Returns^i_{t+1} = \beta_0 + \beta_1 Slope_t + \beta_2 Basis^i_t + \beta_3 TZ_t + \beta_4 Slope \times Low\ TZ_t + \beta_5 Slope \times High\ TZ_t + \gamma X_t + \epsilon^i_{t+1}$ where X_t is a vector of aggregate control variables and ϵ^i_{t+1} is an error term at week $t+1$ for commodity i) with fixed effects at the individual commodity level, but separately for metal and nonmetal commodities in developed markets. The description of each panel is the same as in Table 3.

Variables	*A. Metals*				*B. Nonmetals*				*C. All*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
Slope	−0.42**	−0.43**	−0.36**	−0.39**	−0.25**	−0.29**	−0.29**	−0.29**	−0.27**
	(0.08)	(0.09)	(0.10)	(0.10)	(0.06)	(0.07)	(0.08)	(0.08)	(0.07)
Basis	2.06	2.04	2.21	1.14	−0.09	−0.13	−0.14	−0.20	−0.20
	(1.33)	(1.33)	(1.32)	(1.36)	(0.17)	(0.17)	(0.17)	(0.18)	(0.17)
TZ		0.04	−0.36**	−0.46**		0.18**	−0.05	−0.16	−0.27**
		(0.09)	(0.13)	(0.14)		(0.07)	(0.10)	(0.10)	(0.08)
Slope × Low TZ			−0.78**	−0.77**			−0.34**	−0.28*	−0.46**
			(0.17)	(0.17)			(0.13)	(0.13)	(0.10)
Slope × High TZ			0.10	0.25			0.13	0.25**	0.25**
			(0.12)	(0.13)			(0.09)	(0.10)	(0.08)
MSCI EM				0.04				0.03	0.04
				(0.06)				(0.05)	(0.04)
MSCI China				−0.09				−0.06	−0.07*
				(0.05)				(0.04)	(0.03)
SPX				0.03				0.07*	0.06*
				(0.04)				(0.03)	(0.02)
DXY				−0.05				0.00	−0.02
				(0.07)				(0.05)	(0.04)
BDI				−0.01				0.02**	0.01
				(0.01)				(0.01)	(0.01)
TED spread				−0.45				−0.98**	−0.78**
				(0.44)				(0.34)	(0.27)
LIBOR-Repo spread				−0.46				0.50	0.12
				(0.41)				(0.31)	(0.25)
Metals × Slope									−0.17
									(0.10)
Constant	0.68**	0.66**	1.06**	1.44**	0.40**	0.33**	0.54**	0.83**	1.04**
	(0.15)	(0.15)	(0.18)	(0.21)	(0.10)	(0.11)	(0.13)	(0.15)	(0.12)
Observations	2964	2964	2964	2958	4940	4940	4940	4930	7888
Adjusted R^2	0.007	0.006	0.013	0.021	0.001	0.002	0.003	0.009	0.012

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$.

More interesting is the interaction of *Slope* and *TZ*. First, from Table 5, we see that when *TZ* is high, *Slope* does not predict lower excess returns. For developed markets, the total impact of *Slope* is −0.08 ($-0.33 + 0.25$, column (4) of Table 5), and for China it is −0.01 ($-0.19 + 0.18$, column (8) of Table 5). These results are similar to the ones found for the contemporaneous relationship. Moreover, these findings show that the liquidity risk in the Chinese banking system does not have a first order effect when the potential gains from CCFDs are high, as measured by high *TZ*. However, when *TZ* is low, *Slope* predicts significantly lower futures excess returns in the following week. For developed markets, the total impact of *Slope* when *TZ* is low is −0.79 ($-0.46 - 0.33$, column (4)), compared to −0.33 in a "normal" week. For China, from column (8), we observe an incremental effect of −0.36 on top of a baseline effect of −0.19. This suggests that low liquidity risk in times of low potential gains predicts a significantly lower risk premium.

Table 5 provides strong evidence that the liquidity risk in the Chinese banking system can predict commodity risk premia both in developed and Chinese markets. However, the results do not support the theory of normal backwardation as we observe a lower risk premium following weeks of higher hedging demand. Our results provide new evidence of hedging pressure theory for the commodity as collaterals and add to the line of literature such as Rouwenhorst and Tang (2012), Cheng et al. (2015), and Kang et al. (2020), which complements the theory of normal backwardation by exploring other possible dynamics between the hedging demand and risk premium. One possible explanation of our results comes from a delayed hedging reaction of CCFDs investors. If there is a spillover from week t to $t+1$ on the hedging demand, we would find that liquidity risk in the Chinese banking system would predict lower excess returns in week $t+1$ as in the contemporaneous relationship.

Next, we redo the metal vs. nonmetal analysis for the predictive relationship. In Table 6, we present the results for the developed markets. For all nine specifications, we see that higher *Slope*) in week t predicts lower excess returns in week $t+1$. We do not find significant differences in metal vs. nonmetal commodities. However, comparing the results of column (4) with the ones in column (8), we find that the magnitude of the coefficient on *Slope × Low TZ* is substantially higher for metals than nonmetals. When potential gains are low, an increase of one standard deviation of *Slope* predicts a decrease of next week's metal excess returns of 1.06 percentage points ($0.91 \times (0.39 + 0.77)$). For nonmetals, the effect is a decrease of 0.52 percentage points ($0.91 \times (0.29 + 0.28)$), roughly half of the impact. In other words, this suggests that low liquidity risk in the Chinese banking system in times of low potential gains predicts a significantly lower risk premium for metals than nonmetals. Table 7 repeats the exercise for the Chinese market with qualitatively similar results.

Table 7
Metals vs. nonmetals for commodity futures risk premia in China. This table presents the panel regression results for predicting commodity futures excess returns ($Excess\ Returns^i_{t+1} = \beta_0 + \beta_1 Slope_t + \beta_2 Basis^i_t + \beta_3 TZ_t + \beta_4 Slope \times Low\ TZ_t + \beta_5 Slope \times High\ TZ_t + \gamma X_t + \epsilon^i_{t+1}$ where X_t is a vector of aggregate control variables and ϵ^i_{t+1} is an error term at week $t+1$ for commodity i) with fixed effects at the individual commodity level, but separately for metal and nonmetal commodities in China. The description of each panel is the same as in Table 4.

Variables	*A. Metals*				*B. Nonmetals*				*C. All*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
Slope	−0.20**	−0.19**	−0.13	−0.12	−0.23**	−0.24**	−0.24**	−0.22**	−0.19**
	(0.07)	(0.07)	(0.08)	(0.08)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)
Basis	0.49	0.41	0.43	0.58	−0.39**	−0.39**	−0.39**	−0.38**	−0.34**
	(0.47)	(0.48)	(0.48)	(0.49)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
TZ		−0.05	−0.27*	−0.40**		0.04	−0.15*	−0.26**	−0.31**
		(0.07)	(0.11)	(0.11)		(0.04)	(0.07)	(0.07)	(0.06)
Slope × Low TZ			−0.45**	−0.50**			−0.31**	−0.29**	−0.36**
			(0.12)	(0.12)			(0.08)	(0.08)	(0.07)
Slope × High TZ			0.01	0.13			0.11	0.21**	0.18**
			(0.09)	(0.10)			(0.06)	(0.06)	(0.05)
MSCI EM				0.05				−0.03	−0.00
				(0.05)				(0.03)	(0.03)
MSCI China				−0.04				0.01	−0.00
				(0.04)				(0.02)	(0.02)
SPX				0.05				0.09**	0.08**
				(0.03)				(0.02)	(0.02)
DXY				−0.18**				−0.11**	−0.13**
				(0.05)				(0.04)	(0.03)
BDI				−0.01				0.01	0.00
				(0.01)				(0.00)	(0.00)
TED spread				0.70				−0.29	0.04
				(0.38)				(0.22)	(0.19)
LIBOR-Repo spread				−1.42**				−0.06	−0.48**
				(0.34)				(0.20)	(0.18)
Metals × Slope									0.03
									(0.08)
Constant	0.21	0.23*	0.45**	0.65**	0.28**	0.26**	0.45**	0.62**	0.62**
	(0.11)	(0.11)	(0.14)	(0.16)	(0.07)	(0.07)	(0.09)	(0.10)	(0.08)
Observations	2352	2352	2352	2350	4885	4885	4885	4876	7226
Adjusted R^2	0.001	0.001	0.006	0.030	0.010	0.010	0.012	0.026	0.024

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$.

5.3. Robustness tests

In this subsection, we present results for five different robustness tests. In the first two tests, we modify our main independent variable *Slope*. In the third test, we compute our independent variables, futures excess returns, in a slightly different way. In the fourth test, we regress changes of futures excess return on changes of our independent variables. The last test adds commonly used liquidity measures as control variables. As a preview of the results, our main findings are robust to all five tests.

In our main analysis, we use *Slope* and *TZ* as variables related to the risk and potential gains of CCFDs, respectively. We do not claim that our *Slope* measure is a better measure of CCFD demand but that both measures contain relevant information about the demand of commodities as collateral. The results in the main analysis support this view. However, we acknowledge that both measures can be interconnected (*TZ* also uses 3-month SHIBOR). Hence in our first robustness test, we try to separate the impact of each measure. First, we regress the time series of *Slope* onto *TZ*. Given that we are interested in the part of *Slope* that is orthogonal to *TZ*, we create the variable *Residual Slope* which is the sum of the regression intercept and residual. We then repeat our main analysis by replacing the original *Slope* by *Residual Slope*. This allows us to analyze in a different way, if *Slope* contains relevant information beyond *TZ*.

Table 8 presents the results for the contemporaneous relationship. For developed markets, shown in Panel A, we observe very similar results as in the main analysis: (i) there is a negative relationship between *Residual Slope* and futures excess returns; (ii) this relationship is stronger for metals than nonmetals; (iii) the impact of *Residual Slope* is stronger in weeks of low *TZ* and non-existent in weeks of high *TZ*. For China, shown in Panel B, the results are again very similar to the ones presented in the main analysis. In China, contrary to what we observe in developed markets, we do not see a stronger impact of *Residual Slope* in metals. Note that this result mimics what we found when using the original *Slope*.

The results for the relationship between *Residual Slope* in week t and commodity futures excess returns in week $t+1$ are presented in Table 9. These are nearly identical to the ones presented and discussed in the main analysis.

In our second robustness test, we use a different definition of *Slope*. In the main analysis, *Slope* is constructed as the spread between the 3-month SHIBOR and the overnight SHIBOR. As discussed before, it is not clear which maturity to use to construct the spread to benchmark the overnight rate. Here, we test if our results are specific to that assumption, or they also hold with a different spread. Specifically, we use the spread between the 6-month and the overnight SHIBOR, which we denote by *Slope 6M*.

Table 8

TZ Residual analysis for contemporaneous commodity futures excess returns. This table presents the panel regression results for contemporaneous commodity futures excess returns ($Excess\ Returns_t^i = \beta_0 + \beta_1 Residual\ Slope_t + \beta_2 Basis_t^i + \beta_3 TZ_t + \beta_4 Residual\ Slope \times Low\ TZ_t + \beta_5 Residual\ Slope \times High\ TZ_t + \gamma X_t + \epsilon_t^i$, where $Residual\ Slope_t = \alpha_0 + \zeta_t$ from $Slope_t = \alpha_0 + \alpha_1 TZ_t + \zeta_t$, X_t is a vector of aggregate control variables, and ϵ_t^i and ζ_t are error terms at week t for commodity i) with fixed effects at the individual commodity level. Panel A columns (1) and (4) report results in developed markets (aluminum, copper, lead, zinc, gold, silver, corn, soybeans, soybean meal, soybean oil, wheat, cotton, palm oil, rubber, sugar, and heating oil). Panel A column (2) reports results in developed markets for aluminum, copper, lead, zinc, gold, and silver. Panel A column (3) reports results in developed markets for corn, soybeans, soybean meal, soybean oil, wheat, cotton, palm oil, rubber, sugar, and heating oil. Panel B reports results in Chinese commodity futures markets (aluminum, copper, lead, zinc, gold, silver, corn, soybeans, soybean meal, soybean oil, wheat, cotton, palm oil, rubber, sugar, and fuel oil). Panel B columns (1) and (4) report results in Chinese commodity futures markets (aluminum, copper, lead, zinc, gold, silver, corn, soybeans, soybean meal, soybean oil, wheat, cotton, palm oil, rubber, sugar, and fuel oil). Panel B column (2) reports results in Chinese commodity futures markets for aluminum, copper, lead, zinc, gold, and silver. Panel B column (3) reports results in Chinese commodity futures markets for corn, soybeans, soybean meal, soybean oil, wheat, cotton, palm oil, rubber, sugar, and fuel oil.

Variables	*A. Developed Markets*				*B. China*			
	All	*Metals*	*Nonmetals*	*All*	*All*	*Metals*	*Nonmetals*	*All*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Residual Slope	−0.23**	−0.38**	−0.15	−0.11	−0.23**	−0.15	−0.26**	−0.22**
	(0.07)	(0.11)	(0.09)	(0.08)	(0.05)	(0.09)	(0.06)	(0.06)
Basis	1.13**	5.54**	1.05**	1.13**	0.46**	0.45	0.46**	0.46**
	(0.16)	(1.21)	(0.16)	(0.16)	(0.07)	(0.45)	(0.07)	(0.07)
TZ	−0.07	−0.18	−0.01	−0.07	−0.18**	−0.28**	−0.15*	−0.18**
	(0.07)	(0.10)	(0.08)	(0.07)	(0.05)	(0.09)	(0.06)	(0.05)
Residual Slope × Low TZ	−0.28	−0.32	−0.27	−0.28	−0.27*	−0.37	−0.23	−0.27*
	(0.17)	(0.27)	(0.22)	(0.17)	(0.12)	(0.22)	(0.15)	(0.12)
Residual Slope × High TZ	0.26**	0.33**	0.21*	0.26**	0.32**	0.32**	0.32**	0.32**
	(0.07)	(0.11)	(0.09)	(0.07)	(0.05)	(0.09)	(0.06)	(0.05)
MSCI EM	0.20**	0.21**	0.20**	0.20**	0.15**	0.26**	0.10**	0.15**
	(0.04)	(0.06)	(0.05)	(0.04)	(0.03)	(0.05)	(0.03)	(0.03)
MSCI China	0.02	0.13**	−0.04	0.02	0.06**	0.05	0.07**	0.06**
	(0.03)	(0.04)	(0.03)	(0.03)	(0.02)	(0.04)	(0.02)	(0.02)
SPX	0.13**	0.07*	0.17**	0.13**	−0.02	−0.05	−0.01	−0.02
	(0.02)	(0.04)	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)
DXY	−0.74**	−0.86**	−0.66**	−0.74**	−0.24**	−0.37**	−0.18**	−0.24**
	(0.04)	(0.06)	(0.05)	(0.04)	(0.03)	(0.05)	(0.03)	(0.03)
BDI	0.00	−0.00	0.01	0.00	0.01*	0.01	0.01*	0.01*
	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
TED spread	−0.30	−0.60	−0.17	−0.30	0.08	−0.10	0.14	0.08
	(0.25)	(0.39)	(0.31)	(0.25)	(0.18)	(0.35)	(0.21)	(0.18)
LIBOR-Repo spread	−0.09	0.14	−0.12	−0.09	−0.57**	−0.55	−0.57**	−0.57**
	(0.23)	(0.36)	(0.29)	(0.23)	(0.17)	(0.32)	(0.20)	(0.17)
Metals × Slope				−0.32**				−0.03
				(0.12)				(0.09)
Constant	0.21**	0.47**	0.15	0.21**	0.17**	0.27*	0.14*	0.17**
	(0.08)	(0.13)	(0.10)	(0.08)	(0.06)	(0.11)	(0.07)	(0.06)
Observations	7888	2958	4930	7888	7221	2346	4875	7221
Adjusted R^2	0.158	0.229	0.127	0.159	0.108	0.167	0.086	0.108

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$.

Table 9

TZ Residual analysis for commodity futures risk premia. This table presents the panel regression results for predicting commodity futures excess returns ($Excess\ Returns^i_{t+1} = \beta_0 + \beta_1 Residual\ Slope_t + \beta_2 Basis^i_t + \beta_3 TZ_t + \beta_4 Residual\ Slope \times Low\ TZ_t + \beta_5 Residual\ Slope \times High\ TZ_t + \gamma X_t + \epsilon^i_{t+1}$, where $Residual\ Slope_t = \alpha_0 + \zeta_t$ from $Slope_t = \alpha_0 + \alpha_1 TZ_t + \zeta_t$, X_t is a vector of aggregate control variables, and ϵ^i_{t+1} and ζ_t are error terms at week $t+1$ and t with commodity i, respectively) with fixed effects at the individual commodity level. The description of each column is the same as in Table 8.

Variables	*A. Developed Markets*				*B. China*			
	All (1)	*Metals* (2)	*Nonmetals* (3)	*All* (4)	*All* (5)	*Metals* (6)	*Nonmetals* (7)	*All* (8)
Residual Slope	−0.33**	−0.40**	−0.30**	−0.28**	−0.19**	−0.12	−0.23**	−0.21**
	(0.06)	(0.10)	(0.08)	(0.07)	(0.04)	(0.08)	(0.05)	(0.05)
Basis	−0.20	1.16	−0.20	−0.20	−0.34**	0.57	−0.37**	−0.34**
	(0.17)	(1.36)	(0.18)	(0.17)	(0.07)	(0.49)	(0.07)	(0.07)
TZ	−0.38**	−0.61**	−0.25*	−0.38**	−0.39**	−0.48**	−0.33**	−0.39**
	(0.09)	(0.15)	(0.11)	(0.09)	(0.06)	(0.12)	(0.07)	(0.06)
Residual Slope × Low TZ	−0.47**	−0.77**	−0.28*	−0.47**	−0.36**	−0.53**	−0.28**	−0.36**
	(0.10)	(0.17)	(0.13)	(0.10)	(0.07)	(0.12)	(0.08)	(0.07)
Residual Slope × High TZ	0.27**	0.27*	0.26**	0.27**	0.19**	0.15	0.22**	0.20**
	(0.08)	(0.13)	(0.10)	(0.08)	(0.05)	(0.10)	(0.06)	(0.05)
MSCI EM	0.04	0.04	0.03	0.04	−0.00	0.05	−0.03	−0.00
	(0.04)	(0.06)	(0.05)	(0.04)	(0.03)	(0.05)	(0.03)	(0.03)
MSCI China	−0.07*	−0.09*	−0.06	−0.07*	−0.01	−0.04	0.01	−0.01
	(0.03)	(0.05)	(0.04)	(0.03)	(0.02)	(0.04)	(0.02)	(0.02)
SPX	0.06*	0.03	0.07*	0.06*	0.08**	0.05	0.09**	0.08**
	(0.02)	(0.04)	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)
DXY	−0.02	−0.05	0.00	−0.02	−0.13**	−0.18**	−0.11**	−0.13**
	(0.04)	(0.07)	(0.05)	(0.04)	(0.03)	(0.05)	(0.04)	(0.03)
BDI	0.01	−0.01	0.02**	0.01	0.00	−0.01	0.01	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)
TED spread	−0.77**	−0.45	−0.98**	−0.77**	0.04	0.72	−0.30	0.04
	(0.27)	(0.44)	(0.34)	(0.27)	(0.19)	(0.38)	(0.22)	(0.19)
LIBOR-Repo spread	0.14	−0.43	0.51	0.14	−0.47**	−1.41**	−0.04	−0.47**
	(0.25)	(0.41)	(0.31)	(0.25)	(0.18)	(0.34)	(0.20)	(0.18)
Metals × Slope				−0.14				0.05
				(0.11)				(0.08)
Constant	1.07**	1.48**	0.85**	1.07**	0.64**	0.69**	0.63**	0.64**
	(0.12)	(0.21)	(0.15)	(0.12)	(0.09)	(0.16)	(0.10)	(0.09)
Observations	7888	2958	4930	7888	7226	2350	4876	7226
Adjusted R^2	0.012	0.021	0.009	0.012	0.024	0.030	0.025	0.024

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$.

Table 10

Robustness to slope with the spread between 6-month SHIBOR and Overnight SHIBOR for contemporaneous commodity futures excess returns. This table presents the panel regression results for contemporaneous commodity futures excess returns ($Excess\ Returns_t^i = \beta_0 + \beta_1 Slope\ 6M_t + \beta_2 Basis_t^i + \beta_3 TZ_t + \beta_4 Slope\ 6M \times Low\ TZ_t + \beta_5 Slope\ 6M \times High\ TZ_t + \gamma X_t + \epsilon_t^i$ where X_t is a vector of aggregate control variables and ϵ_t^i is an error term at week t for commodity i) with fixed effects at the individual commodity level. The description of each column is the same as in Table 8.

Variables	A. Developed Markets				B. China			
	All (1)	*Metals* (2)	*Nonmetals* (3)	*All* (4)	*All* (5)	*Metals* (6)	*Nonmetals* (7)	*All* (8)
Slope 6M	−0.15**	−0.26**	−0.09	−0.08	−0.16**	−0.08	−0.21**	−0.17**
	(0.05)	(0.09)	(0.07)	(0.06)	(0.04)	(0.07)	(0.05)	(0.05)
Basis	1.11**	5.47**	1.03**	1.12**	0.46**	0.43	0.46**	0.46**
	(0.16)	(1.21)	(0.16)	(0.16)	(0.07)	(0.45)	(0.07)	(0.07)
TZ	−0.06	−0.06	−0.06	−0.06	−0.21**	−0.24*	−0.20**	−0.21**
	(0.08)	(0.12)	(0.10)	(0.08)	(0.06)	(0.10)	(0.07)	(0.06)
Slope 6M × Low TZ	−0.09	0.05	−0.19	−0.09	−0.16**	−0.10	−0.19**	−0.16**
	(0.09)	(0.14)	(0.11)	(0.09)	(0.06)	(0.10)	(0.07)	(0.06)
Slope 6M × High TZ	0.23**	0.27*	0.20*	0.23**	0.30**	0.25**	0.33**	0.30**
	(0.07)	(0.11)	(0.09)	(0.07)	(0.05)	(0.09)	(0.06)	(0.05)
MSCI EM	0.21**	0.22**	0.20**	0.21**	0.15**	0.27**	0.10**	0.15**
	(0.04)	(0.06)	(0.05)	(0.04)	(0.03)	(0.05)	(0.03)	(0.03)
MSCI China	0.02	0.13**	−0.04	0.02	0.06**	0.05	0.07**	0.06**
	(0.03)	(0.04)	(0.03)	(0.03)	(0.02)	(0.04)	(0.02)	(0.02)
SPX	0.13**	0.07	0.17**	0.13**	−0.02	−0.05	−0.01	−0.02
	(0.02)	(0.04)	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)
DXY	−0.74**	−0.86**	−0.67**	−0.74**	−0.25**	−0.37**	−0.19**	−0.25**
	(0.04)	(0.06)	(0.05)	(0.04)	(0.03)	(0.05)	(0.03)	(0.03)
BDI	0.00	−0.00	0.01	0.00	0.01*	0.01	0.01*	0.01*
	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
TED spread	−0.25	−0.59	−0.10	−0.25	0.15	−0.04	0.21	0.15
	(0.25)	(0.39)	(0.32)	(0.25)	(0.18)	(0.35)	(0.22)	(0.18)
LIBOR-Repo spread	−0.10	0.15	−0.15	−0.10	−0.61**	−0.58	−0.61**	−0.61**
	(0.23)	(0.36)	(0.29)	(0.23)	(0.17)	(0.32)	(0.20)	(0.17)
Metals × Slope 6M				−0.18				0.03
				(0.09)				(0.07)
Constant	0.44**	0.75**	0.36*	0.44**	0.46**	0.39**	0.51**	0.46**
	(0.11)	(0.19)	(0.14)	(0.11)	(0.08)	(0.15)	(0.10)	(0.08)
Observations	7888	2958	4930	7888	7221	2346	4875	7221
Adjusted R^2	0.157	0.226	0.126	0.157	0.106	0.163	0.085	0.106

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$.

Table 10 presents the results for the contemporaneous relationship between *Slope 6M* and commodity futures excess returns. Columns (1) and (5) should be compared with columns (4) and (8) of Table 2. Columns (2)–(4) should be compared with columns (4), (8) and (9) of Table 3. Finally, columns (6)–(8) should be compared with columns (4), (8) and (9) of Table 4.

The results presented in Table 10 are very similar to the ones presented in the main analysis. First, when looking at all commodities, the coefficients on *Slope 6M* are significant, negative, and similar in magnitude both for developed markets and China. Second, the impact of *Slope 6M* is higher for metals than nonmetals in developed markets. For China, as before, we do not observe a stronger impact of the Chinese interbank liquidity risk on metals. Third, we still see an interaction effect between *Slope 6M* and *TZ*. Namely, in weeks of high *TZ*, there is no negative impact of *Slope* on commodity futures excess returns both for developed markets and China.

Table 11 shows the results for the predictive relationship using the new definition of *Slope 6M*. Comparing these results with the ones in the main analysis (Tables 5–7) we find hardly any differences. Low liquidity risk as measured by high *Slope 6M* predicts lower commodity futures risk premia. In developed markets, the impact of *Slope 6M* is stronger for metals than for nonmetals. Looking at the interaction between *Slope 6M* and *TZ*, as in the main analysis, we find that the impact of Chinese interbank liquidity risk in commodity markets is higher when *TZ* is low. In summary, these results show that using either the 3-month or 6-month SHIBOR as the benchmark rate in the spread leads to nearly identical results both for the contemporaneous and predictive relationships.

For our third robustness test, we modify the way we compute our dependent variable: the commodity excess return. Recall from Eq. (1) that F_{t+1,T_1}^i is the futures price of the commodity i at the end of week $t+1$, on the nearest contract whose expiration date is T_1. Here, we repeat the analysis but instead of using the nearest future, we use the price of the second nearest future. We do so to check if the results are sensitive to the choice of which futures contract used when computing returns. Tables 12 and 13 present the results for, respectively, the contemporaneous and predictive regressions. We do not find any significant differences from the main analysis. Thus, our results are not specific to the nearest contract future.

In our fourth robustness test, we run changes-on-changes regressions for the predictive results. In our main analysis, we show that *Slope* predicts commodities risk-premium. However, one may worry that the predictive results just stem from the contemporaneous relationship and, potentially, sticky commodity excess returns. To rule out this concern, we first computed the autocorrelation of the excess returns by the Ljung–box test and found that only one out of 14 (4 out 14) of commodities in developed markets (in China) exhibit significant one-week lag autocorrelation of the excess returns. Moreover, in Table 14 we present the results for the predictive relationship where we regress changes on risk premia on changes of all independent variables. We find that changes in *Slope* predict

Table 11

Robustness to slope with the spread between 6-month SHIBOR and Overnight SHIBOR for commodity futures risk premia. This table presents the panel regression results for predicting 2nd nearest commodity futures excess returns ($Excess\ Returns^i_{t+1} = \beta_0 + \beta_1 Slope\ 6M_t + \beta_2 Basis^i_t + \beta_3 TZ_t + \beta_4 Slope\ 6M \times Low\ TZ_t + \beta_5 Slope\ 6M \times High\ TZ_t + \gamma X_t + \epsilon^i_{t+1}$ where X_t is a vector of aggregate control variables and ϵ^i_{t+1} is an error term at week $t+1$ for commodity i) with fixed effects at the individual commodity level. The description of each column is the same as in Table 8.

Variables	*A. Developed Markets*				*B. China*			
	All *(1)*	*Metals* *(2)*	*Nonmetals* *(3)*	*All* *(4)*	*All* *(5)*	*Metals* *(6)*	*Nonmetals* *(7)*	*All* *(8)*
Slope 6M	−0.30**	−0.34**	−0.29**	−0.25**	−0.18**	−0.09	−0.23**	−0.19**
	(0.06)	(0.10)	(0.07)	(0.07)	(0.04)	(0.07)	(0.05)	(0.05)
Basis	−0.21	1.14	−0.21	−0.21	−0.35**	0.55	−0.38**	−0.35**
	(0.17)	(1.36)	(0.18)	(0.17)	(0.07)	(0.49)	(0.07)	(0.07)
TZ	−0.28**	−0.49**	−0.16	−0.28**	−0.32**	−0.38**	−0.28**	−0.32**
	(0.08)	(0.14)	(0.10)	(0.08)	(0.06)	(0.11)	(0.07)	(0.06)
Slope 6M × Low TZ	−0.40**	−0.70**	−0.21	−0.40**	−0.30**	−0.43**	−0.23**	−0.30**
	(0.09)	(0.15)	(0.12)	(0.09)	(0.06)	(0.11)	(0.08)	(0.06)
Slope 6M × High TZ	0.22**	0.20	0.24*	0.22**	0.17**	0.08	0.22**	0.17**
	(0.08)	(0.13)	(0.10)	(0.08)	(0.05)	(0.10)	(0.06)	(0.05)
MSCI EM	0.04	0.05	0.03	0.04	−0.00	0.05	−0.02	−0.00
	(0.04)	(0.06)	(0.05)	(0.04)	(0.03)	(0.05)	(0.03)	(0.03)
MSCI China	−0.07*	−0.09	−0.06	−0.07*	−0.00	−0.04	0.01	−0.00
	(0.03)	(0.05)	(0.04)	(0.03)	(0.02)	(0.04)	(0.02)	(0.02)
SPX	0.06*	0.03	0.07*	0.06*	0.08**	0.05	0.09**	0.08**
	(0.02)	(0.04)	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)
DXY	−0.02	−0.06	0.00	−0.02	−0.13**	−0.18**	−0.11**	−0.13**
	(0.04)	(0.07)	(0.05)	(0.04)	(0.03)	(0.05)	(0.04)	(0.03)
BDI	0.01	−0.01	0.02**	0.01	0.00	−0.01	0.01	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)
TED spread	−0.76**	−0.43	−0.98**	−0.76**	0.04	0.70	−0.30	0.04
	(0.27)	(0.44)	(0.34)	(0.27)	(0.19)	(0.38)	(0.22)	(0.19)
LIBOR-Repo spread	0.17	−0.39	0.53	0.17	−0.45*	−1.38**	−0.03	−0.45*
	(0.25)	(0.41)	(0.31)	(0.25)	(0.18)	(0.34)	(0.20)	(0.18)
Metals × Slope 6M				−0.14				0.04
				(0.10)				(0.07)
Constant	1.01**	1.39**	0.82**	1.01**	0.61**	0.61**	0.63**	0.61**
	(0.12)	(0.21)	(0.15)	(0.12)	(0.09)	(0.16)	(0.10)	(0.09)
Observations	7888	2958	4930	7888	7226	2350	4876	7226
Adjusted R^2	0.011	0.020	0.009	0.011	0.024	0.028	0.025	0.024

Standard errors in parentheses.
* $p < 0.05$, ** $p < 0.01$.

Table 12
Contemporaneous 2nd nearest commodity futures excess returns. This table presents the panel regression results for contemporaneous 2nd nearest commodity futures excess returns ($Excess\ Returns_t^i = \beta_0 + \beta_1 Slope_t + \beta_2 Basis_t^i + \beta_3 TZ_t + \beta_4 Slope \times Low\ TZ_t + \beta_5 Slope \times High\ TZ_t + \gamma X_t + \epsilon_t^i$ where X_t is a vector of aggregate control variables and ϵ_t^i is an error term at week t for commodity i) with fixed effects at the individual commodity level. The description of each column is the same as in Table 8.

Variables	*A. Developed Markets*				*B. China*			
	All (1)	*Metals* (2)	*Nonmetals* (3)	*All* (4)	*All* (5)	*Metals* (6)	*Nonmetals* (7)	*All* (8)
Slope	−0.17**	−0.31**	−0.10	−0.08	−0.14**	−0.10	−0.16**	−0.12**
	(0.06)	(0.09)	(0.07)	(0.07)	(0.04)	(0.07)	(0.05)	(0.05)
Basis	0.64**	5.04**	0.55**	0.64**	−0.45**	−1.01*	−0.44**	−0.46**
	(0.16)	(1.21)	(0.16)	(0.16)	(0.07)	(0.46)	(0.07)	(0.07)
TZ	−0.04	−0.07	−0.03	−0.04	−0.21**	−0.34**	−0.17*	−0.21**
	(0.07)	(0.12)	(0.09)	(0.07)	(0.06)	(0.10)	(0.07)	(0.06)
Slope × Low TZ	−0.11	0.03	−0.20	−0.11	−0.14*	−0.13	−0.16*	−0.15*
	(0.09)	(0.15)	(0.11)	(0.09)	(0.07)	(0.11)	(0.08)	(0.07)
Slope × High TZ	0.29**	0.33**	0.26**	0.29**	0.33**	0.32**	0.33**	0.33**
	(0.07)	(0.11)	(0.09)	(0.07)	(0.05)	(0.09)	(0.06)	(0.05)
MSCI EM	0.21**	0.22**	0.21**	0.21**	0.15**	0.27**	0.10**	0.15**
	(0.03)	(0.06)	(0.04)	(0.03)	(0.03)	(0.05)	(0.03)	(0.03)
MSCI China	0.02	0.13**	−0.05	0.02	0.06**	0.06	0.06*	0.06**
	(0.03)	(0.04)	(0.03)	(0.03)	(0.02)	(0.04)	(0.02)	(0.02)
SPX	0.13**	0.07*	0.16**	0.13**	−0.00	−0.06*	0.02	−0.00
	(0.02)	(0.04)	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)
DXY	−0.74**	−0.86**	−0.67**	−0.74**	−0.26**	−0.39**	−0.19**	−0.26**
	(0.04)	(0.06)	(0.05)	(0.04)	(0.03)	(0.05)	(0.03)	(0.03)
BDI	0.00	−0.00	0.01	0.00	0.01*	0.01	0.01*	0.01*
	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
TED spread	−0.42	−0.62	−0.35	−0.42	−0.05	−0.03	−0.05	−0.06
	(0.24)	(0.39)	(0.30)	(0.24)	(0.18)	(0.35)	(0.22)	(0.18)
LIBOR-Repo spread	−0.02	0.14	−0.02	−0.02	−0.45**	−0.61	−0.39*	−0.45**
	(0.22)	(0.36)	(0.28)	(0.22)	(0.17)	(0.32)	(0.20)	(0.17)
Metals × Slope				−0.25**				−0.05
				(0.09)				(0.07)
Constant	0.47**	0.80**	0.37**	0.47**	0.38**	0.40**	0.37**	0.38**
	(0.11)	(0.18)	(0.14)	(0.11)	(0.08)	(0.15)	(0.10)	(0.08)
Observations	7888	2958	4930	7888	7221	2346	4875	7221
Adjusted R^2	0.164	0.227	0.135	0.165	0.111	0.172	0.088	0.111

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$.

Table 13

2nd nearest commodity futures risk premia. This table presents the panel regression results for predicting 2nd nearest commodity futures excess returns ($Excess\ Returns^i_{t+1} = \beta_0 + \beta_1 Slope_t + \beta_2 Basis^i_t + \beta_3 TZ_t + \beta_4 Slope \times Low\ TZ_t + \beta_5 Slope \times High\ TZ_t + \gamma X_t + \epsilon^i_{t+1}$ where X_t is a vector of aggregate control variables and ϵ^i_{t+1} is an error term at week $t+1$ for commodity i) with fixed effects at the individual commodity level. The description of each column is the same as in Table 8.

Variables	*A. Developed Markets*				*B. China*			
	All (1)	*Metals* (2)	*Nonmetals* (3)	*All* (4)	*All* (5)	*Metals* (6)	*Nonmetals* (7)	*All* (8)
Slope	−0.32**	−0.40**	−0.28**	−0.25**	−0.19**	−0.14	−0.21**	−0.18**
	(0.06)	(0.10)	(0.07)	(0.07)	(0.04)	(0.08)	(0.05)	(0.05)
Basis	0.02	1.49	0.01	0.02	0.35**	1.55**	0.31**	0.35**
	(0.17)	(1.36)	(0.17)	(0.17)	(0.08)	(0.49)	(0.07)	(0.08)
TZ	−0.25**	−0.46**	−0.13	−0.25**	−0.26**	−0.36**	−0.19**	−0.26**
	(0.08)	(0.14)	(0.10)	(0.08)	(0.06)	(0.11)	(0.07)	(0.06)
Slope × Low TZ	−0.46**	−0.77**	−0.27*	−0.46**	−0.32**	−0.50**	−0.24**	−0.32**
	(0.10)	(0.17)	(0.12)	(0.10)	(0.07)	(0.12)	(0.08)	(0.07)
Slope × High TZ	0.25**	0.24	0.26**	0.25**	0.18**	0.14	0.20**	0.18**
	(0.07)	(0.13)	(0.09)	(0.07)	(0.05)	(0.10)	(0.06)	(0.05)
MSCI EM	0.03	0.05	0.03	0.03	−0.00	0.04	−0.02	−0.00
	(0.04)	(0.06)	(0.05)	(0.04)	(0.03)	(0.05)	(0.03)	(0.03)
MSCI China	−0.06*	−0.09*	−0.05	−0.06*	−0.01	−0.03	0.00	−0.01
	(0.03)	(0.05)	(0.03)	(0.03)	(0.02)	(0.04)	(0.02)	(0.02)
SPX	0.05*	0.03	0.07*	0.05*	0.08**	0.05	0.09**	0.08**
	(0.02)	(0.04)	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)
DXY	−0.03	−0.05	−0.01	−0.03	−0.14**	−0.18**	−0.12**	−0.14**
	(0.04)	(0.07)	(0.05)	(0.04)	(0.03)	(0.05)	(0.04)	(0.03)
BDI	0.01	−0.01	0.02**	0.01	0.00	−0.01	0.01*	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)
TED spread	−0.82**	−0.46	−1.04**	−0.82**	−0.15	0.37	−0.45*	−0.15
	(0.26)	(0.44)	(0.32)	(0.26)	(0.19)	(0.38)	(0.22)	(0.19)
LIBOR-Repo spread	0.15	−0.44	0.54	0.15	−0.34	−1.23**	0.08	−0.34
	(0.24)	(0.41)	(0.30)	(0.24)	(0.18)	(0.34)	(0.21)	(0.18)
Metals × Slope				−0.19				−0.01
				(0.10)				(0.08)
Constant	1.04**	1.46**	0.82**	1.04**	0.62**	0.75**	0.58**	0.62**
	(0.12)	(0.21)	(0.15)	(0.12)	(0.09)	(0.16)	(0.10)	(0.09)
Observations	7888	2958	4930	7888	7226	2350	4876	7226
Adjusted R^2	0.012	0.022	0.010	0.013	0.023	0.033	0.023	0.023

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$.

Table 14

Change-on-change test for commodity futures risk premia. This table presents change-on-change test for commodity futures excess returns ($\Delta Excess\ Returns^i_{t+1} = \beta_0 + \beta_1 \Delta Slope_t + \beta_2 \Delta Basis^i_t + \beta_3 \Delta TZ_t + \beta_4 \Delta Slope \times Low\ \Delta TZ_t + \beta_5 \Delta Slope \times High\ \Delta TZ_t + \gamma \Delta X_t + \epsilon^i_{t+1}$ where $Low\ \Delta TZ$ and $High\ \Delta TZ$ are dummy variables equal to 1 if ΔTZ in that particular week is in the bottom or top quartile of the ΔTZ distribution, respectively, X_t is a vector of aggregate control variables, and ϵ^i_{t+1} is an error term at week $t+1$ for commodity i) with fixed effects at the individual commodity level. The description of each column is the same as in Table 8.

Variables	A. Developed Markets				B. China			
	All (1)	*Metals* (2)	*Nonmetals* (3)	*All* (4)	*All* (5)	*Metals* (6)	*Nonmetals* (7)	*All* (8)
Δ Slope	−0.32*	−0.21*	−0.10	−0.26	−0.01	−0.03	0.02	0.04
	(0.14)	(0.09)	(0.11)	(0.16)	(0.09)	(0.06)	(0.07)	(0.10)
Δ Basis	−3.64**	−12.59**	−3.53**	−3.64**	−1.38**	−1.21**	−1.39**	−1.38**
	(0.46)	(2.37)	(0.36)	(0.46)	(0.12)	(0.46)	(0.10)	(0.12)
Δ TZ	−1.44**	−0.51**	−0.93**	−1.44**	−0.73**	−0.19*	−0.54**	−0.73**
	(0.21)	(0.14)	(0.17)	(0.21)	(0.13)	(0.08)	(0.11)	(0.13)
Δ Slope × Low Δ TZ	0.18	0.16	0.02	0.18	−0.17	−0.06	−0.11	−0.17
	(0.20)	(0.13)	(0.16)	(0.20)	(0.13)	(0.08)	(0.10)	(0.13)
Δ Slope × High Δ TZ	0.19	0.15	0.04	0.19	0.05	−0.04	0.09	0.05
	(0.24)	(0.15)	(0.19)	(0.24)	(0.15)	(0.09)	(0.12)	(0.15)
Δ MSCI EM	−0.13**	−0.04	−0.09**	−0.13**	−0.10**	−0.04**	−0.06**	−0.10**
	(0.04)	(0.02)	(0.03)	(0.04)	(0.02)	(0.01)	(0.02)	(0.02)
Δ MSCI China	−0.08**	−0.05**	−0.02	−0.08**	−0.01	−0.00	−0.00	−0.01
	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.01)	(0.01)	(0.02)
Δ SPX	0.01	0.00	0.01	0.01	0.05**	0.01	0.04**	0.05**
	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
Δ DXY	0.33**	0.16**	0.17**	0.33**	0.01	0.02	−0.01	0.01
	(0.04)	(0.03)	(0.03)	(0.04)	(0.03)	(0.02)	(0.02)	(0.03)
Δ BDI	0.01	−0.01**	0.02**	0.01	−0.01	−0.01**	0.00	−0.01
	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
Δ TED spread	−1.39**	−0.49	−0.90*	−1.39**	0.38	0.38	−0.01	0.38
	(0.52)	(0.34)	(0.41)	(0.52)	(0.33)	(0.20)	(0.26)	(0.33)
Δ LIBOR-Repo spread	0.92*	0.03	0.86*	0.92*	−0.20	−0.45*	0.26	−0.20
	(0.46)	(0.30)	(0.36)	(0.46)	(0.29)	(0.18)	(0.23)	(0.29)
Metals × Δ Slope				−0.17				−0.12
				(0.18)				(0.11)
Constant	−0.01	−0.01	−0.01	−0.01	−0.00	0.00	−0.00	−0.00
	(0.06)	(0.04)	(0.05)	(0.06)	(0.04)	(0.02)	(0.03)	(0.04)
Observations	7872	7872	7872	7872	7872	7872	7872	7872
Adjusted R^2	0.061	0.034	0.036	0.061	0.033	0.009	0.033	0.033

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$.

Table 15

Robustness to various types of funding liquidity risk for contemporaneous commodity futures excess returns. This table presents the panel regression results for contemporaneous commodity futures excess returns ($(Excess\ Returns^i_t = \beta_0+\beta_1 Slope_t+\beta_2 Basis^i_t+\beta_3 TZ_t+\beta_4 Slope \times Low\ TZ_t+\beta_5 Slope \times High\ TZ_t+\gamma X_t+\epsilon^i_t$ where X_t is a vector of aggregate control variables and ϵ^i_t is an error term at week t for commodity i) with fixed effects at the individual commodity level to show robustness of our results to various types of funding liquidity risk. Panel A including columns (1) to (4) reports results in developed markets (aluminum, copper, lead, zinc, gold, silver, corn, soybeans, soybean meal, soybean oil, wheat, cotton, palm oil, rubber, sugar, and heating oil). Panel B reports results in Chinese commodity futures markets (aluminum, copper, lead, zinc, gold, silver, corn, soybeans, soybean meal, soybean oil, wheat, cotton, palm oil, rubber, sugar, and fuel oil). We first add each of the extra liquidity measures, the Swap-Tbill spread (USD) (columns (1) and (5)), the 3M SHIBOR-3M Repo spread (CNY) (columns (2) and (6)), and the SHIBOR 3M-1M spread (CNY) (columns (3) and (7)). Lastly, we include all the extra liquidity measures together (columns (4) and (8)).

Variables	*A. Developed markets*				*B. China*			
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Slope	−0.18**	−0.20**	−0.23**	−0.23**	−0.19**	−0.22**	−0.23**	−0.27**
	(0.06)	(0.06)	(0.07)	(0.08)	(0.04)	(0.04)	(0.05)	(0.05)
Basis	1.12**	1.12**	1.12**	1.12**	0.46**	0.46**	0.47**	0.46**
	(0.16)	(0.16)	(0.16)	(0.16)	(0.07)	(0.07)	(0.07)	(0.07)
TZ	−0.08	−0.07	−0.07	−0.07	−0.23**	−0.20**	−0.21**	−0.21**
	(0.08)	(0.08)	(0.08)	(0.08)	(0.06)	(0.06)	(0.06)	(0.06)
Slope × Low TZ	−0.13	−0.12	−0.12	−0.12	−0.18**	−0.19**	−0.18**	−0.16*
	(0.09)	(0.09)	(0.09)	(0.09)	(0.07)	(0.07)	(0.07)	(0.07)
Slope × High TZ	0.27**	0.28**	0.28**	0.28**	0.34**	0.35**	0.34**	0.36**
	(0.07)	(0.07)	(0.07)	(0.07)	(0.05)	(0.05)	(0.05)	(0.05)
MSCI EM	0.21**	0.21**	0.21**	0.21**	0.15**	0.15**	0.15**	0.14**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)
MSCI China	0.02	0.02	0.02	0.02	0.07**	0.06**	0.06**	0.07**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)
SPX	0.13**	0.13**	0.13**	0.13**	−0.02	−0.02	−0.03	−0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
DXY	−0.74**	−0.74**	−0.74**	−0.74**	−0.24**	−0.24**	−0.24**	−0.24**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)
BDI	0.00	0.00	0.00	0.00	0.01*	0.01*	0.01*	0.01*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
TED spread	−0.36	−0.25	−0.26	−0.26	0.61*	0.17	0.14	0.81**
	(0.40)	(0.25)	(0.25)	(0.41)	(0.30)	(0.18)	(0.18)	(0.30)
LIBOR-Repo spread	−0.13	−0.13	−0.15	−0.15	−0.58**	−0.65**	−0.67**	−0.60**
	(0.23)	(0.23)	(0.23)	(0.23)	(0.17)	(0.17)	(0.17)	(0.17)
Swap-Tbill spread	0.12			0.00	−0.56*			−0.77**
	(0.38)			(0.39)	(0.28)			(0.29)
SHIBOR-Repo spread		0.07		0.01		0.17**		0.16
		(0.09)		(0.12)		(0.06)		(0.08)
SHIBOR 3M-1M spread			0.09	0.08			0.12*	0.06
			(0.08)	(0.11)			(0.06)	(0.08)
Constant	0.46**	0.51**	0.54**	0.54**	0.56**	0.54**	0.54**	0.70**
	(0.13)	(0.12)	(0.12)	(0.15)	(0.09)	(0.08)	(0.09)	(0.11)
Observations	7888	7888	7888	7888	7221	7221	7221	7221
Adjusted R^2	0.158	0.158	0.158	0.157	0.108	0.108	0.108	0.109

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$.

changes in commodities risk premia in developed markets and, particularly, in metal commodities. For the Chinese market, we do not find a predictive relationship. The results are in line with the ones found in the main analysis as these are consistent with hedging being done outside China (See the related discussion in Section 3.1).

Finally, we test for the robustness of our results controlling for other types of funding liquidity risk. Recall that in the main analysis, regressions with the full set of controls included the TED spread and the LIBOR-Repo spread to control for general funding liquidity shocks from global markets. Following Asness et al. (2013), we add one more liquidity measure for global market conditions, the spread between the interest rate swaps and the short-term U.S. Treasury bill rate (*Swap-Tbill spread*). Moreover, we also include the Chinese version of LIBOR-Repo which is defined as the spread between the 3-month SHIBOR and the term repurchase rate in China (*SHIBOR-Repo spread*). This should control for the general funding liquidity risk specific to China. Lastly, we include the spread between the 3-month SHIBOR and the 1-month SHIBOR (*SHIBOR 3M-1M spread*) to confirm the importance of the overnight SHIBOR. Commercial banks trying to resolve their maturity mismatch problems depend on short-term interbank liquidity, often overnight. Hence, we would not expect this spread to eliminate the impact of *Slope*.

In Panel A of Table 15, we present the results for the contemporaneous regressions with the full set of controls in developed markets where we add each of our extra liquidity measures in columns (1) to (3) and then all the measures together in column (4). In a nutshell, the effect of *Slope* on developed commodity futures markets is robust to the inclusion of other types of funding liquidity risk. When we add each of the additional liquidity measures, the coefficient on *Slope* remains close to −20 bps per week. Moreover, none of the new liquidity measures are significant. Panel B, which presents the results for China, shows similar findings. Note that of the new measures added, only *Swap-Tbill spread* is significant when all measures are included.

Lastly, Table 16 presents the results for the predictive regressions. Again, we see that the coefficients on *Slope* continue to be significant and around −35 bps per week for developed markets and around −20 bps for China. The effect of shadow banking risk on commodity markets is much stronger in weeks when *TZ* is low. Of the new liquidity measures, only *Swap-Tbill spread* is significant

Table 16

Robustness to various types of funding liquidity risk for commodity futures risk premia. This table presents the panel regression results for predicting commodity futures excess returns ($Excess\ Returns^i_{t+1} = \beta_0 + \beta_1 Slope_t + \beta_2 Basis^i_t + \beta_3 TZ_t + \beta_4 Slope \times Low\ TZ_t + \beta_5 Slope \times High\ TZ_t + \gamma X_t + \epsilon^i_{t+1}$ where X_t is a vector of aggregate control variables and ϵ^i_{t+1} is an error term at week $t+1$ for commodity i) with fixed effects at the individual commodity level to show robustness of our results to various types of funding liquidity risk. Panel A including columns (1) to (4) reports results in developed markets (aluminum, copper, lead, zinc, gold, silver, corn, soybeans, soybean meal, soybean oil, wheat, cotton, palm oil, rubber, sugar, and heating oil). Panel B reports results in Chinese commodity futures markets (aluminum, copper, lead, zinc, gold, silver, corn, soybeans, soybean meal, soybean oil, wheat, cotton, palm oil, rubber, sugar, and fuel oil). We first add each of the extra liquidity measures, the Swap-Tbill spread (USD) (columns (1) and (5)), the 3M SHIBOR — 3M Repo spread (CNY) (columns (2) and (6)), and the SHIBOR 3M-1M spread (CNY) (columns (3) and (7)). Lastly, we include all the extra liquidity measures together (columns (4) and (8)).

Variables	*A. Developed markets*				*B. China*			
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Slope	−0.36**	−0.34**	−0.32**	−0.38**	−0.19**	−0.21**	−0.21**	−0.21**
	(0.06)	(0.07)	(0.08)	(0.08)	(0.04)	(0.05)	(0.05)	(0.06)
Basis	−0.22	−0.20	−0.20	−0.22	−0.34**	−0.34**	−0.34**	−0.34**
	(0.17)	(0.17)	(0.17)	(0.17)	(0.07)	(0.07)	(0.07)	(0.07)
TZ	−0.29**	−0.27**	−0.27**	−0.28**	−0.32**	−0.31**	−0.31**	−0.31**
	(0.08)	(0.08)	(0.08)	(0.08)	(0.06)	(0.06)	(0.06)	(0.06)
Slope × Low TZ	−0.44**	−0.46**	−0.46**	−0.43**	−0.36**	−0.36**	−0.36**	−0.35**
	(0.10)	(0.10)	(0.10)	(0.10)	(0.07)	(0.07)	(0.07)	(0.07)
Slope × High TZ	0.26**	0.25**	0.25**	0.26**	0.18**	0.19**	0.18**	0.19**
	(0.08)	(0.08)	(0.08)	(0.08)	(0.05)	(0.05)	(0.05)	(0.05)
MSCI EM	0.02	0.04	0.04	0.02	−0.00	−0.00	−0.00	−0.00
	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)
MSCI China	−0.06*	−0.07*	−0.07*	−0.06*	−0.00	−0.00	−0.00	−0.00
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)
SPX	0.07**	0.06*	0.06*	0.07**	0.08**	0.08**	0.08**	0.08**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
DXY	−0.01	−0.02	−0.02	−0.01	−0.13**	−0.13**	−0.13**	−0.13**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)
BDI	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
TED spread	0.12	−0.77**	−0.78**	0.18	0.11	0.05	0.04	0.18
	(0.43)	(0.27)	(0.27)	(0.44)	(0.31)	(0.19)	(0.19)	(0.32)
LIBOR-Repo spread	0.23	0.12	0.13	0.22	−0.47**	−0.50**	−0.50**	−0.48**
	(0.25)	(0.25)	(0.25)	(0.25)	(0.18)	(0.18)	(0.18)	(0.18)
Swap-Tbill spread	−1.09**			−1.15**	−0.08			−0.15
	(0.41)			(0.43)	(0.29)			(0.30)
SHIBOR-Repo spread		0.02		0.07		0.09		0.11
		(0.09)		(0.12)		(0.07)		(0.09)
SHIBOR 3M-1M spread			−0.03	0.00			0.04	−0.02
			(0.09)	(0.12)			(0.06)	(0.08)
Constant	1.23**	1.05**	1.02**	1.26**	0.63**	0.65**	0.64**	0.67**
	(0.14)	(0.13)	(0.13)	(0.16)	(0.10)	(0.09)	(0.09)	(0.11)
Observations	7888	7888	7888	7888	7226	7226	7226	7226
Adjusted R^2	0.013	0.012	0.012	0.012	0.024	0.025	0.024	0.024

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$.

and only for developed markets. The results highlight the significance of *Slope* as a novel liquidity measure and how it impacts commodity markets.

6. Conclusion

In this paper, we show that liquidity risk in the Chinese banking system impacts commodity futures markets, through the CCFDs channel. Due to capital restrictions, investors engage in CCFDs by importing and collateralizing commodities, and subsequently, investing in high-yielding banking products in China. We show that the liquidity risk of the Chinese banking system affects the attractiveness of these CCFDs and, ultimately, affects commodity markets.

We focus on liquidity risk of the Chinese interbank market to show the impact of CCFDs on global commodity markets because liquidity in the Chinese banking system plays a crucial role in several steps of CCFDs. To measure liquidity risk, we use *Slope*, the difference between the 3-month and the overnight SHIBOR.

Empirically, we find evidence that liquidity risk in the Chinese banking system, as measured by *Slope* impacts global and Chinese commodity markets. First, we provide evidence of a contemporaneous relationship between the risk and commodity excess returns. In weeks where we observe high *Slope*, we also observe lower commodity futures returns. This is in line with our argument that these weeks pose little risk of engaging in CCFDs, which in turn increases the need to hedge commodity positions that stem from the increased demand for CCFDs. Consistent with this argument, we find that the effect is much larger for metal than for nonmetal commodities. Second, we also find a predictive relationship between the risk and commodity excess returns. Specifically, we show that an increase in *Slope* predicts a decrease in the commodity futures risk premium one-week ahead in both developed and Chinese markets. Our results are robust to how we construct both the main independent variable *Slope* and the dependent variable, futures excess returns. Moreover, we show that our results also hold when we add an array of commonly used liquidity measures as control variables.

Our results shed light on an unexplored side of the financialization of commodities. Capital controls in China create unexpected links from the Chinese interbank money market to global commodity markets. This specific but substantial example of the financialization of commodities calls for new attention from both researchers and policymakers. In particular, changes in financial conditions in China can impact commodity markets and, eventually, affect the production of real assets on a global scale.

CRediT authorship contribution statement

Yonghwan Jo: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **Jihee Kim:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **Francisco Santos:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing.

Declaration of competing interest

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

Appendix

Table A.1

Summary of individual commodity futures excess returns and basis. This table presents the summary statistics for individual weekly commodity futures excess returns and basis. Futures excess returns and basis are calculated from Oct. 13th, 2006 to Mar. 25th, 2016. The abbreviation of the exchanges is following: LME (London Metal Exchange), NYMEX (New York Mercantile Exchange), eCBOT (Electronic Chicago Board of Trade), ICE US (ICE Futures US), CME (Chicago Mercantile Exchange), KLCE (Kuala Lumpur Commodities Exchange), TOCOM (Tokyo Commodity Exchange), SHFE (Shanghai Futures Exchange), DCE (Dalian Commodity Exchange), and ZCE (Zhengzhou Commodity Exchange). The code in parenthesis indicates the ticker symbol code of commodity in the exchange. The fourth column indicates the number of the observations. The table shows average (Mean), the standard deviations (SD), maximum (Max), and minimum (Min) of both weekly excess returns and annual basis. The table shows the sample mean tests of the null hypothesis that excess return and basis are zero, respectively. The estimates marked with two (one) asterisks are significantly different from zero at the 1% (5%) level, respectively.

		Exchange		Excess Return				*Basis*			
Sector	Commodity	(Code)	N	Mean	SD	Max	Min	Mean	SD	Max	Min
Panel A: Developed Market											
Industrial	Aluminum	LME (AH)	494	−0.17	3.17	−9.03	−16.08	−5.35**	4.25	12.72	−15.35
Metals	Copper	LME (CA)	494	0.00	3.97	14.44	−21.68	0.55**	2.21	8.99	−6.35
	Lead	LME (PB)	494	0.15	5.42	28.02	−17.31	−0.93**	3.79	27.51	−6.55
	Zinc	LME (ZS)	494	−0.11	4.49	14.16	−15.87	−3.15**	3.50	11.77	−17.35
Precious	Gold	NYMEX (GC)	494	0.15	2.70	13.11	−9.64	−1.45**	1.73	0.04	−6.44
Metals	Silver	NYMEX (SI)	494	0.14	4.82	15.56	−27.39	−1.73**	1.53	0.16	−6.31
Grains	Corn	eCBOT (C)	494	0.00	4.46	20.78	−16.39	−4.78**	18.74	100.82	−20.42
	Soybeans	eCBOT (S)	494	0.23	3.48	9.72	−14.57	4.53**	19.73	113.26	−16.00
	Soybean Meal	eCBOT (SM)	494	0.42	3.97	13.47	−15.73	12.32**	24.77	127.27	−12.91
	Soybean Oil	eCBOT (BO)	494	0.02	3.33	9.95	−13.23	−4.84**	3.37	12.66	−15.83
	Wheat	eCBOT (W)	494	−0.16	4.64	16.46	−17.12	−10.26**	10.38	74.37	−36.72
Softs	Cotton	ICE US (CT)	494	0.03	3.97	18.41	−13.88	−1.58**	17.56	89.43	−35.04
	Palm Oil	KLCE (FCOP)	494	0.22	3.84	24.20	−14.79	1.29	17.03	272.77	−39.45
	Rubber	TOCOM (N/A)	494	−0.02	4.79	20.87	−21.83	−4.48**	21.50	170.27	−34.30
	Sugar	ICE US (SB)	494	0.07	4.26	12.86	−17.47	−0.41	20.93	102.61	−35.99
Energies	Heating Oil	NYMEX (HO)	494	−0.12	4.02	15.83	−16.06	−5.54**	9.92	28.06	−34.07
Panel B: China											
Industrial	Aluminum	SHFE (AL)	494	−0.13	1.99	6.28	−16.53	−2.38**	7.31	27.85	−23.32
Metals	Copper	SHFE (CU)	494	0.01	3.55	15.34	−17.73	2.83**	7.01	47.01	−15.01
	Lead	SHFE (PB)	262	−0.13	2.02	9.10	−11.12	−1.53**	6.98	19.56	−18.27
	Zinc	SHFE (ZN)	470	−0.16	3.46	11.30	−16.96	−3.80**	5.62	17.90	−22.69
Precious	Gold	SHFE (AU)	429	0.07	2.63	10.97	−12.90	−1.53**	6.79	30.36	−62.51
Metals	Silver	SHFE (AG)	203	−0.31	3.11	13.53	−16.12	−4.01**	5.68	25.87	−24.02
Grains	Corn	DCE (C)	494	−0.05	1.26	5.03	−7.53	−4.25**	16.39	64.85	−59.38
	Soybeans	DCE (B)	494	0.19	2.34	9.97	−15.56	−4.81**	25.92	118.17	−87.98
	Soybean Meal	DCE (M)	494	0.30	2.71	9.13	−18.22	11.13**	23.90	134.06	−74.44
	Soybean Oil	DCE (Y)	494	0.06	2.89	12.17	−11.83	−3.33**	16.39	57.74	−110.18
	Wheat	DCE (WS)	494	−0.11	1.39	5.84	−6.98	−11.42**	19.07	64.12	−81.19
Softs	Cotton	ZCE (CF)	494	−0.01	2.14	14.21	−12.00	−0.00	17.24	82.88	−25.10
	Palm Oil	DCE (P)	439	−0.35	3.32	10.20	−20.60	−9.95**	54.80	469.82	−499.26
	Rubber	SHFE (RU)	494	−0.08	3.97	16.91	−20.32	−2.24**	19.78	71.67	−81.96
	Sugar	ZCE (SR)	494	0.07	2.49	10.51	−11.19	−3.75**	16.73	42.56	−79.93
Energies	Fuel Oil	SHFE (FU)	494	−0.11	3.37	16.27	−20.46	−9.13**	38.72	141.29	−176.47

References

Acharya, Viral V., Gale, Douglas, Yorulmazer, Tanju, 2011. Rollover risk and market freezes. J. Finance 66 (4), 1177–1209.
Acharya, Viral V., Lochstoer, Lars A., Ramadorai, Tarun, 2013. Limits to arbitrage and hedging: Evidence from commodity markets. J. Financ. Econ. 109 (2), 441–465.
Acharya, Viral V., Merrouche, Ouarda, 2013. Precautionary hoarding of liquidity and interbank markets: Evidence from the subprime crisis. Rev. Finance 17 (1), 107–160.
Acharya, Viral V., Qian, Jun, Su, Yang, Yang, Zhishu, 2021. In the shadow of banks: Wealth management products and issuing banks' risk in China. NYU Stern Sch. Bus..
Acharya, Viral V., Skeie, David, 2011. A model of liquidity hoarding and term premia in inter-bank markets. J. Monetary Econ. 58 (5), 436–447.
Allen, Franklin, Qian, Yiming, Tu, Guoqian, Yu, Frank, 2019. Entrusted loans: A close look at China's shadow banking system. J. Financ. Econ. 133 (1), 18–41.
Asness, Clifford S., Moskowitz, Tobias J., Pedersen, Lasse Heje, 2013. Value and momentum everywhere. J. Finance 68 (3), 929–985.
Bakshi, Gurdip, Gao, Xiaohui, Rossi, Alberto G., 2019. Understanding the sources of risk underlying the cross section of commodity returns. Manage. Sci. 65 (2), 619–641.
Bakshi, Gurdip, Panayotov, George, Skoulakis, Georgios, 2011. The baltic dry index as a predictor of global stock returns, commodity returns, and global economic activity. In: AFA 2012 Chicago Meetings Paper.
Basak, Sulleyman, Pavlova, Anna, 2016. A model of financialization of commodities. J. Finance 71 (4), 1511–1556.
Bessembinder, Hendrik, 1992. Systematic risk, hedging pressure, and risk premiums in futures markets. Rev. Financ. Stud. 5 (4), 637–667.
Brunnermeier, Markus K., 2009. Deciphering the liquidity and credit crunch 2007–2008. J. Econ. Perspect. 23 (1), 77–100.
Brunnermeier, Markus K., Nagel, Stefan, Pedersen, Lasse H., 2008. Carry trades and currency crashes. NBER Macroecon. Annu. 23 (1), 313–348.
Brunnermeier, Markus K., Oehmke, Martin, 2013. The maturity rat race. J. Finance 68 (2), 483–521.
Carter, Colin A., Rausser, Gordon C., Schmitz, Andrew, 1983. Efficient asset portfolios and the theory of normal backwardation. J. Polit. Econ. 319–331.
Chang, Eric C., 1985. Returns to speculators and the theory of normal backwardation. J. Finance 40 (1), 193–208.
Chen, Ting-Hsuan, Chou, Hsiu-Hsia, Chang, Yuan, Fang, Hao, 2015. The effect of excess lending on bank liquidity: Evidence from China. Int. Rev. Econ. Finance 36, 54–68.
Chen, Zhuo, He, Zhiguo, Liu, Chun, 2020. The financing of local government in China: Stimulus loan wanes and shadow banking waxes. J. Financ. Econ. 137 (1), 42–71.
Cheng, Ing-Haw, Kirilenko, Andrei, Xiong, Wei, 2015. Convective risk flows in commodity futures markets. Rev. Finance 19 (5), 1733–1781.
Cornett, Marcia Millon, McNutt, Jamie John, Strahan, Philip E, Tehranian, Hassan, 2011. Liquidity risk management and credit supply in the financial crisis. J. Financ. Econ. 101 (2), 297–312.
Covitz, Daniel, Liang, Nellie, Suarez, Gustavo A., 2013. The evolution of a financial crisis: Collapse of the asset-backed commercial paper market. J. Finance 68 (3), 815–848.
Dang, Tri Vi, Wang, Honglin, Yao, Aidan, 2014. Chinese shadow banking: Bank-centric misperceptions, HKIMR Working Paper, 22.
De Roon, Frans A., Nijman, Theo E., Veld, Chris, 2000. Hedging pressure effects in futures markets. J. Finance 1437–1456.
Dewally, Michaël, Ederington, Louis H, Fernando, Chitru S, 2013. Determinants of trader profits in commodity futures markets. Rev. Financ. Stud. 26 (10), 2648–2683.
Diamond, Douglas W., Rajan, Raghuram G., 2005. Liquidity shortages and banking crises. J. Finance 60 (2), 615–647.
Elliott, Douglas, Kroeber, Arthur, Qiao, Yu, 2015. Shadow banking in China: A primer. Econ. Stud. Brook. 3, 1–7.
Estrella, Arturo, Trubin, Mary, 2006. The yield curve as a leading indicator: Some practical issues. Curr. Issues Econ. Finance 12 (5).
Fama, Eugene F., French, Kenneth R., 1987. Commodity futures prices: Some evidence on forecast power, premiums, and the theory of storage. J. Bus. 60 (1), 55.
Farhi, Emmanuel, Tirole, Jean, 2012. Collective moral hazard, maturity mismatch, and systemic bailouts. Am. Econ. Rev. 102 (1), 60–93.
Fungáčová, Zuzana, Korhonen, Iikka, 2011. Like China, the Chinese banking sector is in a class of its own.
Gârleanu, Nicolae, Pedersen, Lasse Heje, 2013. Dynamic trading with predictable returns and transaction costs. J. Finance 68 (6), 2309–2340.
Garvey, Marcus, Shaw, Andrew, 2014. Base Metals: Copper - Collateral Damage. Technical report, Credit Suisse Fixed Income Research.
Gorton, Gary B., Hayashi, Fumio, Rouwenhorst, K. Geert, 2013. The fundamentals of commodity futures returns. Rev. Finance 17 (1), 35–105.
Gorton, Gary, Rouwenhorst, K. Geert, 2006. Facts and fantasies about commodity futures. Financ. Anal. J. 62 (2), 47–68.
Gunji, Hiroshi, Yuan, Yuan, 2010. Bank profitability and the bank lending channel: Evidence from China. J. Asian Econ. 21 (2), 129–141.
He, Zhiguo, Xiong, Wei, 2012. Dynamic debt runs. Rev. Financ. Stud. 25 (6), 1799–1843.
Henderson, Brian J., Pearson, Neil D., Wang, Li, 2014. New evidence on the financialization of commodity markets. Rev. Financ. Stud. 28 (5), 1285–1311.
Hicks, John R., 1946. Value and Capital. The Clarendon Press, Oxford, p. 340.
Hirshleifer, David, 1988. Residual risk, trading costs, and commodity futures risk premia. Rev. Financ. Stud. 1 (2), 173–193.
Hirshleifer, David, 1990. Hedging pressure and futures price movements in a general equilibrium model. Econometrica 411–428.
Hong, Harrison, Yogo, Motohiro, 2012. What does futures market interest tell us about the macroeconomy and asset prices? J. Financ. Econ. 105 (3), 473–490.
Ivashina, Victoria, Scharfstein, David, 2010. Bank lending during the financial crisis of 2008. J. Financ. Econ. 97 (3), 319–338.
Kacperczyk, Marcin, Schnabl, Philipp, 2010. When safe proved risky: commercial paper during the financial crisis of 2007–2009. J. Econ. Perspect. 24 (1), 29–50.
Kang, Wenjin, Rouwenhorst, K. Geert, Tang, Ke, 2020. A tale of two premiums: The role of hedgers and speculators in commodity futures markets. J. Finance 75 (1), 377–417.
Keynes, John Maynard, 1930. A Treatise on Money: The Applied Theory of Money. Macmillan, London.
Layton, Max, Yuan, Roger, Currie, Jeffrey, 2013. Metal Detector: Copper Curve Ball. Technical report, Goldman Sachs Global Economics, Commodities and Strategy Research.
Lewis, Michael, Hsueh, Michael, Fu, Xiao, 2014. Commodities Weekly: China Copper Financing Deals. Technical report, Deutsche Bank Market Rsearch.
Li, Tong, 2009. China's nonperforming loans: A $540 billion problem unsolved. In: Barth, James R., Tatom, John A., Yago, Glenn (Eds.), China's Emerging Financial Markets: Challenges and Opportunities. Springer US, Boston, MA, pp. 403–422.
Li, Tong, 2014. Shadow banking in China: expanding scale, evolving structure. J. Financial Econ. Policy 6 (3), 198–211.
Marechal, Valerie, Tekin, Pelin, Guliyeva, Humay, 2009. China's new property rights law: An important step towards improving access to credit for small and medium enterprises. Celebrating Reforms 2009.
Nagel, Stefan, 2012. Evaporating liquidity. Rev. Financ. Stud. 25 (7), 2005–2039.
Nguyen, Vu Hong Thai, Boateng, Agyenim, 2013. The impact of excess reserves beyond precautionary levels on bank lending channels in China. J. Int. Financial Mark. Inst. Money 26, 358–377.
Perry, Emily, Weltewitz, Florian, 2015. Wealth management products in China. RBA Bull. 59–68.
Ping, Shi Jian, 2013. China SME Finance Report. Technical report, Mintai Institute of Finance and Banking.
Rouwenhorst, K. Geert, Tang, Ke, 2012. Commodity investing. Annu. Rev. Financial Econ. 4 (1), 447–467.
Singleton, Kenneth J., 2013. Investor flows and the 2008 boom/bust in oil prices. Manage. Sci. 60 (2), 300–318.
Sockin, Michael, Xiong, Wei, 2015. Informational frictions and commodity markets. J. Finance 70 (5), 2063–2098.

Stoll, Hans R., 1979. Commodity futures and spot price determination and hedging in capital market equilibrium. J. Financ. Quant. Anal. 14 (04), 873–894.
Sun, Guofeng, 2019. China's shadow banking: Bank's shadow and traditional shadow banking, BIS Working Paper, 822.
Szymanowska, Marta, De Roon, Frans, Nijman, Theo, Van Den Goorbergh, Rob, 2014. An anatomy of commodity futures risk premia. J. Finance 69 (1), 453–482.
Tang, Ke, Xiong, Wei, 2012. Index investment and the financialization of commodities. Financ. Anal. J. 68 (5), 54–74.
Tang, Ke, Zhu, Haoxiang, 2016. Commodities as collateral. Rev. Financ. Stud. 29 (8), 2110–2160.
Yang, Fan, 2013. Investment shocks and the commodity basis spread. J. Financ. Econ. 110 (1), 164–184.
Yuan, Roger, Layton, Max, Currie, Jeffrey, Cai, Amber, 2014a. Cooper: Expecting Very Near-Term LME Spread Tightening. Technical report, Goldman Sachs Global Investment Research.
Yuan, Roger, Layton, Max, Currie, Jeffrey, Courvalin, Damien, 2014b. Days Numbered for Chinese Commodity Financing Deals. Technical report, Goldman Sachs Global Investment Research.
Zhang, Xuechun, 2012. Informal Finance in China. Technical report, The People's Bank of China.