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# Leverage and systemic risk pro-cyclicality in the Chinese financial system

Peter Cincinelli [a], Elisabetta Pellini [b], Giovanni Urga [c,*]

[a] Department of Management, University of Bergamo, Italy
[b] Centre for Econometric Analysis, Bayes Business School (formerly Cass), City University of London, UK
[c] Centre for Econometric Analysis, Faculty of Finance, Bayes Business School (formerly Cass), City University of London, UK

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ABSTRACT

In this paper, we investigate the relationship between balance sheet size and leverage (i.e., leverage pro-cyclicality) and the pro-cyclicality of systemic risk using three systemic risk measures such as $\Delta CoVaR$ (Adrian and Brunnermeier (2016)), *MES* (Acharya et al. (2017)), *SRISK* (Brownlees and Engle (2016)). We conduct an extensive panel data analysis using a sample of 264 Chinese listed financial institutions (43 commercial banks, 74 finance services and 147 real estate finance services) over 2005:4–2019:4. We also study the impact of different phases of the financial turmoil by considering three subperiods, the "*Global Financial Crisis*" (2007:1–2009:4), the "*Monetary Policy Restriction*" (2010:1–2014:4), and the "*2015 Chinese Stock Crash*" (2015:1–2019:4). We find that leverage pro-cyclicality mainly affects CBs, in particular during the global financial crisis and the monetary policy restriction. We also find that larger financial institutions increase systemic risk, in particular commercial banks, which from 2016 started increasing shadow banking activities, and the real estate financial services with their activity closer to commercial banking.

## 1. Introduction

Since the global financial crisis of 2007–2009, the financial system has undergone deep and remarkable changes. On the one hand, in the run-up of the crisis, credit and asset prices increased and deviated from their fundamental trend. During such period of exuberance, financial intermediaries lending activity and their stock of debts are high due to an expansion in the aggregate demand. On the other hand, when the process is reversed, due to an exogenous shock, asset prices decrease, the value of collateral diminishes and the borrowers' profitability deteriorates. As a consequence, the level of the credit supply in the economy is reduced. That is, financial system is pro-cyclical. The term pro-cyclicality refers to the dynamic interactions between the financial system and the real sectors of the economy (Bank for International Settlements, 2008; Financial Stability Board, 2009)[1] and can be traced to two fundamental sources: (i) the high pro-cyclicality of risk management techniques[2]; (ii) the distortions in incentives.[3] In traditional models of the financial accelerator, the pro-cyclicality of asset prices may explain business cycle' booms and recession. The ensuing credit expansion (contraction) fuels, as a financial accelerator, cyclical upturns (downturns) (Bernanke & Gertler, 1989; Kiyotaki & Moore, 1997).[4]

The aim of this paper is to study the way financial institutions manage their balance sheets and how the changes translated into systemic risk within the financial sector. We focus on the Chinese financial system — composed of Commercial Banks (CBs), Finance Services (FSs), and Real Estate Finance Services (REFs) — where the leverage[5] almost septupled from 0.391% to 2.814% between 2007 and 2019.

* Corresponding author.
*E-mail address:* g.urga@city.ac.uk (G. Urga).

[1] In their reports, the BIS (2008, pag. 1) and the FSB (2009, pag. 8) define dynamic interactions as "*positive feedback mechanisms*".

[2] A financial variable is pro-cyclically if its co-movement with the real economy strengthens the evolution of the latter. For example, if the measures of risk increase as the economy contracts, they are said to be pro-cyclical (even if they actually move counter-cyclically in a numerical sense) because they would tend to strengthen the contraction. It has been extensively documented that risk management techniques often spike once tensions arise, triggering strains, but may be quite low even as vulnerabilities and risk build-up during the expansion phase.

[3] They involve the conflicts of interest between providers and users of funds, and the actions that may be rational from the perspective of individual agents, but collectively may result as an undesirable outcome.

[4] In this way, the financial system plays an amplification effect on the business cycle (i.e., demand-side of credit channel). Different is Bernanke & Blinder (1988)' model, which relies on a supply side of credit effect. In this model, there is no amplification since the banks' net worth is ignored (Ben & Blinder, 1988).

[5] We consider the "*quasi-market leverage*" ratio defined as the ratio between market capitalization of equity plus debt and market capitalization. See Acharya et al. (2017).

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Our paper has two main objectives. First, we investigate the relationship between balance sheet size and leverage (i.e., leverage pro-cyclicality). Second, we evaluate the presence of pro-cyclicality of systemic risk considering three prominent measures such as $\Delta CoVaR$ (Adrian & Brunnermeier, 2016), *MES* (Acharya et al., 2017), *SRISK* (Brownlees & Engle, 2016). The pro-cyclicality of leverage and systemic risk are analysed using a sample of 264 Chinese financial institutions (43 CBs, 74 FSs, 147 REFs) listed on the Shanghai and Shenzhen Stock Exchanges over the years 2006–2019. The choice to investigate the Chinese financial system is motivated by that by the end of 2011, it has become the second largest equity market in terms of market capitalization after only the USA (Pan et al., 2016), and financial innovation has played an important role in influencing Chinese financial institutions and regulatory development (Yang & He, 2019; Zhang et al., 2020). We also identify three regimes, namely (i) the Global Financial Crisis (GFC) from 2007:1 to 2009:4; (ii) the Monetary Policy Restriction (MPR) conducted by the People Bank of China (PBoC) from 2010:1 to 2014:4; and (iii) the 2015 Chinese stock crash and its effects, which lasted up to 2019:4. In this way, we evaluate how financial institutions' adjust their balance sheets over the short run and how assets' growth may hold information on market conditions.

It is also important to consider different categories of financial institutions in the light of that they conduct businesses that are likely to affect their leverage and systemic risk pro-cyclicality. In particular, (i) CBs take deposits or other repayable funds from the public and grant credits for its own account; (ii) FSs provide a valuable alternative financing way for many firms and households, fostering competition in the supply of financing and supporting economic activity. They provide credit or credit guarantees, or performing liquidity and/or maturity transformation without being regulated like a bank; (iii) REFs play an important role in the economy and its developments may have a material influence on the financial system. They are involved in the real estate industry which provide real estate leasing investment services and investments.

After the global financial crisis, several authors have investigated the consequences of pro-cyclical leverage in the banking system and how banks' management actively manage their balance sheets. Leverage is pro-cyclical when the balance sheet of the financial institutions expands and contracts with the economic cycle (Adrian & Shin, 2010). Formally, leverage ($L_t$), defined as the ratio between total assets ($A_t$) over total equity ($E_t$), is pro-cyclical if $\Delta L_t = f(\Delta A_t)$, and $f'$>0. Gropp and Heider (2010) analyse a large sample of US and European banks over the 1991–2004 time period to find that banks' target leverage is time-invariant and bank specific. Kalemli-Ozcan et al. (2012), over the period 2000–2009, report that the both US investment banks and large commercial banks are pro-cyclical. Baglioni et al. (2013), using a sample of 77 European banks over 2000–2009 time period, find that pro-cyclical leverage is reported by those banks for which the investment banking activity prevails. Damar et al. (2013), using Canadian data, show that financial institutions that use wholesale funding report high degrees of pro-cyclicality. Beccalli et al. (2015), over 2001–2010 time period, find that US banks which are more involved in securitization have a more pro-cyclical leverage.

Further, there is a number of contributions arguing that higher financial leverage, especially short-term leverage, induces banks to engage in illiquid and risky lending as well as securities activities that resulted in the widespread failures (Acharya et al., 2013; Acharya & Thakor, 2016; Adrian & Shin, 2010; Mian & Sufi, 2011; Shleifer & Vishny, 2010). In this vein, there is an emerging acceptance of the fact that higher leverage may increase systemic risk of financial institutions, i.e. pro-cyclical leverage may translate into pro-cyclical systemic risk and they become difficult to separate. As for pro-cyclicality of leverage, systemic risk is pro-cyclical if $\Delta Systemic\ Risk_t = f(\Delta A_t)$, and $f'$>0. Regarding the systemic risk measures, over the last decade global systemic risk measures (SRMs) have been proposed (see Benoit et al., 2017) accounting for specific sources such as contagion, bank runs or liquidity crises. In particular, the $\Delta CoVaR$ of Adrian and Brunnermeier (2016), the *SRISK* of Brownlees and Engle (2016), and the Marginal Expected Shortfall (*MES*) of Acharya et al. (2017) of are the most central metrics in the systemic risk literature (Benoit et al., 2017; Dičpinigaitienė & Novickytė, 2018; Grundke & Tuchscherer, 2019; Zhang et al., 2015). The choice of $\Delta CoVaR$, *MES* and *SRISK* is justified by that, according to extant literature, they are the most appropriate measure allowing the generation of time-varying estimates of systemic risk contributions from individual financial institutions to the entire financial system. An extended description of the systemic risk measures is reported in Section 2.

The main findings in this paper can be summarized as follows. There is evidence of a persistent pro-cyclicality of the Chinese financial institutions' leverage. We also find that in the presence of financial crisis: (i) leverage is high during booms and low during financial turmoil (Adrian & Shin, 2010); (ii) the risk-bearing capacity of the financial system may be severely diminished when leverage falls due to an increase in collateral requirements (Geanakoplos, 2010; Gorton & Metrick, 2012).

With respect to the different financial institution, we find that pro-cyclicality mainly affects CBs, which are pro-cyclical during the GFC and the MPR. This finding confirms the rapid increase and growing complexity in Chinese banks' balance sheets (Chen & Kang, 2018). A different behaviour is reported by FSs, which are counter-cyclical during the GFC, and REFS, which become pro-cyclical during the monetary policy restriction and prior to the 2015 stock crash.

As far as the pro-cyclicality of systemic risk is concerned, we find that larger financial institutions increase systemic risk, in line with (Fang et al., 2018; Financial Stability Board, 2021; Yu et al., 2018; Zhang et al., 2020). In particular, we notice that the pro-cyclicality is pronounced for CBs. A possible explanation is that from 2016, they started increasing shadow banking activities off balance sheet and then bringing into the market shadow banking products, i.e. wealth management products (WMPs), into a special investment category on the asset side of their balance sheets. This assets' expansion also led to a higher interconnectedness among financial institutions (Chen & Kang, 2018; Fang et al., 2018). Moreover, we also find that the pro-cyclicality features not only commercial banks but also other financial intermediaries, such as REFs, mainly oriented to commercial banking activity. The real estate transactions, involving borrowing, may cause instability in the financial system and the real economy, confirming the findings of Crowe et al. (2013), Morelli and Vioto (2020).

In this paper, we contribute on pro-cyclicality literature in several ways. First, Andries and Sprincean (2020) examine cyclical behaviour of banks' systemic risk finding that both systemic risk contribution and exposure are positively related to business cycle. In our work, we empirically estimate the procyclicality of systemic risk by adding Finance Services and Real Estate Finance Developers for which both regulators and central banks posed particular attention. Moreover, despite the emerging amount of research aimed at investigating leverage pro-cyclicality (Adrian & Shin, 2010; Beccalli et al., 2015; Damar et al., 2013; Danielsson et al., 2012; Danielsson & Zigrand, 2008; Tasca & Battiston, 2016), so far the academic literature has not developed a framework where this strand of research is evaluated within the Chinese financial system. Most of the above literature focuses on developed economies (such as US and Europe), with relatively little research in emerging markets, including China, as the second largest economy. Claessen & Ghosh (2013) analyse how financial integration may pose severe and serious challenges to financial stability in emerging markets. They argue that emerging markets are more likely to larger shock than advanced economies because of their less diversified economy, less domestic and political stability. In addition, shocks (both positive or negative) are exacerbated because of structural and financial institution characteristics. Claessens and Ghosh (2013), analysing 2,800 banks in 48 countries (both advanced countries and emerging markets) over 2000–2010, find that caps on debt-to-income and loan-to-value ratios

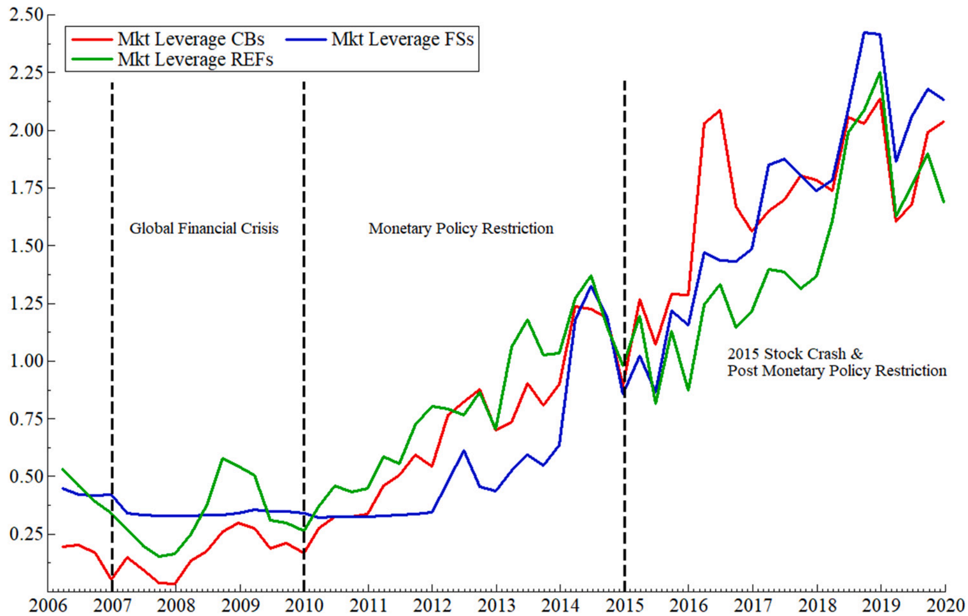


**Fig. 1.** Market Leverage — Chinese Financial Institutions.

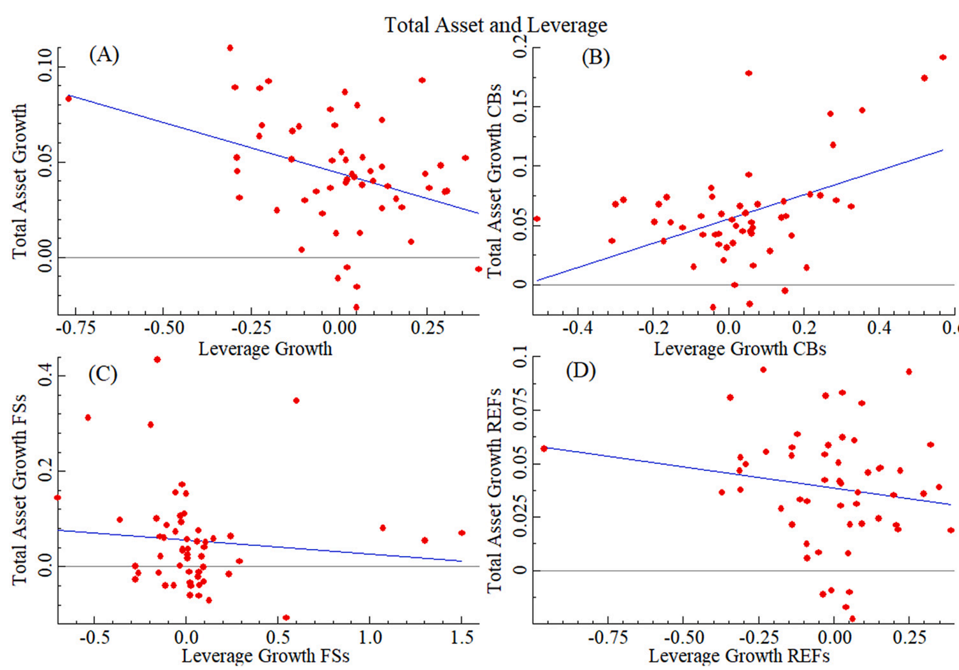


**Fig. 2.** Total Aggregate leverage and total asset growth — Chinese Financial System.
The scatter charts report the relationship between total assets and leverage growth (quarterly) for the entire Chinese financial system and for Commercial Banks (CBs), Finance Services (FSs), Real Estate Finance Developers (REFs). On the *x-axis* there is the percentage change of leverage and on the *y-axis* the percentage change of total assets.

are effective macroprudential policies in reducing leverage, asset and non-core to core liabilities growth.

Secondly, our work aims at enhancing the knowledge of the impact of pro-cyclicality on both banks and other financial intermediaries, such as FSs and REFs, for which regulators and central banks has devoted particular attention in triggering systemic risk. We shed some light on the Chinese financial system given that its dynamic economic activity and trading activities have played a dominant role in the equity markets across the Asian region. In this vein, we contribute and extend recent contribution by Morelli and Vioto (2020). Thirdly, we also argue that our paper contributes to the recent asset-pricing literature which has explored the impact of leverage on asset returns Adrian et al. (2014, 2010), Adrian et al. (2016).

Finally, our work also contributes to the lively debate regarding the appropriate policy tools to mitigate the procyclical effects arising from leverage and market asset valuation Arnold et al. (2012), Bank for International Settlements (2009). During the G20 Summit in October 2010, the BIS asked banks to enforce effective implementation of Basel III tools. Among others indicators, starting from 2018, the BIS includes the leverage ratio[6] as an indicator of the regulatory system. In

[6] Basel III provides the following definition of leverage ratio: *Leverage ratio*=(Tier 1 Capital — Tier 1 Capital deductions) over on- and off-balance asset after adjustment. The advantage of this definition is that the off-balance risks are considered (in real practice, different assets are assigned different

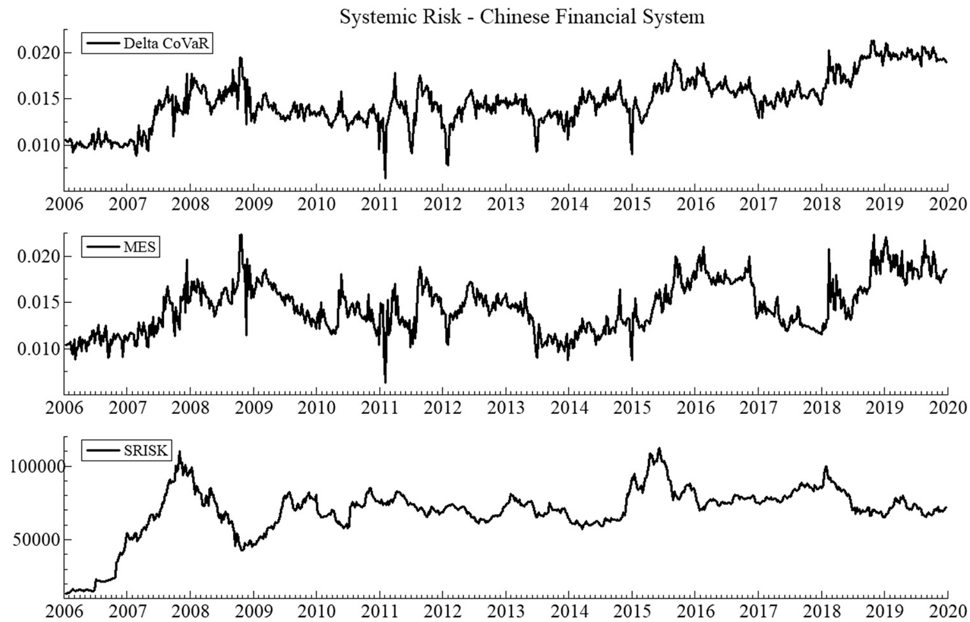


**Fig. 3.** Systemic Risk Measures — Chinese Financial System.

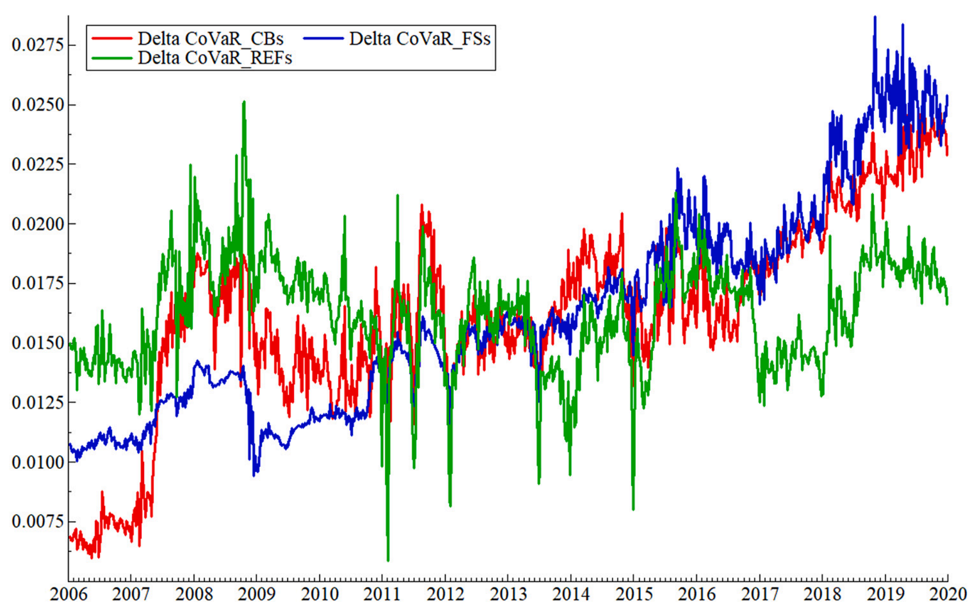


**Fig. 4.** $\Delta CoVaR$ — CBs, FSs, REFs.

June 2011, based on the relevant contents in Basel III, China Banking Regulatory Commission (CBRC) issued measures for the administration of the leverage ratio of commercial banks and established the overall framework and regulatory principles of the leverage rate regulatory policy for the Chinese banking system.

The reminder of the paper is organized as follows. Section 2 outlines the systemic risk measures. Section 3 describes the data and reports some summary statistics of the variables. In Section 4, we present the methodology to modelling and testing for pro-cyclicality, while in Section 5 we report discuss the main empirical findings. Section 6 concludes.

risk weights). This approach can realize the embedded characteristics of the leverage ratio and better reflect the market risks for banks.

## 2. Measures of systemic risk

Since the global financial crisis, the identification of the main drivers of systemic risk has been a popular issue in the institutional and academic debate. Systemic risk, by its nature, includes both a cross-sectional and a time dimension. The existing literature proposes measures that capture these two dimensions and different classifications are offered by Bisias et al. (2012), De Bandt et al. (2013) and Benoit et al. (2017) .

Benoit et al. (2017) propose two different approaches: the *"source-specific approach"* and the *"global approach"*. Within the first approach, authors proposed methods to measure the various sources of systemic risk such as: systemic risk-taking (Acharya, 2009; Blei & Ergashev, 2014; Cai et al., 2018; De Nicolò & Lucchetta, 2011; Giesecke & Kim, 2011; He & Krishnamurthy, 2019; Lehar, 2005), contagion between financial institutions (Acemoglu et al., 2015; Acharya & Merrouche,

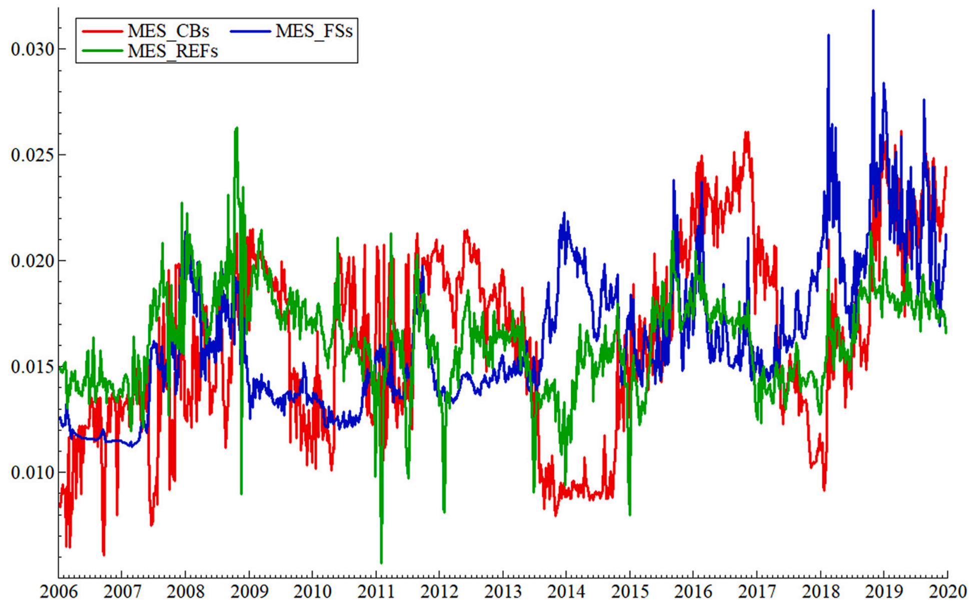


**Fig. 5.** *MES* — CBs, FSs, REFs.


**Fig. 6.** *SRISK* — CBs, FSs, REFs.

2013; Afonso & Shin, 2011; Allen et al., 2009; Drehmann & Tarashev, 2011; Elsinger et al., 2006; Gabrieli & Georg, 2014; Gourieroux et al., 2012; Iyer & Peydro, 2011; Markose, 2012; Upper, 2011; Upper & Worms, 2004), the amplification mechanisms either in traditional banks or in the shadow banking system (Brunnermeier et al., 2014; Duarte & Eisenbach, 2021; Greenwood et al., 2015; Jobst, 2014).

The *"global approach"*, instead, considers a multi-channel approach to systemic risk providing several measures based on market data which can be gathered and freely computed in real time. Several papers report the progress on the systemic risk measures (Abendschein & Grundke, 2018; Benoit et al., 2017; Bisias et al., 2012; De Bandt et al., 2013; Dičpinigaitienė & Novickytė, 2018; Grundke & Tuchscherer, 2019). Over the last decade global Systemic Risk Measures (SRMs) have been proposed (see Benoit et al., 2017) accounting for specific sources such as contagion, bank runs or liquidity crises. In particular, the *ΔCoVaR* of Adrian and Brunnermeier (2016), the *SRISK* of Brownlees and Engle (2016), and the Marginal Expected Shortfall (*MES*) of Acharya et al. (2017) are the most central metrics in the systemic risk literature (Benoit et al., 2017; Dičpinigaitienė & Novickytė, 2018; Grundke & Tuchscherer, 2019; Zhang et al., 2015).

We select these three measures on the basis of two criteria. First, their computations have to rely on readily available data that can be collected over an extensive time period. In this regard, while $\Delta CoVaR$ and *MES* are computed only from market data, *SRISK* uses information on leverage, as the ratio between book value of debt over the market value of equity, as well. Thus, *SRISK* captures the (potential) undercapitalization of an individual bank during a crisis affecting the whole financial system. Second, these measures can be evaluated for large samples of financial institutions, including banks and other financial institutions. As a consequence, we exclude any method which uses Shapley values to allocate systemic risk (Drehmann & Tarashev, 2011;

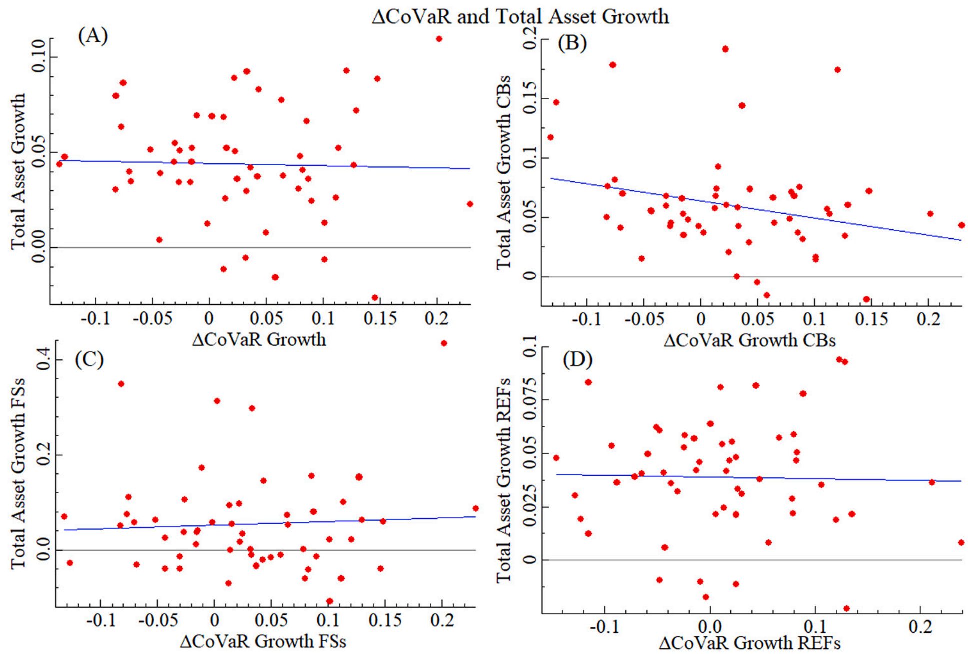


**Fig. 7.** $\Delta CoVaR$ and total asset growth — Chinese Financial System.
The scatter charts report the relationship between total assets and MES growth (quarterly) for the entire Chinese financial system and for Commercial Banks (CBs), Finance Services (FSs), Real Estate Finance Developers (REFs).

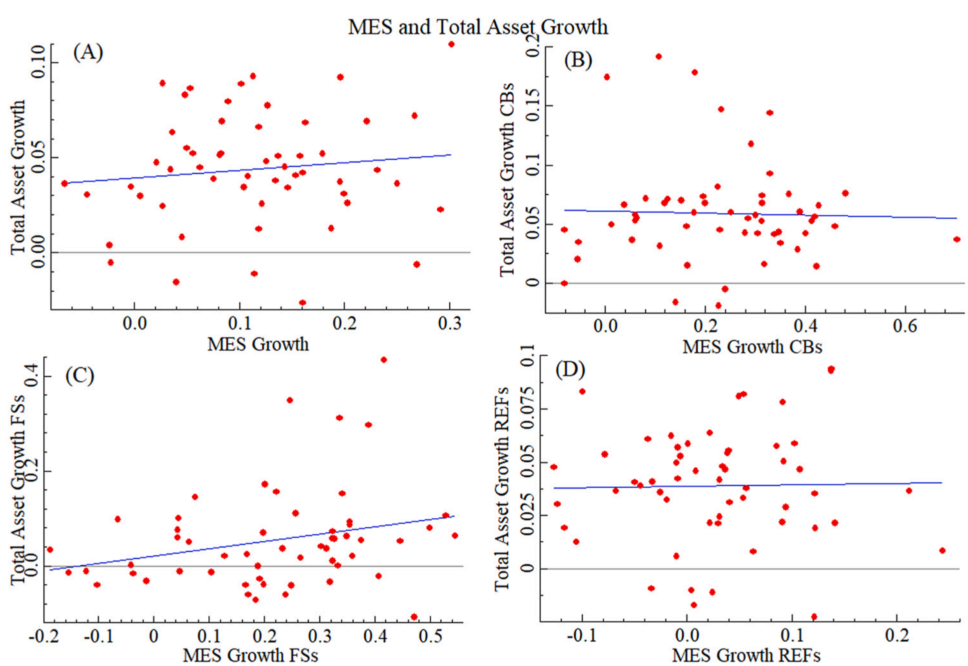


**Fig. 8.** MES and total asset growth — Chinese Financial System.
The scatter charts report the relationship between total assets and MES growth (quarterly) for the entire Chinese financial system and for Commercial Banks (CBs), Finance Services (FSs), Real Estate Finance Developers (REFs).

Shapley, 2016; Zhang et al., 2015).[7] Moreover, we do not consider models that require the estimation of the joint probabilities of failures (Segoviano & Goodhart, 2009; Zhou, 2010) because their estimation becomes problematic in large data sets. Finally, we also exclude measures that require the computation of the implied default probability from credit default swaps (CDS) (Huang et al., 2012), because CDS are not usually available neither for a long time period nor for an extensive international sample of financial institutions. Table 1 summarizes the main features, the advantages and disadvantages of the systemic risk measures used in this work.

In the what follows, we briefly present the three measures of systemic risk *ΔCoVaR* (*Section* 2.1), *MES* (*Section* 2.2), and *SRISK* (*Section* 2.3).

[7] The Shapley' approach is a game-theoretic instrument that is applied to evaluate how important a financial institution is for the overall system and what payoff it can expect from interacting with other financial institutions. Following Drehmann and Tarashev (2011), the purpose of this approach is to quantify how financial institutions contribute to a systemic event given the possibility that a financial institution adds to the propagation of shocks in the system and because it is itself exposed to propagated shocks.

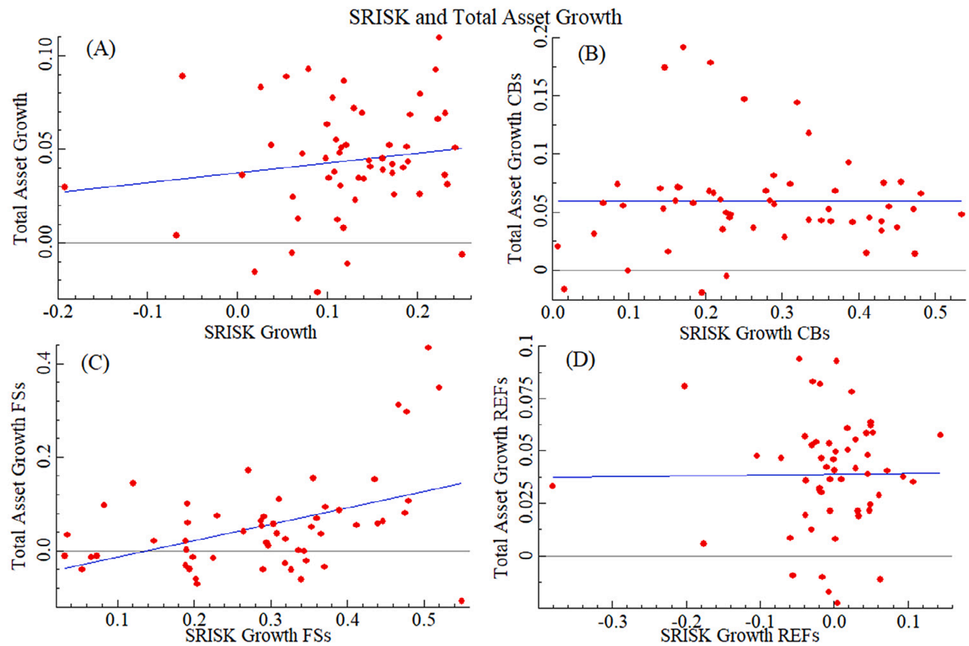


**Fig. 9.** SRISK and total asset growth — Chinese Financial System.
The scatter charts report the relationship between total assets and SRISK growth (quarterly) for the entire Chinese financial system and for Commercial Banks (CBs), Finance Services (FSs), Real Estate Finance Developers (REFs).

**Table 1**
*ΔCoVaR*, MES, SRISK: features, advantages and disadvantages.
*Source:* Own elaboration on Arsov et al. (2013), and Benoit et al. (2017)

| N. | Indicator | Definition | Advantages | Disadvantages |
|---|---|---|---|---|
| **1** | *ΔCoVaR* (Adrian & Brunnermeier, 2016) | The Value at Risk of the financial system conditional on institutions being under distress. The *ΔCoVaR* of firm *i* is then defined as the difference between the VaR of the financial system conditional on this particular firm being in financial distress and the VaR of the financial system conditional on firm i being in its median state. | (i) Intuitive: it adopts a wide variety of data; (ii) Easy to implement with the possibility of frequent updates; (iii) As a near-coincident indicator, may also provide crucial warnings of an imminent crisis and compel authorities and systemic institutions to take action to mitigate the crisis. | (i) Depends on the choice of systemic state variables; the quantiles are estimate with linear regressions which may not accurately capture the underlying relationship; (ii) The proportionality coefficient between *ΔCoVaR* and VaR is firm-specific implies that the most risky institutions (in terms of VaR) are not necessarily the most systemically risky ones (in terms of *ΔCoVaR*). |
| **2** | MES (Acharya et al., 2017) | The marginal contribution for a given banks to systemic risk which is defined as the amount the bank' equity drops below its target level set by regulators in case the banking sector is undercapitalized as whole. | (i) Easy to implement with the possibility of frequent updates; (ii) As an ex ante indicator, it is useful to quantify the build-up of systemic risk for regulators; | (i) The systemic risk ranking of financial institutions based on MES is strictly equivalent to the ranking that would be produced by sorting them according to their betas; (ii) For a given financial institution, the time profile of its systemic risk measured by its MES may be different from the evolution of its systematic risk measured by its conditional beta. |
| **3** | SRISK (Brownlees & Engle, 2016) | The expected capital shortfall of a given financial institution, conditional on a crisis affecting the whole financial system. The SRISK extends the MES in order to take into account both the liabilities and the size of the financial institution. | (i) Possibility of frequent updates; (ii) As an ex ante indicator, it is useful to quantify the build-up of systemic risk for regulators; | (i) Accounting for market capitalization and liabilities in the definition of the systemic risk measure tends to increase the systemic risk score of large firms. |

**Table 2**
Financial institutions characteristics — Summary statistics.

| | Variable | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| Chinese Financial System | Total Assets Thousands of $ | 74,924,418 | 358,370,067 | 24 | 4,465,119,744 |
| | Size (ln) | 14.567 | 2.592 | 3.192 | 22.220 |
| | Size growth (%) | 0.043 | 0.151 | −1.000 | 1.832 |
| | Market Leverage (%) | 1.687 | 4.089 | 0.001 | 42.379 |
| | Market Leverage Growth (%) | 0.004 | 0.535 | −3.325 | 4.141 |
| | Accounting Leverage (%) | 5.542 | 5.350 | −3.720 | 37.441 |
| | Accounting Leverage Growth (%) | 0.012 | 0.501 | −30.311 | 2.485 |
| Commercial banks | Total Assets Thousands of $ | 525,288,690 | 860,552,669 | 10,584,600 | 4,465,119,744 |
| | Size (ln) | 18.911 | 1.571 | 16.175 | 22.220 |
| | Size growth (%) | 0.050 | 0.071 | −0.132 | 0.744 |
| | Market Leverage (%) | 7.309 | 8.546 | 0.001 | 42.379 |
| | Market Leverage Growth (%) | 0.036 | 0.224 | −0.611 | 0.873 |
| | Accounting Leverage (%) | 16.391 | 3.876 | 9.612 | 37.441 |
| | Accounting Leverage Growth (%) | −0.018 | 0.097 | −0.715 | 0.335 |
| Finance services | Total Assets Thousands of $ | 14,527,550 | 31,001,248 | 1,007 | 286,917,632 |
| | Size (ln) | 14.886 | 2.150 | 6.915 | 19.475 |
| | Size growth (%) | 0.055 | 0.201 | −0.993 | 1.832 |
| | Market Leverage (%) | 1.613 | 3.749 | 0.001 | 23.940 |
| | Market Leverage Growth (%) | 0.055 | 0.719 | −3.325 | 4.141 |
| | Accounting Leverage (%) | 3.629 | 2.466 | −3.720 | 13.960 |
| | Accounting Leverage Growth (%) | 0.037 | 0.292 | −1.733 | 2.480 |
| Real Estate Finance Developers | Total Assets Thousands of $ | 4,235,677 | 14,401,124 | 24 | 253,623,712 |
| | Size (ln) | 13.599 | 1.871 | 3.192 | 19.351 |
| | Size growth (%) | 0.038 | 0.146 | −1.000 | 1.766 |
| | Market Leverage (%) | 0.857 | 1.844 | 0.001 | 13.150 |
| | Market Leverage Growth (%) | −0.013 | 0.517 | −2.871 | 1.941 |
| | Accounting Leverage (%) | 3.952 | 3.317 | −1.360 | 20.008 |
| | Accounting Leverage Growth (%) | 0.010 | 0.572 | −30.311 | 2.485 |

The table reports quarterly summary statistics of listed Chinese financial institutions: Commercial Banks, Finance Services, Real Estate Finance Developers over the time period 2006:1 to 2019:4. $Size_{i,t}$ is natural logarithm of the total assets of financial institution $i$ at quarter $t$; $\Delta Size_{i,t}$ is the quarterly growth of total assets of financial institution $i$; $Market\ Leverage_{i,t}$ is the quasi-market leverage ratio defined as the market value of assets (market capitalization of equity plus debt) over market capitalization (equal to the share price multiplied by the number of shares outstanding) of financial institution $i$ at quarter $t$; $AccountingLeverage_{i,t}$ is the total assets to equity ratio of financial institution $i$ at quarter $t$.

### 2.1. Measuring systemic risk via CoVaR

While the Value-at-Risk (VaR) of an institution focuses on the risk of an individual entity in isolation, the CoVaR is an indicator of systemic risk that can be defined as the VaR of the financial system as a whole, conditional on another firm (or set of firms), exceeding its (their) firm specific VaR. VaR is defined as the threshold loss (in currency) that will not be exceeded at a given level of confidence. The $CoVaR_q^{system|C(X^i)}$ is defined by the q-th quantile of the conditional probability distribution:

$$Prob(X^{system|C(X^i)} \leq CoVaR_q^{system|C(X^i)}) = q\% \tag{1}$$

where $X^i$ is the market-valued asset return of institution $i$, and $X^{system}$ is the return of the portfolio, computed as the average of the $X^i$'s weighted by the lagged market value assets of the institutions in the portfolio.[8] Adrian and Brunnermeier (2016) measure the contribution of each single institution to systemic risk by the *ΔCoVaR*, namely the difference between $CoVaR$ conditional on the institution being in distress and *CoVaR* in the median state of the institution. Formally, the $\Delta CoVaR_q^i$, i.e. the contribution to systemic risk of institution $i$ during the $q$ quartile, is defined as follows:

$$\Delta CoVaR_q^i = CoVaR_q^i - CoVaR_{50}^i = \hat{\beta}_q^i (VaR_q^i - VaR_{50}^i) \tag{2}$$

where the $q$ is always set to be 5%, so that $CoVaR^i$ identifies the system losses predicted on the 5% loss of institution $i$, while $\Delta CoVaR^i$ identifies the deterioration in the system losses, when the institution $i$ moves from its median state to its 5% worst scenario. As far as the estimation method is concerned, quantile regressions (q) Koenker and Bassett (1978) are employed to estimate the VaRs and CoVaRs (see Adrian and Brunnermeier (2016)).

### 2.2. Measuring systemic risk via MES

The second measure of systemic risk is the Marginal Expected Shortfall (MES) based on Acharya et al. (2017). The *MES* of a financial institution is defined as the contribution of that institution to the Expected Shortfall (ES) of the system. The *ES* of the system is defined as the expected value of the market return conditional to the event that the market return is lower than a certain threshold $C$ with the market return defined as the weighted average of all financial institutions' returns:

$$ES_{m,t}(C) = \mathbb{E}_{t-1}(r_{m,t}|r_{m,t} < C) = \sum_{i=1}^{N} \omega_{i,t}\mathbb{E}_{t-1}(r_{i,t}|r_{m,t} < C) \tag{3}$$

where $r_{m,t} = \sum_{i=1}^{N} \omega_{i,t} r_{i,t}$,[9] and $\omega_{i,t}$ is the market share or capitalization of financial institution $i$. In the operational definition of a crisis event, the value of the threshold $C$ is crucial.[10] The contribution of institution $i$ to the System Expected Shortfall (the *MES* of institution $i$) is, therefore,

[8] Indicating with $ME_t^i$ the market value of a financial institution and with $LEV_t^i$ the ratio between total assets and common equity, we can define: $X^i = \frac{ME_t^i \times LEV_t^i - ME_{t-1}^i \times LEV_{t-1}^i}{ME_{t-1}^i \times LEV_{t-1}^i}$. The sum of all the $X^i$ of the sample gives $X^{system}$, namely the growth rate of the market value of the total asset of financial sector under analysis.

[9] The risk management framework for a single institution can be extended to the whole financial system, "by letting $r_{m,t}$ be the return of the aggregate banking sector or the overall economy" (Acharya et al., 2017). In this case, the conditioning event is a systemic event, which is thought of as the 5% worst days of any given year in terms of stock returns.

[10] To ensure comparability with the other measures of systemic risk, we set the threshold at 5% level.

defined as the partial derivative of the *ES* with respect to the weight of institution *i*:

$$MES_{i,t} = \frac{\partial ES_{m,t}(C)}{\partial \omega_{i,t}} = \mathbb{E}_{t-1}(r_{i,t}|r_{m,t} < C) \quad (4)$$

The *MES* of a financial institution can be interpreted as reflecting its participation in overall systemic risk. However, it is still possible to define the same statistic whenever the observed financial institution does not belong to the market index. Rather than a measure of how a particular financial institution' risk adds to the market risk, the *MES* should then be viewed simply as a measure of the sensitivity (or resilience) of this financial institution' stock price to exceptionally bad market events (Idier et al., 2014).

### 2.3. Measuring systemic risk via SRISK

The third measure of systemic risk is *SRISK*, based on Brownlees and Engle (2016). The SRISK measures the expected capital shortage faced by a financial institution during a period of system distress when the market declines substantially. More precisely:

$$SRISK_{i,t} = max[0; \kappa(D_{i,t}) + (1 - LRMES_{i,t}W_{i,t}) - (1 - LRMES_{i,t})W_{i,t}] \quad (5)$$

where $\kappa$ is the minimum fraction of capital as a ratio of total assets that each financial institution needs to hold ($\kappa$ is set equal to the prudential capital ratio of 8%), and $D_{i,t}$ and $W_{i,t}$ are the book value of its debt (total liabilities) and the market value of its equity, respectively, $LRMES$ is the long-run Marginal Expected Shortfall (the MES on a six-months horizon). According to Brownlees and Engle (2016), to compute the $LRMES$, we used the non-simulation method to estimate the expected fractional loss of the financial intermediary in a crisis when the Market Composite Indexes decline significantly in a six-months period (i.e., Long-Run Marginal Expected Shortfall or LRMES). Specifically, it is calculated as:

$$LRMES_{i,t} = 1 - exp(log(1 - d) * MES_{i,t}) \quad (6)$$

where $d$ is the six-month crisis threshold for the market index decline and its default value is 40%, consistent with Systemic Risk Analysis with simulation. By defining leverage as $L_{i,t} = (D_{i,t} + W_{i,t})/W_{i,t}$, the formula can be transformed into the following:

$$\begin{aligned} SRISK_{i,t} = & max[0; (\kappa L_{i,t} - 1 + (1-\kappa)LRMES_{i,t})W_{i,t}], \\ & W_{i,t}[\kappa L_{i,t} + (1-\kappa)LRMES_{i,t} - 1] \end{aligned} \quad (7)$$

Unlike Acharya et al. (2012), other authors (e.g., Laeven et al. (2016)) do not limit SRISK from below to zero, allowing SRISK to take on negative values, with a view that highly capitalized banks with large buffers that can easily absorb systemic shocks subtract systemic risk from the financial system. Acharya et al. (2012) limit SRISK from below to zero because they are interested in estimating capital shortages that by definition cannot take on negative values.

## 3. Data and preliminary analyses

In this section, we describe the sample composition (*Section* 3.1), the financial institutions characteristics (*Section* 3.2), and some stylized facts regarding the systemic risk measures for the Chinese financial system (*Section* 3.3).

### 3.1. Data description

Our empirical analysis focuses on a panel of 264 Chinese financial institutions listed on the Shanghai and Shenzhen Stock Exchanges between 2005:4 and 2019:4 time period. The dataset contains both 43 Commercial Banks (CBs), 74 Finance Services/Broker Companies (FSs) and 147 Real Estate Finance Services (REFs). The data source is *Thomson Reuters Data Stream*.

#### 3.1.1. Commercial banks

According to the China Banking Regulatory Commission (CBRC), the Chinese banking system is composed of five banks categories: (i) State Owned Banks (SOB); (ii) policy banks; (iii) joint-stock or commercial banks; (iv) rural banks; (v) small cooperative banks. The state banks, controlled by the central government, are: the Industrial and Commercial Bank of China, the Bank of China, the Construction Bank of China, the Agricultural Bank of China and the Bank of Communication. The remaining commercial banks are non-state banks, including China CITIC Bank, China Everbright Bank, China Merchants Bank, Shanghai Pudong Development Bank, the Industrial Bank of China and the Bank of Beijing%.[11]

For this analysis, we survey 43 continuously listed Chinese commercial banks. We collect the accounting and financial variables from Thomson Reuters Data Stream which provides a specific section labelled as "Banks".

#### 3.1.2. Finance services

Finance Services, known also as Securities Companies or Broker Companies, as stock market intermediaries, were developed from the securities departments of commercial banks and trust companies. They have a high degree of dependence on intermediary business, in particular with agency securities trading business. During 2014 and the first half of 2015, the China' securities considerably grew amid enthusiastic market sentiment. However, during the second half of 2015, due to unusual volatility in the Shanghai and Shenzhen indices, some investors were forced to liquidate their positions when the price of underlying stocks fell below a certain threshold.

Comparing both the list in the CSRC 2018 report and the core business descriptions of each company available for each financial institution identified as "Finance Services" provided by Thomson Reuters Data Stream, we collected reliable data at corporate level of accounting and financial variables for 74 continuously listed finance services/broker companies.

#### 3.1.3. Real estate finance services

Real Estate is considered as a pillar industry of the Chinese economy and its growth, through the years, has been promoted by the deep support of financial sector, particularly, the banking sector. The business model of Real Estate Developers relies on a higher leverage, than other sectors (e.g., the finance services sector), and a long turnover cycle. A large share of capital, required by real estate companies, comes from bank loans causing a long-term structural unbalanced financing structure with banks bearing the majority of real estate market risk. Two main reasons explain this situation. On the one hand, real estate developers have insufficient funds of their own. On the other hand, although the development of China' capital market has opened financing channels for real estate companies (e.g., issuance of shares, bonds, trust financing), these channels are subject to many restrictions (He, 2016).[12]

Real Estate Finance Developers face different kinds of financial risks, all of them closely linked and interacted. At micro level, they could incur in operational, liquidity and credit risks; at macro level, policy and bubbles risk require close attention by regulatory authorities.

For the purpose of this paper, we select continuously listed 147 Real Estate Finance Developers included in the group "Real Estate Finance & Services" provided by Thomson Reuters Data Stream.

[11] Agricultural Bank of China, Bank of China, China Construction Bank Corporation and Industrial and Commercial Bank of China are also recognized as Systemically Important Financial Institutions (SIFIs).

[12] In addition, the real estate sector is particularly policy-sensitive. From December 2009 to December 2013, China began a massive real estate controls in order to curb housing prices. These policy include: industrial, land, financial and tax policies.

**Table 3**
Financial institutions characteristics for the different sub-periods summary statistics.

| Description | Variable | Global Financial Crisis: 2007:1–2009:4 | | | | Monetary Policy Restriction: 2010:1–2014:4 | | | | Second Stock Crash: 2015:1–2019:4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Dev. | Min. | Max. | Mean | Std. Dev. | Min. | Max. | Mean | Std. Dev. | Min. | Max. |
| Chinese Financial System | Size (ln) | 13.214 | 2.459 | 5.251 | 21.268 | 14.509 | 2.443 | 6.768 | 21.934 | 15.410 | 2.418 | 8.878 | 22.220 |
| | Δ Size (%) | 0.057 | 0.200 | −0.993 | 1.748 | 0.049 | 0.124 | −0.874 | 1.708 | 0.034 | 0.142 | −0.823 | 1.832 |
| | Mkt Leverage (%) | 0.391 | 0.825 | 0.001 | 12.188 | 1.120 | 2.165 | 0.001 | 23.940 | 2.814 | 5.694 | 0.001 | 42.379 |
| | Δ Mkt Leverage (%) | −0.050 | 0.596 | −3.325 | 4.141 | 0.050 | 0.540 | −3.325 | 4.141 | 0.002 | 0.519 | −3.325 | 4.141 |
| | Acc Leverage (%) | 4.721 | 5.688 | −3.720 | 37.441 | 5.372 | 4.983 | −1.557 | 24.559 | 6.143 | 5.270 | −3.720 | 23.814 |
| | Δ Acc Leverage Growth (%) | −0.005 | 0.377 | −2.846 | 2.485 | 0.039 | 0.251 | −2.225 | 2.480 | −0.004 | 0.673 | −30.311 | 2.143 |
| Commercial banks | Size (ln) | 18.780 | 1.426 | 16.175 | 21.268 | 18.942 | 1.606 | 16.258 | 21.934 | 18.930 | 1.594 | 16.350 | 22.220 |
| | Δ Size (%) | 0.087 | 0.097 | −0.132 | 0.403 | 0.065 | 0.077 | −0.106 | 0.744 | 0.033 | 0.054 | −0.117 | 0.295 |
| | Mkt Leverage (%) | 1.385 | 1.179 | 0.043 | 5.738 | 4.653 | 3.487 | 0.367 | 23.059 | 10.390 | 10.152 | 0.001 | 42.379 |
| | Δ Mkt Leverage (%) | 0.066 | 0.336 | −0.611 | 0.873 | 0.054 | 0.226 | −0.575 | 0.873 | 0.026 | 0.177 | −0.611 | 0.752 |
| | Acc Leverage (%) | 18.966 | 6.443 | 9.612 | 37.441 | 16.419 | 2.342 | 11.069 | 24.559 | 15.412 | 2.478 | 9.612 | 23.814 |
| | Δ Acc Leverage Growth (%) | −0.001 | 0.136 | −0.715 | 0.319 | −0.018 | 0.076 | −0.293 | 0.193 | −0.018 | 0.082 | −0.587 | 0.335 |
| Finance services | Size (ln) | 13.075 | 2.388 | 6.915 | 17.222 | 14.724 | 1.930 | 8.504 | 18.384 | 15.389 | 1.989 | 8.878 | 19.475 |
| | Δ Size (%) | 0.040 | 0.215 | −0.993 | 1.289 | 0.078 | 0.199 | −0.322 | 1.708 | 0.050 | 0.202 | −0.823 | 1.832 |
| | Mkt Leverage (%) | 0.056 | 0.157 | 0.001 | 1.280 | 0.536 | 1.749 | 0.001 | 23.940 | 2.472 | 4.544 | 0.001 | 23.940 |
| | Δ Mkt Leverage (%) | −0.064 | 0.727 | −3.325 | 4.141 | 0.154 | 0.988 | −3.325 | 4.141 | 0.037 | 0.556 | −3.325 | 4.141 |
| | Acc Leverage (%) | 3.325 | 2.258 | −3.720 | 11.449 | 3.282 | 2.057 | −1.557 | 13.960 | 3.932 | 2.583 | −3.720 | 13.960 |
| | Δ Acc Leverage Growth (%) | −0.048 | 0.334 | −1.179 | 1.668 | 0.089 | 0.353 | −1.733 | 2.480 | 0.025 | 0.232 | −1.052 | 1.791 |
| Real Estate Finance Developers | Size (ln) | 12.630 | 1.681 | 5.251 | 16.813 | 13.617 | 1.663 | 6.768 | 18.225 | 14.408 | 1.774 | 10.268 | 19.351 |
| | Δ Size (%) | 0.057 | 0.206 | −0.993 | 1.748 | 0.041 | 0.109 | −0.874 | 1.214 | 0.028 | 0.127 | −0.789 | 1.766 |
| | Mkt Leverage (%) | 0.334 | 0.760 | 0.001 | 12.188 | 0.786 | 1.531 | 0.001 | 13.150 | 1.268 | 2.462 | 0.001 | 13.150 |
| | Δ Mkt Leverage (%) | −0.059 | 0.598 | −2.871 | 1.941 | 0.031 | 0.445 | −2.871 | 1.941 | −0.015 | 0.554 | −2.871 | 1.941 |
| | Acc Leverage (%) | 3.254 | 2.999 | −1.360 | 20.008 | 3.915 | 2.869 | −1.360 | 20.008 | 4.531 | 3.798 | −1.360 | 20.008 |
| | Δ Acc Leverage Growth (%) | 0.000 | 0.398 | −2.846 | 2.485 | 0.037 | 0.241 | −2.225 | 1.985 | −0.012 | 0.840 | −30.311 | 2.143 |

The table reports quarterly summary statistics of listed Chinese financial institutions: Commercial Banks, Finance Services, Real Estate Finance Developers over the time period 2006:1 to 2019:4. $Size_{i,t}$ is natural logarithm of the total assets of financial institution $i$ at quarter $t$; $\Delta Size_{i,t}$ is the quarterly growth of total assets of financial institution $i$; $Market\ Leverage_{i,t}$ is the quasi-market leverage ratio defined as the market value of assets (market capitalization of equity plus debt) over market capitalization (equal to the share price multiplied by the number of shares outstanding) of financial institution $i$ at quarter $t$; $Accounting Leverage_{i,t}$ is the total assets to equity ratio of financial institution $i$ at quarter $t$.

**Table 4**
State variables — Summary statistics.

| | Shanghai Composite Index | Liquidity spread | Change T-Bill | Change Y-curve slope | 5y Gov. Bonds | VIX |
|---|---|---|---|---|---|---|
| Mean | 0.001 | 1.041 | 0.001 | 0.597 | 3.263 | 18.777 |
| Median | 0.003 | 0.823 | 0.000 | 0.552 | 3.206 | 16.200 |
| Minimum | −0.173 | −1.108 | −0.812 | −0.472 | 1.900 | 9.190 |
| Maximum | 0.192 | 5.741 | 0.365 | 1.942 | 4.610 | 80.860 |
| Std. Dev. | 0.036 | 1.005 | 0.049 | 0.557 | 0.548 | 9.006 |
| Skewness | −0.352 | 1.079 | −8.766 | 0.303 | 0.270 | 2.643 |
| Kurtosis | 5.806 | 4.394 | 149.569 | 2.127 | 2.282 | 12.641 |

Summary statistics of the state variables: *Shanghai Composite Index*: is the weekly return of the index of the SHANGHAI stock exchange; *Liquidity spread*: is the liquidity spread calculated as the difference between the three months Chinese repo-rate and the three months Chinese T-bill; *T-Bill change*: indicates the change in Chinese treasury bill 3 month rate; *Yield-Curve slope*: indicates the change in slope of the yield curve represented by Chinese 5-years minus three-months interest rate on government bonds; *5yBonds*: indicates the slope of the Chinese 5-years government bonds; (*VIX*) is the CBOE option implied volatility index.

### 3.2. Some descriptive statistics

Table 2 reports the firm-level characteristics for the balance sheets of all the financial institutions belonging to our sample. $Size_{i,t}$ is natural logarithm of the total assets of financial institution $i$ at quarter $t$; $\Delta Size_{i,t}$ is the quarterly growth of total assets of financial institution $i$ at quarter $t$; $Market\ Leverage_{i,t}$ is the quasi-market leverage ratio (see Acharya et al., 2017) defined as the market value of assets (market capitalization of equity plus debt) over market capitalization (equal to the share price multiplied by the number of shares outstanding) of financial institution $i$ at quarter $t$; $Accounting Leverage_{i,t}$ is the total assets to equity ratio of financial institution $i$ at quarter $t$. These ratio are proxies for the level of solvency of a financial institution. For both Leverage ratios, we calculate their quarterly growth rate.

We consider both accounting and market leverage ratio for the following motivations. First, both central banks and regulators have focused on book values. For the availability of credit, book values are key. Secondly, market values are also important to bear in mind, especially regarding their relationship with book leverage over the cycle. Market capitalization of a financial institution reflects the market value of the equity holders' stake, and hence an assessment by market participants of the creditworthiness of the bank as a borrower. If market participants have reservations about a bank's business model or creditworthiness, then market capitalization will be correspondingly very thin, and the market-to-book ratio of bank equity will be small. In effect, this means that a greater proportion of the bank's value is held by the creditors, rather than the equity holders, and therefore that the bank has a high market value leverage.

In relation to the *Size*, CBs are, on average, 36 times larger than FSs and REFs. We find that the quarterly growth of assets is the same for CBs and FSs and greater than REFS. CBs have the higher *Leverage*, both at market and accounting values, rather than FSs and REFs. However, there are some notable differences among financial institutions. CBs and FSs show 0.036% and 0.055%, respectively, while REFSs have a negative market leverage growth, −0.013%.

We also investigate the data over three sub-periods: (1) the Global Financial Crisis (GFC) from 2007:1 to 2009:4; (2) the Monetary Policy Restriction conducted by the People Bank of China (PBoC) from 2010:1 to 2014:4; (3) the second stock crash from 2015:1 to 2019:4. By inspection Table 3, it is possible to have an idea of the quarterly summary statistics for the financial institutions characteristics over the three sub-periods. The attention is focused on the *Market Leverage* ratio.

**Table 5**
*ΔCoVaR, MES, SRISK* summary statistics.

| | Variable | Mean | Std. Dev. | Min. | Max |
|---|---|---|---|---|---|
| Chinese Financial System | ΔCoVaR (%) | 1.49 | 1.55 | −5.38 | 23.72 |
| | MES (%) | 1.46 | 2.03 | −0.47 | 12.37 |
| | SRISK (%) | 0.38 | 2.19 | 0.00 | 54.88 |
| Commercial banks | ΔCoVaR (%) | 1.69 | 2.13 | −4.30 | 17.07 |
| | MES (%) | 2.62 | 3.99 | −0.47 | 12.37 |
| | SRISK (%) | 2.22 | 5.04 | 0.00 | 54.88 |
| Finance services | ΔCoVaR (%) | 1.10 | 1.81 | −2.10 | 20.17 |
| | MES (%) | 0.44 | 1.11 | −0.47 | 12.37 |
| | SRISK (%) | 0.03 | 0.09 | 0.00 | 1.04 |
| Real Estate Finance Developers | ΔCoVaR (%) | 1.62 | 1.12 | −5.38 | 23.72 |
| | MES (%) | 1.63 | 1.10 | −0.47 | 12.37 |
| | SRISK (%) | 0.02 | 0.05 | 0.00 | 0.75 |

The table reports weekly summary statistics of the three measures of systemic risk for the sample of listed Chinese financial institutions. $\Delta\ CoVaR$, *MES*, *SRISK* are computed over the period 1st January 2006 to 31st December 2019, expressed in percentages in relation to the: (i) Chinese Financial System; (ii) Commercial Banks; (iii) Finance Services; (iv) Real Estate Finance Developers.

We notice that for the entire Chinese financial system, the leverage is almost septupled over 2007 to 2019 time period. Particularly, at the end of the time period, the market leverage ratio is seven times greater for CBs, for REFs is almost four times, while, surprisingly, for FSs is almost forty-four times.

Looking at the $\Delta Mkt\ Leverage$, it increases over the whole period considered particularly for CBs and REFs (see Fig. 1). FSs and REFs show a negative leverage growth (see Table 3, −0.064%, −0.059%, respectively) during the global financial crisis relative to CBs. In particular, FSs seems to have a counter-cyclical effect during financial market turmoil. During the Monetary Policy Restriction, all financial institutions increased their market leverage. In the third sub-period considered, i.e., the 2015 Stock Crash & Post Monetary Policy Restriction, FSs shows a larger leverage growth (0.037%) relative to CBs, 0.06%, and REFs, −0.015%.

In order to get some preliminary evidence on the relationship between total asset and leverage growth, we perform a graphical analysis by reporting scatter charts of the rate of change between time $t$ and $t+1$ of total assets and leverage. Fig. 2 shows the relationship between leverage and total assets both for the Chinese financial system as a whole and for each financial institution. The comparison of the scatter charts shows that, within the Chinese financial system (scatter A), leverage is counter cyclical. However, when we consider each type of financial intermediary, we notice that the positive relationship between total assets and leverage is positive for CBs (scatter B), indicating procyclicality. Regarding both FSs and REFs (scatters C, D, respectively), the relationship is inverse relationship, indicating that leverage is countercyclical.

### 3.3. ΔCoVaR, MES, SRISK patterns in China

To estimate the time-varying $VaR_t$ and $CoVaR_t$, we include a set of state variables to capture the time variation in conditional moments of asset returns. The Chinese state variables used in this analysis are: *Shanghai Composite Index*: is the weekly return of the index of the SHANGHAI stock exchange; *Liquidity spread*: is the liquidity spread calculated as the difference between the three months Chinese repo-rate and the three months Chinese T-bill; *T-Bill change*: indicates the change in Chinese treasury bill 3 month rate; *Yield-Curve slope*: indicates the change in slope of the yield curve represented by Chinese 5-years minus three-months interest rate on government bonds; *5yBonds*: indicates the slope of the Chinese 5-years government bonds. We also include the weekly Volatility Index (*VIX*) of the Chicago Board Options Exchange (CBOE) as a measure of market risk and investors' sentiments.[13] Table 4 reports the summary statistics for the state variables.

In Appendix, we report the correlation matrix between *ΔCoVaR* and the full set of state variables. The correlations do not show any extremely high value.

Table 5 reports the summary statistics of our three measures of systemic risk. We find that *ΔCoVaR* ranges from a low of −5.38% to a high of 23.72%, *MES* ranges from a low of −0.47% to a high of 12.37%, and the *SRISK* ranges from a low of 0% to a high of 54.88%. For all the systemic risk measures (*ΔCoVaR*, *MES*, *SRISK*), on average, commercial banks show a higher systemic risk (4.32%, 6.56%, 6.82%) in comparison to finance services (3.23%, 4.18%, 0.08%) and real estate finance services (1.62%, 2.42%, 0.02%).[14]

We estimate the individual institutions systemic risk measures over the period form January 2006 to December 2019.[15] Financial institutions' stock prices and state variables are taken from Thomson Reuters Eikon database. In our analysis, we take the positive value of *ΔCoVaR* and *MES*, and we consider the percentage of *SRISK* for each financial institution interpreted as systemic risk share (Brownlees & Engle, 2016).

From July 2008 to January 2009, Chinese exports fallen by 18%, imports by more than 40% and Foreign Direct Investment (FDI) by 30%. The stock crash, that took place in 2008, triggered the process for the Chinese government financial stability mechanism with macroprudential approaches and effective methods. The Shanghai Composite Index (SHCI) dropped from 5,362.7 on 2007:4 to 1,806.9 on 2008:4; during the same painful period, the Shenzhen Composite Index (SZCI) fell 58.67 percent, from 1,261.2 to 521.19. Both the SHCI and the SZCI further dropped 29% on 2015:3, respectively, when the renmimbi (RMB) suffered a 1.6 and 12% depreciation in relation to US Dollar and Euro exchange rate, respectively. When announcing its stimulus response to the 2008 Global Financial Crisis (GFC), Beijing pushed all the efforts to *"target spheres that would promote and consolidate the expansion of consumer credit"* (The Economist, November 2008). Moreover, at the end of 2009, after an increase in the M2 supply, and till the end of 2015, the PBoC began to tighten the M2 supply for fear of an overblown bank credit expansion after the 2008 financial crisis. As M2 growth continued to slow down, banks became more vulnerable to unexpected deposit withdrawals, which exposed banks to the risk of violating the Loan-to-Deposit Ratio (LDR).[16]

Fig. 3 shows the fluctuations of the three measures of systemic risk. As expected, well identified episodes of financial distress, such as the Global Financial Crisis and the second stock crash in 2015, are

[13] This state variable seems reasonable because of the strong degree of globalization in the financial industry and the predominance of the US and Chinese economies.

[14] To avoid outliers, we winsorized *ΔCoVaR*, *MES* and *SRISK* at 1st and 99th percentiles.

[15] It is worth noticing that the dataset used for the estimation also includes the 31 days of December 2005 so that we can obtain an estimate of the *ΔCoVaR*, *MES* and *SRISK* of the first week of 2006.

[16] As other central banks, the PBoC adopts several instruments (e.g., open market operations) to influence the amount of credit in the banking system with the harmonization of a twofold China's banking regulations related both to the quantity and the quality of banks loans: a) the LDR regulation; b) the quality-control regulation called the safe-loan regulation. The LDR regulation, established in 1994, is a 75% threshold level on the ratio of banks loans to bank deposits for each commercial bank as a way to manage the total amount of bank loans. To meet unexpected deposit shortfalls against the LDR threshold, the bank attracted additional deposits by offering a much higher rate than the official deposit rate imposed by the PBoC. However, the issue for banks is not the LDR, but the risk of surpassing the threshold due to unexpected deposit shortfalls. This is the case for nonstate banks, for which the LDR was above 75% on average in the earlier part of the 2006–2012 period and needed the last-minute rush to keep the ratio below the 75% threshold around the time of the PBoC audit.

**Table 6**
Regression results pro-cyclicality leverage.

| Dependent variable | (ln) leverage$_{i,t-1}$ ($\beta_1$) | ΔSize$_{i,t}$ ($\beta_2$) | Constant | Fixed effects | Time dummy | N. Obs. | $R^2$ Adj. |
|---|---|---|---|---|---|---|---|
| Panel A: full time period — 2006:1–2019:4 | | | | | | | |
| Δ market leverage | −0.0602*** | 0.0522 | −0.1865*** | YES | YES | 10,167 | 0.08 |
| | (0.0033) | (0.0489) | (0.0214) | | | | |
| Δ accounting leverage | −0.1685*** | 0.1815*** | 0.2214*** | YES | YES | 10,162 | 0.09 |
| | (0.0357) | (0.0318) | (0.0567) | | | | |
| Panel B: Global Financial Crisis (GCF) — 2007:1–2009:4 | | | | | | | |
| Δ market leverage | −0.1839*** | 0.0153 | −0.5606*** | YES | YES | 1,903 | 0.21 |
| | (0.0140) | (0.0869) | (0.0379) | | | | |
| Δ accounting leverage | −0.5282*** | 0.0379 | 0.6388*** | YES | YES | 1,811 | 0.33 |
| | (0.0424) | (0.0416) | (0.0532) | | | | |
| Panel C: Monetary Policy Restriction (MPR) — 2010:1–2014:4 | | | | | | | |
| Δ market leverage | −0.1222*** | 0.2518** | −0.1787*** | YES | YES | 3,556 | 0.08 |
| | (0.0097) | (0.0821) | (0.0193) | | | | |
| Δ accounting leverage | −0.3139*** | 0.3927*** | 0.4483*** | YES | YES | 3,548 | 0.17 |
| | (0.0438) | (0.0581) | (0.0624) | | | | |
| Panel D: Post Monetary Policy Restriction (PMPR) — 2015:1–2019:4 | | | | | | | |
| Δ market leverage | −0.0832*** | −0.0383 | −0.2714*** | YES | YES | 4,414 | 0.08 |
| | (0.0064) | (0.1103) | (0.0266) | | | | |
| Δ accounting leverage | −0.4050*** | 0.1038** | 0.6157*** | YES | YES | 4,529 | 0.26 |
| | (0.0489) | (0.0441) | (0.0754) | | | | |

The table reports regressions using alternative specifications. $\Delta Size_{i,t}$ is the increase in size (as natural logarithm of total assets) for financial institution $i$ at quarter $t$. $(ln)Leverage_{i,t-1}$ is the natural logarithm of total assets for financial institution $i$ at quarter $t-1$. Alternatively to "*quasi-market leverage*" ratio, we consider, as robustness, "*accounting leverage*", as the ratio between total asset and total equity without considering assets valued at fair value; *Time Dummy* is a set of dummies capturing fixed effects for each quarter. Results are reported for all the financial institutions over full period (2006:1–2019:4) in Panel A; the Global Financial Crisis (GFC) from 2007:1 to 2009:4 in Panel B; (ii) the Monetary Policy Restriction (MPR) conducted by the People Bank of China (PBoC) from 2010:1 to 2014:4 in Panel C; (iii) the second stock crash and the post monetary period restriction (PMPR) from 2015:1 to 2019:4 in Panel D.
Sample period: 2006:1–2019:4.
*, **, *** denote the 10%, 5% and 1% significance level, respectively.

**Table 7**
Regression results pro-cyclicality leverage — Chinese financial system.

| | Δ Market leverage | | | | Δ Accounting leverage | | | |
|---|---|---|---|---|---|---|---|---|
| | [i] | [ii] | [iii] | [iv] | [i] | [ii] | [iii] | [iv] |
| (ln)market leverage$_{i,t-1}$ ($\beta_1$) | −0.0601*** | −0.0597*** | −0.0601*** | −0.0597*** | | | | |
| | (0.0033) | (0.0031) | (0.0033) | (0.0031) | | | | |
| (ln)accounting leverage$_{i,t-1}$ ($\beta_1$) | | | | | −0.1690*** | −0.1671*** | −0.1690*** | −0.1671*** |
| | | | | | (0.0357) | (0.0355) | (0.0357) | (0.0355) |
| ΔSize$_{i,t}$ ($\beta_2$) | 0.6027*** | 0.6549*** | 0.6023*** | 0.6550*** | 0.3928*** | 0.3430*** | 0.3932*** | 0.3432*** |
| | (0.1579) | (0.1381) | (0.1579) | (0.1381) | (0.1030) | (0.0969) | (0.1031) | (0.0969) |
| ΔSize$_{i,t}$*Non CBs ($\beta_3$) | −0.5635*** | −0.6371*** | | | −0.2164** | −0.1669* | | |
| | (0.1626) | (0.1455) | | | (0.1054) | (0.1002) | | |
| ΔSize$_{i,t}$*FSs ($\beta_4$) | | | −0.5331** | −0.6488*** | | | −0.2379** | −0.1836* |
| | | | (0.1995) | (0.1891) | | | (0.1113) | (0.1059) |
| ΔSize$_{i,t}$*REFs ($\beta_5$) | | | −0.5746*** | −0.6328*** | | | −0.2061* | −0.1587 |
| | | | (0.1624) | (0.1451) | | | (0.1078) | (0.1033) |
| GFC | | 0.0068 | | 0.0067 | | −0.0316 | | −0.0317 |
| | | (0.0248) | | (0.0248) | | (0.0236) | | (0.0237) |
| MPR | | 0.1322*** | | 0.1322*** | | 0.023 | | 0.0231 |
| | | (0.0227) | | (0.0227) | | (0.0292) | | (0.0292) |
| PMPR | | 0.1215*** | | 0.1215*** | | 0.0207 | | 0.0209 |
| | | (0.0219) | | (0.0220) | | (0.0307) | | (0.0307) |
| Constant | −0.1893*** | −0.1892*** | −0.1892*** | −0.1892*** | 0.2208*** | 0.2195*** | 0.2207*** | 0.2193*** |
| | (0.0214) | (0.0211) | (0.0214) | (0.0211) | (0.0566) | (0.0565) | (0.0566) | (0.0566) |
| Fixed effects | YES | YES | YES | YES | YES | YES | YES | YES |
| Time dummy | YES | NO | YES | NO | YES | NO | YES | NO |
| Crisis dummy | NO | YES | NO | YES | NO | YES | NO | YES |
| N. Obs. | 10,167 | 10,167 | 10,167 | 10,167 | 10,162 | 10,162 | 10,162 | 10,162 |
| $R^2$ Adjusted | 0.08 | 0.04 | 0.08 | 0.04 | 0.08 | 0.08 | 0.085 | 0.082 |

The table reports regressions using alternative specifications. $\Delta Size_{i,t}$ is the increase in size (as natural logarithm of total assets) for financial institution $i$ at quarter $t$. $(ln)Leverage_{i,t-1}$ is the natural logarithm of total assets for financial institution $i$ at quarter $t-1$. Alternatively to "*quasi-market leverage*" ratio, we consider, as robustness, "*accounting leverage*", as the ratio between total asset and total equity without considering assets valued at fair value; *Time Dummy* is a set of dummies capturing fixed effects for each quarter; *Crisis Dummy* is a set of four dummy variables capturing fixed effects for the four sub-periods identified in our analysis, namely: (i) the Global Financial Crisis (GFC) from 2007:1 to 2009:4; (ii) the Monetary Policy Restriction (MPR) conducted by the People Bank of China (PBoC) from 2010:1 to 2014:4; (iii) the second stock crash and the post monetary period restriction (PMPR) from 2015:1 to 2019:4. [i] is the benchmark specification using independent variables and time dummies; [ii] includes independent variables and replaces time dummies with the four regimes; [iii] includes independent variables, time dummies and the interaction of explanatory variables with FSs and REFs (dummy variable equal to 1 for FSs and REFs, and 0 elsewhere); [iv] includes independent variables, the interaction of explanatory variables with FSs and REFs (as for specification [iii]) and replaces time dummies with the four regimes.
Sample period: 2006:1–2019:4.
*, **, *** denote the 10%, 5% and 1% significance level, respectively.

**Table 8**
Regression results pro-cyclicality leverage (marginal effects for CBs, FSs, REFs, and sub-periods.)

| | Δ market leverage | | | Δ accounting leverage | | |
|---|---|---|---|---|---|---|
| | [i] | [ii] | [iii] | [i] | [ii] | [iii] |
| (ln)market leverage$_{i,t-1}$ ($\beta_1$) | −0.0596*** | −0.0598*** | −0.0599*** | | | |
| | (0.0031) | (0.0031) | (0.0032) | | | |
| (ln)accounting leverage$_{i,t-1}$ ($\beta_1$) | | | | −0.1673*** | −0.1665*** | −0.1676*** |
| | | | | (0.0356) | (0.0355) | (0.0356) |
| ΔSize$_{i,t}$ ($\beta_2$) | 0.0176 | 0.0409 | −0.0167 | 0.1767*** | 0.1905*** | 0.1305*** |
| | (0.0514) | (0.0494) | (0.1078) | (0.0322) | (0.0428) | (0.0363) |
| ΔSize$_{i,t}$*CBs*GFC ($\beta_3$) | 1.0535*** | | | 0.3748** | | |
| | (0.2333) | | | (0.1753) | | |
| ΔSize$_{i,t}$*CBs*MPR ($\beta_4$) | 0.7067*** | | | −0.0766 | | |
| | (0.1327) | | | (0.1105) | | |
| ΔSize$_{i,t}$*CBs*PMPR ($\beta_5$) | 0.0988 | | | 0.1928 | | |
| | (0.2006) | | | (0.1254) | | |
| ΔSize$_{i,t}$*FSs*GFC ($\beta_3$) | | −0.2774** | | | −0.3002 | |
| | | (0.1362) | | | (0.1831) | |
| ΔSize$_{i,t}$*FSs*MPR ($\beta_4$) | | −0.1095 | | | 0.143 | |
| | | (0.1072) | | | (0.0998) | |
| ΔSize$_{i,t}$*FSs*PMPR ($\beta_5$) | | 0.0888 | | | −0.0604 | |
| | | (0.2169) | | | (0.0536) | |
| ΔSize$_{i,t}$*REFs*GFC ($\beta_3$) | | | 0.0549 | | | −0.0084 |
| | | | (0.1429) | | | (0.0633) |
| ΔSize$_{i,t}$*REFs*MPR ($\beta_4$) | | | 0.2540* | | | 0.3437*** |
| | | | (0.1348) | | | (0.0731) |
| ΔSize$_{i,t}$*REFs*PMPR ($\beta_5$) | | | −0.0189 | | | 0.0311 |
| | | | (0.1462) | | | (0.1063) |
| GFC | 0.0024 | 0.0087 | 0.0074 | −0.0338 | −0.0304 | −0.0294 |
| | (0.0248) | (0.0250) | (0.0245) | (0.0237) | (0.0237) | (0.0239) |
| MPR | 0.1302*** | 0.1334*** | 0.1259*** | 0.0239 | 0.0215 | 0.0125 |
| | (0.0227) | (0.0228) | (0.0226) | (0.0293) | (0.0293) | (0.0294) |
| PMPR | 0.1211*** | 0.1189*** | 0.1206*** | 0.0201 | 0.0209 | 0.0191 |
| | (0.0218) | (0.0220) | (0.0220) | (0.0308) | (0.0307) | (0.0309) |
| Constant | −0.1871*** | −0.1864*** | −0.1854*** | 0.2203*** | 0.2192*** | 0.2231*** |
| | (0.0209) | (0.0212) | (0.0209) | (0.0566) | (0.0566) | (0.0566) |
| Fixed effects | YES | YES | YES | YES | YES | YES |
| Time dummy | NO | NO | NO | NO | NO | NO |
| Crisis dummy | YES | YES | YES | YES | YES | YES |
| N. Obs. | 10,167 | 10,167 | 10,167 | 10,162 | 10,162 | 10,162 |
| $R^2$ Adjusted | 0.04 | 0.04 | 0.04 | 0.08 | 0.08 | 0.08 |

The table reports regressions using alternative specifications. $\Delta Size_{i,t}$ is the increase in size (as natural logarithm of total assets) for financial institution $i$ at quarter $t$. $(ln)Leverage_{i,t-1}$ is the natural logarithm of total assets for financial institution $i$ at quarter $t-1$. Alternatively to "*quasi-market leverage*" ratio, we consider, as robustness, "*accounting leverage*", as the ratio between total asset and total equity without considering assets valued at fair value; *Time Dummy* is a set of dummies capturing fixed effects for each quarter; *Crisis Dummy* is a set of four dummy variables capturing fixed effects for the four sub-periods identified in our analysis, namely: (i) the Global Financial Crisis (GFC) from 2007:1 to 2009:4; (ii) the Monetary Policy Restriction (MPR) conducted by the People Bank of China (PBoC) from 2010:1 to 2014:4; (iii) the second stock crash and the post monetary period restriction (PMPR) from 2015:1 to 2019:4. [i] is the specification using independent variables and the interaction of explanatory variable $\Delta Size$ with $CBs$ (dummy variable taking value 1 for *"Commercial Banks"* and zero for FSs and REFs) and *Crisis Dummy*; [ii] is the specification using independent variables and the interaction of explanatory variable $\Delta Size$ with $FSs$ (dummy variable taking value 1 for *"Finance Services"* and zero for CBs and REFs) and *Crisis Dummy*; [iii] is the specification using independent variables and the interaction of explanatory variable $\Delta Size$ with $CBs$ (dummy variable taking value 1 for *"Real Estate Finance Developers"* and zero for CBs and FSs) and *Crisis Dummy*.
Sample period: 2006:1–2019:4.
*, **, *** denote the 10%, 5% and 1% significance level, respectively.

associated with a clusters of larger increases in systemic risk measures. Moreover, as most available statistical measures of systemic importance, the dynamic of $\Delta CoVaR$, *MES*, and *SRISK* tend to be procyclical suggesting that protracted periods of financial distress are generally associated with higher $\Delta CoVaR$, *MES*, and *SRISK* (Figs. 4, 5, 6).[17]

Likewise the scatter plots in Figs. 7, 8, 9 report the relationship between systemic risk' measures ($\Delta CoVaR$, *MES*, *SRISK*) and the size growth both for the entire Chinese financial system and for each financial institution.

## 4. Modelling and testing for pro-cyclicality

### 4.1. Baseline model

We start by examining the relationship between the change in leverage and the change in total assets, i.e., the pro-cyclicality of leverage:

$$\Delta Leverage_{i,t} = \alpha_0 + \beta_1 (ln) Leverage_{i,t-1} + \beta_2 \Delta Size_{i,t} + \sum_{i=1}^{264} Financial\ Institutions_i + \left[\sum_{t=2006:1}^{2019:4} Time_t\right] + \varepsilon_{i,t} \quad (8)$$

where: $\Delta Leverage_{i,t}$ is the "*quasi-market leverage*" ratio growth and $\Delta Size_{i,t}$ is the increase in size (as natural logarithm of total assets) for financial institution $i$ at quarter $t$. The $\beta_2$ coefficient if positive and statistically significant means that an increase in assets valued at fair value lead to an increase in leverage; $(ln)Leverage_{i,t-1}$ is the natural logarithm leverage ratio for financial institution $i$ at quarter *t-1*. This variable captures financial institutions' reaction to the leverage level in the previous quarter. Alternatively to "*quasi-market leverage*" ratio, we consider, as robustness, "*accounting leverage*", as the ratio between total asset and total equity without considering assets valued at fair value; *Financial Institutions* is a set of dummies capturing fixed effects for each institution CBs, FSs, and REFs; *Time* is a set of dummies

[17] Idier et al. (2014) and Adrian and Brunnermeier (2016) also find that their *MES* and $\Delta CoVaR$ are procyclical.

capturing fixed effects for each quarter. The Eq. (8) is also regressed for different sub-periods namely: (i) the Global Financial Crisis (GFC) from 2007:1 to 2009:4 (based on the classification of the Bank for International Settlements, 2010); (ii) the Monetary Policy Restriction (MPR) conducted by the People Bank of China (PBoC) from 2010:1 to 2014:4 (according to Chen et al. (2018) and Fang et al. (2018))[18]; (iii) the second stock crash and the post monetary period restriction (PMPR) from 2015:1 to 2019:4 (according to Fang et al. (2018) who refer to stock market crash and post-crash).

The second step of our empirical research is testing how differences in the financial institutions' business model affect the leverage management of financial institutions. By so doing, we are in the position to further test on a large sample of Chinese financial institutions and extend Adrian and Shin (2010) and Beccalli et al. (2015) contributions, by considering Finance Services and Real Estate Finance Developers in addition to Commercial Banks. Once again the regression is run for both "*quasi-market leverage*" and "*accounting leverage*". The regression model becomes:

$$\begin{aligned} \Delta Leverage_{i,t} = & \alpha_0 + \beta_1 (ln) Leverage_{i,t-1} + \beta_2 \Delta Size_{i,t} \\ & + \beta_3 \Delta Size_{i,t} * NonCBs_i + \\ & + \beta_4 \Delta Size_{i,t} * NonFSs_i + \beta_5 \Delta Size_{i,t} * REFs_i \\ & + \sum_{i=1}^{264} Financial\ Institutions_i + \\ & + [\sum_{t=2006:1}^{2019:4} Time_t]\ or\ [\sum_{t=1}^{3} Crisis\ Dummy_t] + \varepsilon_{i,t} \end{aligned} \tag{9}$$

where $NonCBs_i$ is a dummy variable taking value 1 for *"non commercial banks"* (i.e., FSs and REFs together), and zero for CBs. In regression (9), $\beta_2$ represents the slope of the regression line for the group of CBs, while $(\beta_2 + \beta_3)$ represents the coefficient for the group of non commercial banks. Thus, the expected sign of $\beta_2$ is positive, reflecting the pro-cyclical pattern of commercial banks' leverage, while the expected sign of $\beta_3$ is negative. As suggested by Beccalli et al. (2015), the idea is that pro-cyclicality in leverage characterizes financial institutions that are involved consistently in banking activity, so the sum $(\beta_2 + \beta_3)$ should be close to zero, indicating a policy of leverage targeting by mainly commercial banks. $\beta_1$ is expected to be negative as it reflects the behaviour of banks that try to correct deviations from some target levels.

Moreover, to evaluate the effect of FSs and REFs separately on leverage pro-cyclicality, we also add two dummy variables: $FSs_i$ is a dummy variable taking value 1 for *"Finance Services"* and zero for CBs and REFs, and $REFs_i$ is a dummy variable taking value 1 for *"Real Estate Finance Developers"* and zero for CBs and FSs. $\beta_4$ represents the slope for the group FSs, while $\beta_5$ is the slope for the group REFs. We expect that $(\beta_2 + \beta_3)$, $(\beta_2 + \beta_4)$, and $(\beta_2 + \beta_5)$ being positive. We then test whether different financial entities, such as CBs, FSs, and REFs in different financial regimes, may have a different impact on the pro-cyclicality of leverage. Formally:

$$\begin{aligned} \Delta Leverage_{i,t} = & \alpha_0 + \beta_1 (ln) Leverage_{i,t-1} + \beta_2 \Delta Size_{i,t} \\ & + \beta_3 \Delta Size_{i,t} * CBs_i * Crisis\ Dummy_t + \\ & + \beta_4 \Delta Size_{i,t} * FSs_i * Crisis\ Dummy_t \\ & + \beta_5 \Delta Size_{i,t} * REFs_i * Crisis\ Dummy_t + \\ & + \sum_{i=1}^{264} Financial\ Institutions_i + [\sum_{t=1}^{3} Crisis\ Dummy_t] + \varepsilon_{i,t} \end{aligned} \tag{10}$$

[18] Chen et al. (2018) refer the 2010–2014 period as the period of monetary policy tightening by People Bank of China. Fang et al. (2018) define the period from January 2010 to June 2014 as *"tranquil period"*.

**Table 9**
Regression results pro-cyclicality systemic risk *ΔCoVaR*.

| Dependent variable: *ΔCoVaR* | [i] | [ii] | [iii] |
|---|---|---|---|
| (ln)ΔCoVaR$_{i,t-1}$ | −0.1750*** | −0.1888*** | −0.1889*** |
| | (0.0135) | (0.0135) | (0.0135) |
| ΔSize$_{i,t}$ | −0.0174 | −0.0224 | −0.05 |
| | (0.0175) | (0.0182) | (0.0362) |
| ΔSize$_{i,t}$*GFC | | | 0.0306 |
| | | | (0.0469) |
| ΔSize$_{i,t}$*MPR | | | 0.0016 |
| | | | (0.0386) |
| ΔSize$_{i,t}$*PMPR | | | 0.0459 |
| | | | (0.0398) |
| GFC | | 0.0646*** | 0.0638*** |
| | | (0.0097) | (0.0101) |
| MPR | | 0.0211*** | 0.0217*** |
| | | (0.0061) | (0.0063) |
| PMPR | | 0.0359*** | 0.0347*** |
| | | (0.0046) | (0.0049) |
| Constant | −0.2937*** | −0.3159*** | −0.3154*** |
| | (0.0216) | (0.0214) | (0.0216) |
| Fixed effects | YES | YES | YES |
| Time dummy | YES | NO | NO |
| Crisis dummy | NO | YES | YES |
| N. Obs. | 9,929 | 9,929 | 9,929 |
| $R^2$ Adjusted | 0.14 | 0.10 | 0.10 |

The table reports regressions using alternative specifications. $\Delta Size_{i,t}$ is the increase in size (as natural logarithm of total assets) for financial institution *i* at quarter *t*. (ln)ΔCoVaR$_{i,t-1}$ is the natural logarithm of $\Delta CoVaR$ of financial institution *i* at quarter *t* − 1. *Time Dummy* is a set of dummies capturing fixed effects for each quarter; *Crisis Dummy* is a set of four dummy variables capturing fixed effects for the four sub-periods identified in our analysis, namely: (i) the Global Financial Crisis (GFC) from 2007:1 to 2009:4; (ii) the Monetary Policy Restriction (MPR) conducted by the People Bank of China (PBoC) from 2010:1 to 2014:4; (iii) the second stock crash and the post monetary period restriction (PMPR) from 2015:1 to 2019:4. [i] is the benchmark specification using explanatory variables and time dummies. [ii] includes explanatory variables and replaces time dummies with the three regimes. [iii] includes explanatory variables and the interaction of explanatory variables with the three regime dummies.
Sample period: 2006:1–2019:4.
*, **, *** denote the 10%, 5% and 1% significance level, respectively.

where $CBs_i$ is a dummy variable taking value 1 for *"Commercial Banks"* and zero for FSs and REFs; $FSs_i$ and $REFs_i$ are dummy variables described in Eq. (9); *Crisis Dummy* is a set of four dummy variables, capturing fixed effects for the four sub-periods identified in our analysis (see Eq. (8)).

### 4.2. Testing for pro-cyclicality of systemic risk

In this section, we examine to what extent the change in the fair value of assets may translate in the risk appetite of financial institutions' management. We investigate the pro-cyclicality of systemic risk measures (i.e., *ΔCoVaR*, *MES*, *SRISK*) by the following equation:

$$\begin{aligned} \Delta Systemic\ Risk_{i,t} = & \alpha_0 + \beta_1 (ln) Systemic\ Risk_{i,t-1} + \beta_2 \Delta Size_{i,t} \\ & + \sum_{i=1}^{264} Financial\ Institutions_i + \\ & + [\sum_{t=2006:1}^{2019:4} Time_t]\ or [\sum_{t=1}^{3} Crisis\ Dummy_t] + \varepsilon_{i,t} \end{aligned} \tag{11}$$

where $Systemic\ Risk_{i,t}$ and $(ln) Systemic\ Risk_{i,t-1}$ allow three systemic risk indicators, namely *ΔCoVaR*, *MES*, *SRISK* respectively. $\Delta Systemic\ Risk_{i,t}$ is the growth in each systemic risk measure for financial institution *i* at quarter *t*; $(ln) Systemic\ Risk_{i,t-1}$ is the natural logarithm of each systemic risk measure for financial institution *i* at quarter *t-1*. This variable captures financial institutions' reaction to the systemic risk level in the previous quarter. The $\beta_2$ coefficient, if positive and statistically significant, means that an increase in assets valued at fair value lead to an increase in systemic risk.

As for pro-cyclicality of leverage, we also test whether an increase in total assets has different effects on the increase in systemic risk

**Table 10**
Regression results pro-cyclicality systemic risk *MES*.

| Dependent variable: MES | [i] | [ii] | [iii] |
|---|---|---|---|
| (ln)MES$_{i,t-1}$ | −0.1802*** | −0.1876*** | −0.1877*** |
| | (0.0128) | (0.0123) | (0.0123) |
| ΔSize$_{i,t}$ | 0.0245 | 0.0144 | −0.0252 |
| | (0.0173) | (0.0175) | (0.0542) |
| ΔSize$_{i,t}$*GFC | | | 0.0078 |
| | | | (0.0638) |
| ΔSize$_{i,t}$*MPR | | | 0.0453 |
| | | | (0.0580) |
| ΔSize$_{i,t}$*PMPR | | | 0.0693 |
| | | | (0.0660) |
| GFC | | 0.0643*** | 0.0652*** |
| | | (0.0150) | (0.0160) |
| MPR | | 0.0137 | 0.0126 |
| | | (0.0116) | (0.0122) |
| PMPR | | 0.0191* | 0.0174 |
| | | (0.0115) | (0.0120) |
| Constant | −0.3341*** | −0.3469*** | −0.3463*** |
| | (0.0255) | (0.0249) | (0.0250) |
| Fixed effects | YES | YES | YES |
| Time dummy | YES | NO | NO |
| Crisis dummy | NO | YES | YES |
| N. Obs. | 9,888 | 9,888 | 9,888 |
| $R^2$ Adjusted | 0.11 | 0.09 | 0.09 |

The table reports regressions using alternative specifications. $\Delta Size_{i,t}$ is the increase in size (as natural logarithm of total assets) for financial institution $i$ at quarter $t$. (ln)$MES_{i,t-1}$ is the natural logarithm of $MES$ of financial institution $i$ at quarter $t-1$. *Time Dummy* is a set of dummies capturing fixed effects for each quarter; *Crisis Dummy* is a set of four dummy variables capturing fixed effects for the four sub-periods identified in our analysis, namely: (i) the Global Financial Crisis (GFC) from 2007:1 to 2009:4; (ii) the Monetary Policy Restriction (MPR) conducted by the People Bank of China (PBoC) from 2010:1 to 2014:4; (iii) the second stock crash and the post monetary period restriction (PMPR) from 2015:1 to 2019:4. [i] is the benchmark specification using explanatory variables and time dummies. [ii] includes explanatory variables and replaces time dummies with the three regimes. [iii] includes explanatory variables and the interaction of explanatory variables with the three regime dummies.
Sample period: 2006:1–2019:4.
*, **, *** denote the 10%, 5% and 1% significance level, respectively.

**Table 11**
Regression results pro-cyclicality systemic risk *SRISK*.

| Dependent Variable: SRISK | [i] | [ii] | [iii] |
|---|---|---|---|
| (ln)SRISK$_{i,t-1}$ | −0.0528*** | −0.0543*** | −0.0545*** |
| | (0.0067) | (0.0066) | (0.0065) |
| ΔSize$_{i,t}$ | 0.1420*** | 0.1394*** | 0.1490* |
| | (0.0244) | (0.0244) | (0.0818) |
| ΔSize$_{i,t}$*GFC | | | −0.0569 |
| | | | (0.0974) |
| ΔSize$_{i,t}$*MPR | | | −0.061 |
| | | | (0.0900) |
| ΔSize$_{i,t}$*PMPR | | | 0.0684 |
| | | | (0.0930) |
| GFC | | 0.2526*** | 0.2552*** |
| | | (0.0146) | (0.0146) |
| MPR | | 0.2573*** | 0.2597*** |
| | | (0.0157) | (0.0155) |
| PMPR | | 0.2783*** | 0.2760*** |
| | | (0.0162) | (0.0160) |
| Constant | −0.6230*** | −0.6320*** | −0.6329*** |
| | (0.0404) | (0.0397) | (0.0394) |
| Fixed effects | YES | YES | YES |
| Time dummy | YES | NO | NO |
| Crisis dummy | NO | YES | YES |
| N. Obs. | 10,081 | 10,081 | 10,081 |
| $R^2$ Adjusted | 0.11 | 0.10 | 0.10 |

The table reports regressions using alternative specifications. $\Delta Size_{i,t}$ is the increase in size (as natural logarithm of total assets) for financial institution $i$ at quarter $t$. (ln)$SRISK_{i,t-1}$ is the natural logarithm of $SRISK$ of financial institution $i$ at quarter $t-1$. *Time Dummy* is a set of dummies capturing fixed effects for each quarter; *Crisis Dummy* is a set of four dummy variables capturing fixed effects for the four sub-periods identified in our analysis, namely: (i) the Global Financial Crisis (GFC) from 2007:1 to 2009:4; (ii) the Monetary Policy Restriction (MPR) conducted by the People Bank of China (PBoC) from 2010:1 to 2014:4; (iii) the second stock crash and the post monetary period restriction (PMPR) from 2015:1 to 2019:4. [i] is the benchmark specification using explanatory variables and time dummies. [ii] includes explanatory variables and replaces time dummies with the three regimes. [iii] includes explanatory variables and the interaction of explanatory variables with the three regime dummies.
Sample period: 2006:1–2019:4.
*, **, *** denote the 10%, 5% and 1% significance level, respectively.

depending on the sub-sample of *"non commercial banks"* (Eq. (12)) and for FSs and REFs separately (Eq. (13)). The regression models become:

$$\begin{aligned}\Delta Systemic\ Risk_{i,t} =& \alpha_0 + \beta_1 (ln) Systemic\ Risk_{i,t-1} + \beta_2 \Delta Size_{i,t} \\ &+ \beta_3 \Delta Size_{i,t} * NonCBs_i \\ &+ \sum_{i=1}^{264} Financial\ Institutions_i \\ &+ [\sum_{t=2006:1}^{2019:4} Time_t]\ or\ [\sum_{t=1}^{3} Crisis\ Dummy_t] + \\ &+ \varepsilon_{i,t}\end{aligned} \tag{12}$$

$$\begin{aligned}\Delta Systemic\ Risk_{i,t} =& \alpha_0 + \beta_1 (ln) Systemic\ Risk_{i,t-1} \\ &+ \beta_2 \Delta Size_{i,t} + \beta_3 \Delta Size_{i,t} * FSs_i + \\ &+ \beta_4 \Delta Size_{i,t} * REFs_i + \sum_{i=1}^{264} Financial\ Institutions_i \\ &+ [\sum_{t=2006:1}^{2019:4} Time_t]\ or \\ &[\sum_{t=1}^{3} Crisis\ Dummy_t] + \varepsilon_{i,t}\end{aligned} \tag{13}$$

In both Eqs. (12) and (13), the base-group is the category of commercial banks. Consequently, $\beta_2$ is the estimated coefficient of the base-group and its expected sign is positive, reflecting a positive impact of assets growth which leads to an increase in systemic risk. The expected signs of $\beta_3$ in Eq. (12) and $\beta_3$, and $\beta_4$ in Eq. (13) is negative.

## 5. Empirical results

### 5.1. Leverage pro-cyclicality

The results of the estimation of Eq. (8) for the full period and for the entire Chinese financial system are reported in Table 6 (Panel A). The estimated $\beta_2$ is positive and highly statistically significant, setting the case for leverage pro-cyclicality in the sample of Chinese financial institutions. However, we notice that accounting leverage turns out statistically significant than market leverage (the latter is not statistically significant). Panel B, C and D of Table 6 report the results of the three regression models for the global financial crisis, the monetary policy restriction and second stock-crash sub-periods, respectively. For the crisis period (Table 6, Panel B), the leverage pro-cyclicality vanishes, proving that the outbreak of the financial crisis contributed to change the previous pattern of Chinese financial institutions' behaviour. These findings are in line with Adrian and Shin (2010) and Beccalli et al. (2015). The coefficient $\beta_1$ has remained negative and statistically significant, like in the other sub-periods, but now it has a higher negative value. One possible explanation is that the adjustment mechanism of financial institutions' leverage to some target levels has become stronger.

As for the monetary policy restriction, (Table 6, Panel C), the results substantially confirm those obtained for the full time period with market leverage becoming statistically significant. A possible explanation is that during downturns, when the value of a financial institution is low, the pro-cyclicality of market leverage derives from the fact that a greater proportion of its value is in the hands of the debt holders (Adrian et al., 2014; Adrian & Shin, 2010). Similarly to the crisis period,

$\beta_1$ shows a further strengthening of the adjustment process performed by financial institutions to bring leverage to the target level. Regarding the post monetary policy restriction and the second stock market crash in 2015 (Table 6, Panel D), we document that accounting leverage remains positive and statistically significant than market leverage. The pro-cyclicality of the book leverage depends on the fact that financial institutions reduce lending by reducing their debt, i.e. deleveraging. Thus, book leverage is lower during downturns and higher during economic expansion, confirming Adrian & Shin (2010) and Adrian et al. (2014)' findings Adrian et al. (2014), Adrian and Shin (2010).

Summarizing, the breakdown of the analysis into sub-periods shows a permanence over time of pro-cyclicality of Chinese financial institutions' leverage, and in particular accounting leverage measure. In addition, the management behaviour of financial institution has been influenced by the financial crisis, confirming that: (i) leverage is high during booms and low during financial turmoil (Adrian & Shin, 2010); and (ii) risk-bearing capacity of the financial system may be severely diminished when leverage falls due to an increase in collateral requirements (Geanakoplos, 2010; Gorton & Metrick, 2012).

Table 7 reports the results for Eq. (9). We report our outcomes according to the following specifications for both market and accounting leverage: [i] is the benchmark specification using independent variables and time dummies; [ii] includes independent variables and replaces time dummies with the four regimes; [iii] includes independent variables, time dummies and the interaction of explanatory variables with FSs and REFs (dummy variable equal to 1 for FSs and REFs, and 0 elsewhere); [iv] includes independent variables, the interaction of explanatory variables with FSs and REFs (as for specification [iii]) and replaces time dummies with the four regimes.

In all specifications, the estimated $\beta_2$ is positive and highly statistically significant, setting the case for leverage pro-cyclicality (both for market and accounting values) in the sample of Chinese commercial banks. Once we specialize the regression to consider the impact of the non commercial banks entities (i.e., *NonCBs* dummy variable is equal to 1 for all FSs and REFs and 0 elsewhere), other results emerge. The $\beta_3$ (for *Non CBs*) is negative and statically significant, so that the estimated slope coefficient for Non CBs ($\beta_2 + \beta_3$) is still positive but very low. The active pro-cyclical management of leverage concerns not only CBs but also FSs and REFs. Despite this, in the Chinese financial system above all, it is true that the pro-cyclicality concerns in prevalence commercial banks. A first explanation relies on the rapid increase of Chinese banks' balance sheets. At the end of December 2019, the total banking system assets were \$44.0 trillion, having more than quadrupled since the global financial crisis (Chen & Kang, 2018). During 2004–2010, the Chinese banking system was re-engineered and stabilized, and since 2010, both financial innovation and regulatory development strengthened and developed banks to meet the challenges of the economy in transition (Zhang et al., 2020). Amid this time period, in 2008, Wall Street' crash had some consequences for Chinese banks, particularly related to the fear that demand for China' export would dry up as Western economies went into recession. As response, 4 trillion yuan stimulus was launched by Beijing Government, where most of the funds were released in the form of bank credit extension. Since banks played a pivotal role in financing the expansion, they started to expand off-balance sheet business, both to circumvent stringent regulation on capital and liquidity, and to acquire new clients and asset classes (Liao et al., 2016).

A second explanation refers to the complexity of the banking system. The banks' balance sheets expansion was funded by complex structures, extending beyond deposit funding to interbank markets, shadow banking products, such as WMPs. The latter expanded from 2012 to 2016, with funding from banks redirected into third-party non-bank financial institutions engaged in riskier lending or leveraged speculative investments into financial markets.

In specifications [iii] and [iv], when we add the marginal effects for FSs and REFs, the results confirm the fact that CBs are much more involved in active pro-cyclical of leverage. The pro-cyclicality of leverage is even higher when focusing on FSs: ($\beta_2 + \beta_3$) is positive and greater than ($\beta_2 + \beta_4$), when we consider the REFs. The estimated value of $\beta_1$ is negative and significant, confirming that financial institutions react to the previous quarter leverage by correcting levels that deviate from some target levels. Finally, we notice that the findings is still the same despite different dependent variables.

Table 7 reveals that, in the Chinese financial system, the active management of leverage concerns not only the CBs category but it is extended to a broader class of financial institutions such as finance services and real estate finance developers.

In Table 8, the impact of pro-cyclical leverage during different sub-periods and for each kind of financial institution are investigated. Both the outbreak of the financial crisis and the monetary policy restriction conducted by the PBoC contributed to change the Chinese financial intermediaries' behaviour. In particular, there is evidence of pro-cyclicality of leverage for CBs during the global financial crisis and the monetary policy restriction. One possible explanation is that from 2009 to 2011, China's banking system assets expanded by 49.6 trillion yuan. Most of this was in the form of new lending, as banks extended 27 trillion yuan (\$4.2 trillion) in loans (People's Bank of China, 2011). Moreover, a second explanation for such pro-cyclicality, according with Chen and Kang (2018) refers to the increase in shadow banking products. The contractionary monetary policy, although exerting an expected effect on traditional bank loans, stimulated shadow banking and encouraged banks to bring shadow banking products onto their balance sheets in the form of risky non loan assets.

We also notice interestingly results for FSs and REFs. The FSs are counter-cyclical during the financial crisis whereas REFs become pro-cyclical during the monetary policy restriction. FSs, in trading securities on their own account or on behalf of customers, are characterized by a lower level of leverage with respect to commercial banks and real estate finance developers. Moreover, as demonstrated by Engle et al. (2015), they may become dependent on market trends during difficult times, and that their pro-cyclicality also depends on their ability to manage balance sheets aggressively and actively (Adrian et al., 2014). However, for these entities, we do not find any pro-cyclicality effect during the post monetary policy restriction. On the other hand, the pro-cyclicality of leverage for REFs may be explained by the excess of liquidity pumped by the Chinese Government, after the financial crisis, which pushed up demand for real estate consumption and investment. The high leverage ratio (see Table 3) may enlarge the procyclicality of their business operation, by weakening the resilience of the industry to shocks, and pose a severe threat for the capital chain by contributing to increase liquidity risk (People's Bank of China, 2018). During the 2015 stock crash and the post monetary policy restriction, the pro-cyclicality of all financial institutions vanishes.

### 5.2. Systemic risk pro-cyclicality

In this section, we report the results of systemic risky pro-cyclicality. Tables 9–11 show the result with respect to each systemic risk measure $\Delta CoVaR$, *MES*, *SRISK* respectively. We report our outcomes according to the following specifications: [i] is the benchmark specification using explanatory variables and time dummies; [ii] includes independent variables and replaces time dummies with the four regimes; [iii] includes independent variables and the interaction of explanatory variables with the three regimes.

We notice that financial institutions are systemic risk pro-cyclical only when we consider the *SRISK* measure. These findings are in line with Financial Stability Board (2021), in which Acharya, in presenting the evolution of *SRISK* since the 2008, shows that the level of systemic risk in the Chinese financial have consistently increased since 2007, reflecting the rapidly increasing leverage. Similar results are also found by Fang et al. (2018), Yu et al. (2018), Zhang et al. (2020). Furukawa et al. (2021), by comparing emerging markets and advanced economies

**Table 12**
Regression results pro-cyclicality systemic risk ($\Delta CoVaR$, *MES*, *SRISK*) and marginal effects for sub-periods and Non Commercial Banks.

| | ΔCoVaR | | MES | | SRISK | |
|---|---|---|---|---|---|---|
| | [i] | [ii] | [i] | [ii] | [i] | [ii] |
| (ln)$\Delta$CoVaR$_{i,t-1}$ ($\beta_1$) | −0.1750*** | −0.1889*** | | | | |
| | (0.0135) | (0.0135) | | | | |
| (ln)MES$_{i,t-1}$ ($\beta_1$) | | | −0.1802*** | −0.1875*** | | |
| | | | (0.0128) | (0.0123) | | |
| (ln)SRISK$_{i,t-1}$ ($\beta_1$) | | | | | −0.0593*** | −0.0746*** |
| | | | | | (0.0062) | (0.0078) |
| $\Delta$Size$_{i,t}$ ($\beta_2$) | −0.0311 | −0.0478 | 0.1056 | 0.0672 | 0.5010*** | 0.5984*** |
| | (0.0404) | (0.0417) | (0.0698) | (0.0705) | (0.0788) | (0.0828) |
| $\Delta$Size$_{i,t}$*Non CBs$_i$ ($\beta_3$) | 0.0121 | 0.0207 | −0.0601 | −0.0395 | −0.1042 | −0.1338* |
| | (0.0424) | (0.0441) | (0.0584) | (0.0591) | (0.0722) | (0.0710) |
| GFC | | 0.0645*** | | 0.0642*** | | 0.0350* |
| | | (0.0097) | | (0.0150) | | (0.0187) |
| MPR | | 0.0211*** | | 0.0137 | | 0.0071 |
| | | (0.0061) | | (0.0116) | | (0.0177) |
| PMPR | | 0.0356*** | | 0.0195* | | 0.0546** |
| | | (0.0047) | | (0.0114) | | (0.0215) |
| Constant | −0.2935*** | −0.3156*** | −0.3354*** | −0.3477*** | 0.6311*** | 0.7570*** |
| | (0.0217) | (0.0215) | (0.0254) | (0.0247) | (0.0558) | (0.0700) |
| Fixed effects | YES | YES | YES | YES | YES | YES |
| Time dummy | YES | NO | YES | NO | YES | NO |
| Crisis dummy | NO | YES | NO | YES | NO | YES |
| N. Obs. | 9,929 | 9,929 | 9,888 | 9,888 | 9,953 | 9,953 |
| $R^2$ Adjusted | 0.14 | 0.10 | 0.11 | 0.09 | 0.23 | 0.11 |

The table reports regressions using alternative specifications. $\Delta Size_{i,t}$ is the increase in size (as natural logarithm of total assets) for financial institution *i* at quarter *t*. (ln)$\Delta$CoVaR$_{i,t-1}$, (ln)MES$_{i,t-1}$, and (ln)SRISK$_{i,t-1}$ is the natural logarithm of $\Delta CoVaR$, *MES*, and *SRISK* of financial institution *i* at quarter $t-1$. *Time Dummy* is a set of dummies capturing fixed effects for each quarter; *Crisis Dummy* is a set of four dummy variables capturing fixed effects for the four sub-periods identified in our analysis, namely: (i) the Global Financial Crisis (GFC) from 2007:1 to 2009:4; (ii) the Monetary Policy Restriction (MPR) conducted by the People Bank of China (PBoC) from 2010:1 to 2014:4; (iii) the second stock crash and the post monetary period restriction (PMPR) from 2015:1 to 2019:4; $NonCBs_i$ is a dummy variable taking value 1 for *"non commercial banks"* (i.e., FSs and REFs together), and zero for CBs. [i] is the benchmark specification using explanatory variables, time dummies, and the interaction of explanatory variables with the kind of financial institution; [ii] includes explanatory variables, the interaction of explanatory variables with the kind of financial institution, and replaces time dummies with the three regimes.
Sample period: 2006:1–2019:4.
*, **, *** denote the 10%, 5% and 1% significance level, respectively.

during 2000–2019 time period, find that the former are characterized by a higher level of systemic risk, reflecting the growing presence of emerging markets' financial institutions in the global financial system. Emerging markets are more likely to larger shock due to their less diversified economy, less domestic and political stability. In addition, shocks (both positive or negative) are exacerbated because of structural and financial institution characteristics (Claessens & Ghosh, 2013).

We also notice that, among systemic risk measures, only *SRISK* is pro-cyclical. One possible explanation relies on the construction of this measure. Although $\Delta CoVaR$[19] and *MES* can actually assess quite carefully the degree of systemic risk contribution of each institution, they lack the ability to properly take into account the impact dimension and are less sensitive to size and leverage (Acharya et al., 2012). Thus, relying only on the $\Delta CoVaR$ and *MES* alone might not be sufficient for a thorough assessment of the pro-cyclicality of the financial system.

When we consider the interaction variable $\Delta Size_{i,t}$*$NonCBs_i$ (see Table 12), we find different results depending on the systemic risk measure. Particularly, on the one hand, when the dependent variable is $\Delta CoVaR$, and *MES* we do not find that the financial institution seem to be pro-cyclical. On the other hand, when we consider *SRISK* as dependent variable, the ($\beta_2$) remains positive and highly statistically significant which indicates a clear systemic risk pro-cyclicality especially for CBs. Moreover, the $\beta_3$ coefficient is negative and statistically significant so that the estimated slope coefficient for *"non commercial banks"* ($\beta_2$ + $\beta_3$ in specification [ii] for *SRISK*) is still positive. This means that also FSs and REFs become more systemic increasing their systemic risk.

Table 13 shows the marginal effects for FSs and REFs. First, $\beta_2$ remains positive and statistically significant, which indicates a clear pro-cyclicality of systemic risk especially for commercial banks. We argue that this pro-cyclicality may be explained by the rapid increase of WMPs, which have become, since 2016, the marginal source of funding for Chinese banks. The pro-cyclicality risk of CBs is also explained by significant volumes of new funds which were being channelled into unregulated shadow banking products.[20] In particular, the contractionary monetary policy gave to non state banks a strong incentive to take advantage of the "lax regulatory environment"[21] of shadow banking by first increasing shadow banking activities off balance sheet and then bringing shadow banking products into a special investment category on the asset side of their balance sheets (Chen et al., 2018). This assets' expansion also led to a higher interconnectedness among financial institutions (banks and finance services) which caused a sharp rise risk related to the sizable maturity mismatch between asset and liabilities (Chen & Kang, 2018; Fang et al., 2018). As a result, Chinese authorities started an aggressive deleveraging campaign, which was primarily designed to reduce the potential for systemic risks emerging

[19] While Arsov et al. (2013) argue that the $\Delta CoVaR$ is one of the most accurate systemic risk indicators, Adrian and Brunnermeier (2016) show that there might be a loose link between an institution' VaR and its contribution to the systemic risk, for which the contribution to systemic risk is related to the return that each financial institution realizes during a crisis event and to its leverage.

[20] As a matter of facts, until 2012, China' banking system had been generally stable. The principal source of funding was deposits, and loans were granted to state-owned enterprises.

[21] In 2010, the PBoC and the CBRC issued a notice to reinforce the 2006 announcement made by the State Council that banks shall not partake in risky investments to maintain "*the soundness of the banking system*". Differently to non state owned banks, Government controlled state banks should not and did not circumvent the safe-loan regulation by bringing risky shadow banking products into their balance sheet. Despite the regulations intended for limiting the risk on the balance sheet, non state banks had largely benefited from China's lax regulatory system for shadow banking until the end of 2015.

**Table 13**
Regression results pro-cyclicality systemic risk ($\Delta CoVaR$, *MES*, *SRISK*) and marginal effects for sub-periods and for FSs and REFs.

| | ΔCoVaR | | MES | | SRISK | |
|---|---|---|---|---|---|---|
| | [i] | [ii] | [i] | [ii] | [i] | [ii] |
| (ln)ΔCoVaR$_{i,t-1}$ ($\beta_1$) | −0.1748*** | −0.1887*** | | | | |
| | (0.0134) | (0.0134) | | | | |
| (ln)MES$_{i,t-1}$ ($\beta_1$) | | | −0.1803*** | −0.1876*** | | |
| | | | (0.0128) | (0.0124) | | |
| (ln)SRISK$_{i,t-1}$ ($\beta_1$) | | | | | −0.0589*** | −0.0740*** |
| | | | | | (0.0062) | (0.0078) |
| ΔSize$_{i,t}$ ($\beta_2$) | −0.0118 | −0.0339 | 0.0954 | 0.051 | 0.4523*** | 0.5270*** |
| | (0.0525) | (0.0545) | (0.0775) | (0.0777) | (0.0791) | (0.0809) |
| ΔSize$_{i,t}$*FSs$_i$ ($\beta_3$) | −0.0458 | −0.0207 | −0.0293 | 0.0085 | 0.0462 | 0.0852 |
| | (0.0913) | (0.0957) | (0.1010) | (0.0997) | (0.0949) | (0.0897) |
| ΔSize$_{i,t}$*REFs$_i$ ($\beta_4$) | 0.0146 | 0.0224 | −0.0611 | −0.041 | −0.1145 | −0.1487** |
| | (0.0394) | (0.0414) | (0.0576) | (0.0585) | (0.0708) | (0.0690) |
| GFC | | 0.0644*** | | 0.0644*** | | 0.0352* |
| | | (0.0098) | | (0.0150) | | (0.0186) |
| MPR | | 0.0213*** | | 0.0135 | | 0.005 |
| | | (0.0061) | | (0.0116) | | (0.0176) |
| PMPR | | 0.0359*** | | 0.0192* | | 0.0515** |
| | | (0.0047) | | (0.0114) | | (0.0212) |
| Constant | −0.2937*** | −0.3158*** | −0.3352*** | −0.3474*** | 0.6294*** | 0.7550*** |
| | (0.0218) | (0.0217) | (0.0253) | (0.0246) | (0.0559) | (0.0700) |
| Fixed effects | YES | YES | YES | YES | YES | YES |
| Time dummy | YES | NO | YES | NO | YES | NO |
| Crisis dummy | NO | YES | NO | YES | NO | YES |
| N. Obs. | 9,929 | 9,929 | 9,888 | 9,888 | 9,953 | 9,953 |
| $R^2$ Adjusted | 0.1409 | 0.1018 | 0.1119 | 0.0926 | 0.2313 | 0.11 |

The table reports regressions using alternative specifications. $\Delta Size_{i,t}$ is the increase in size (as natural logarithm of total assets) for financial institution $i$ at quarter $t$. (ln)ΔCoVaR$_{i,t-1}$, (ln)MES$_{i,t-1}$, and (ln)SRISK$_{i,t-1}$ is the natural logarithm of $\Delta CoVaR$, *MES*, and *SRISK* of financial institution $i$ at quarter $t-1$. *Time Dummy* is a set of dummies capturing fixed effects for each quarter; *Crisis Dummy* is a set of four dummy variables capturing fixed effects for the four sub-periods identified in our analysis, namely: (i) the Global Financial Crisis (GFC) from 2007:1 to 2009:4; (ii) the Monetary Policy Restriction (MPR) conducted by the People Bank of China (PBoC) from 2010:1 to 2014:4; (iii) the second stock crash and the post monetary period restriction (PMPR) from 2015:1 to 2019:4; $FSs_i$ is a dummy variable taking value 1 for *"Finance Services"* and zero for CBs and REFs, and $REFs_i$ is a dummy variable taking value 1 for *"Real Estate Finance Developers"* and zero for CBs and FSs. [i] is the benchmark specification using explanatory variables, time dummies, and the interaction of explanatory variables with the kind of financial institution; [ii] includes explanatory variables, the interaction of explanatory variables with the kind of financial institution, and replaces time dummies with the three regimes.
Sample period: 2006:1–2019:4.
*, **, *** denote the 10%, 5% and 1% significance level, respectively.

within the financial system. However, the sharp contraction in credit growth has reduced systemic risks on the funding side of banks' balance sheets but has increased the credit risk within China's financial asset markets.

This confirms our second set of results. We find that, in addition to CBs, the REFs become pro-cyclical to systemic risk. The estimated slope coefficient for REFs ($\beta_2 + \beta_4$ in specification [ii] for *SRISK*) is positive and statistically significant. One possible explanation is that the active pro-cyclicality of systemic risk concerns not only traditional banks but also other financial intermediaries, such as REFs, mainly oriented to commercial banking. This highlights the increasing systemic importance of the real estate sector after the monetary policy restriction and prior to the stock market crash (see also Table 8). Moreover, the increasing systemic importance of this sector, as documented also by Crowe et al. (2013) and by Morelli and Vioto (2020), given that real estate transactions involving borrowing, may cause instability in the financial system and the real economy. Given that real estate booms are often financed through borrowing, such booms are associated with rapid growth in credit levels and increases in leverage, the consequences of which when the boom suddenly ends have threatening implications for the stability of the financial system as a whole. The estimated value of $\beta_1$ (for all specifications and systemic risk measures) is negative and significant, confirming that financial institutions react to the previous quarter systemic risk by correcting levels that deviate from some target levels.

## 6. Concluding remarks and policy implications

In this paper, we evaluated the existence of a relationship between assets growth and leverage (leverage pro-cyclicality), and between fair value assets growth and systemic risk (systemic risk pro-cyclicality), where systemic risk is measured via $\Delta CoVaR$, *MES*, and *SRISK*. We conducted an extensive panel data regression analysis with time and group fix effects using a sample of 264 Chinese listed financial institutions (43 CBs, 74 FSs and 147 REFs) over 2005:4–2019:4. Moreover, we evaluated the stability of the relationships by considering three regimes in the Chinese stock market: the global financial crisis (2007:1–2009:4), the monetary policy restriction (2010:1–2014:4), and the 2015 Chinese stock crash (2015:1–2019:4).

First, over the whole sample period, there is strong evidence of leverage pro-cyclicality. However, the impact of the leverage variable changed during the global financial crisis period, being high during booms and low during financial turmoil (Adrian & Shin, 2010), with a lower risk-bearing capacity of the financial system due to an increase in collateral requirements (Geanakoplos, 2010; Gorton & Metrick, 2012).

Second, focusing on the three different groups of financial institutions, we observe that pro-cyclicality affected CBs during the global financial crisis and the monetary policy restriction periods, while the FSs only during the global financial crisis and the REFs during the monetary policy restriction.

Third, regarding the pro-cyclicality of systemic risk, we found that larger financial institutions, in particular CBs, increased systemic risk. From 2016, they started increasing shadow activities by bringing shadow banking products (wealth management products) into a special investment category. Among non commercial banks, we also noticed that only REFs were mainly oriented to commercial banking activity, with their transactions, involving borrowing, causing instability in the financial system.

Our results have also important policy implications. First, our analysis showed that the effects of both leverage and systemic risk pro-cyclicality are apparent during downturns. A financial institution may react to a negative shock by excessively shrinking their balance sheets,

**Table A.1**
Correlation matrix among state variables. Dependent variable *ΔCoVaR*.

| | DeltaCoVaR | Shanghai composite index | Liquidity spread | Change T-Bill | Change Y-curve slope | 5y Gov. Bonds | VIX |
|---|---|---|---|---|---|---|---|
| DeltaCoVaR | 1 | | | | | | |
| Shanghai Composite Index | −0.0383* | 1 | | | | | |
| Liquidity Spread | −0.0571* | −0.0495* | 1 | | | | |
| Change T-Bill | −0.0159* | −0.0210* | 0.0214* | 1 | | | |
| Change Y-curve slope | −0.0354* | 0.0118* | 0.3101* | 0.0690* | 1 | | |
| 5y Gov. Bonds | 0.0340* | −0.1159* | 0.5691* | 0.0983* | 0.3484* | 1 | |
| VIX | 0.0312* | −0.1220* | −0.0167* | −0.2742* | 0.2155* | −0.1731* | 1 |

The table reports the correlations among state variables on weekly data from 2006 to 2019. The state variables are: *Shanghai Composite Index*: is the weekly return of the index of the SHANGHAI stock exchange; *Liquidity spread*: is the liquidity spread calculated as the difference between the three months Chinese repo-rate and the three months Chinese T-bill; *T-Bill change*: indicates the change in Chinese treasury bill 3 month rate; *Yield-Curve slope*: indicates the change in slope of the yield curve represented by Chinese 5-years minus three-months interest rate on government bonds; *5yBonds*: indicates the slope of the Chinese 5-years government bonds; (*VIX*) is the CBOE option implied volatility index. * denotes the statistical significance at 5% level.

**Table A.2**
List of commercial banks.

| Commercial banks # | Bank name |
|---|---|
| 1 | PING AN BANK |
| 2 | CHINA MERCHANTS BANK |
| 3 | CHINA MINSHENG BANK |
| 4 | HUA XIA BANK COMPANY |
| 5 | CHINA CONSN |
| 6 | BANK OF CHINA LTD |
| 7 | INDUSTRIAL & COML.BK.OF CHINA |
| 8 | INDUSTRIAL BANK |
| 9 | CHINA CITIC BANK |
| 10 | BANK OF COMMN |
| 11 | BANK OF NINGBO |
| 12 | BANK OF NANJING |
| 13 | BANK OF BEIJING CO |
| 14 | SHANGHAI PUDONG |
| 15 | AGRICULTURAL BANK |
| 16 | CHINA EVERBRIGHT |
| 17 | CHONGQING RUR.COML.BK. |
| 18 | HARBIN BANK CO LTD |
| 19 | BANK OF CHONGQING |
| 20 | HUISHANG BANK CO LTD |
| 21 | SHENGJING BANK |
| 22 | BANK OF QINGDAO CO. |
| 23 | BANK OF JINZHO |
| 24 | BANK OF ZHENGZHOU CO. |
| 25 | CHINA ZHESHANG BANK |
| 26 | BANK OF JIANGSU |
| 27 | BANK OF GUIYANG |
| 28 | JIANGSU JYN.RUR.CMLBK. |
| 29 | WUXI RURAL CMLBK. |
| 30 | POSTAL SAVINGS BOC. |
| 31 | JIANGSU CHGSH.RUR.CMLBK. |
| 32 | BANK OF HANGZHOU CO LTD |
| 33 | JIANGSU ZHANGJIAGANG RCBK. |
| 34 | ZHONGYUAN BANK |
| 35 | BANK OF CHENGDU |
| 36 | JIANGXI BANK |
| 37 | BANK OF JIUJIANG |
| 38 | BANK OF CHANGSHA |
| 39 | JIANGSU ZIJIN RURAL COMMERCIAL BANK |
| 40 | BANK OF XI AN |
| 41 | QINGDAO RURAL COMMERCIAL BANK |
| 42 | JINSHANG BANK |
| 43 | BANK OF SUZHOU |

and thus originating negative externalities. Financial regulators should outline a regulatory framework that contributes to the financial stability and prepares to act quickly whenever financial instability threatens the health of the financial system. In this vein, the Basel III Committee on Banking Supervision has already provided some guidelines regarding a common definition of the leverage ratio in order to overcome differences in national accounting frameworks (Bank for International Settlements, 2014).

Second, our paper emphasized the consequences related to the rapid growth and development of the Chinese financial system. We noticed that the financial innovation favoured the creation of a new set of financial products (wealth management products) which led to a rapid increase and a growing complexity in the banks' balance sheets. The financial innovation has also exacerbated the sizable maturity mismatch between asset and liabilities of financial institutions, in particular for traditional banks. Differently from non bank financial intermediaries, their maturity mismatches tend to be much longer and thus may trigger financial instability. The rapid development has also strengthened the interconnectedness among banks and other non bank financial intermediaries, and thus increased systemic risk. Therefore, it is urgent to quantify systemic risk by accurately assessing the interconnectedness among China' financial institutions. The financial crisis reminds that the supervision of the financial system in isolation can no longer effectively prevent systemic risk. This requires important monitoring actions from the Chinese financial authorities (Chen & Kang, 2018).

Thirdly, our results also confirm that the pro-cyclicality of asset prices may explain business cycle' booms and recession, particularly in emerging economies such as China, and that a decisive policy action is still needed to deal with abnormal credit trajectories. As an example, in 2017, the IMF (2017) has identified five cases of excessive credit booms, that began when the credit-to-GDP ratio were above 100%, as in China' case, and that led to financial crises. In particular, we like to mention (i) the boom in Hong Kong (special administrative region) in 1983; (ii) the credit booms in Switzerland (1985) and (iii) in Indonesia (1990) which led to crises after further credit expansion; (iv) the credit boom in New Zealand in 1992 due to a one-off credit expansion in 1988 from a low base; (v) the boom in Finland in 2003 as a result of economic recovery after large deleveraging in late 1990s. Therefore, it is urgent for the financial authorities to supply emerging markets with a broader set of micro and macro prudential toolkit.

Finally, even though there is some consensus on the causes and the effects of pro-cyclicality, little progress has been made in identifying the reasons why in some countries (advanced vs. emerging countries) credit systems are more pro-cyclical than in others. This is an interesting issue which requires further developments.

## 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

See Tables A.1–A.4.

**Table A.3**
List of finance services.

| # | Finance services name |
|---|---|
| 1 | SOUTHWEST SECURITIES |
| 2 | SHAANXI INTL.TRUST |
| 3 | SHANGHAI AJ GP. |
| 4 | HAITONG SECURITIES |
| 5 | CITIC SECURITIES |
| 6 | CHINA FINANCE ONLINE ADR 1:840 |
| 7 | PACIFIC SECURITIES |
| 8 | EVERBRIGHT SECS. |
| 9 | CHINA MERCHANTS SECS. |
| 10 | HUATAI SECURITIES |
| 11 | INDUSTRIAL SECS. |
| 12 | SHANXI SECURITIES |
| 13 | NOAH HOLDINGS 'A' 2:791 |
| 14 | FOUNDER SECURITIES |
| 15 | SOOCHOW SECURITES |
| 16 | AVIC CAPITAL |
| 17 | GUOSHENG FINL.HLDG. |
| 18 | WESTERN SECURITIES |
| 19 | HANHUA FINANCIAL HLDG. |
| 20 | CHINA GALAXY SECURITIES |
| 21 | NORTHEAST SECURITIES |
| 22 | GUANGDONG GLDN. DRAGON DEV. |
| 23 | SDIC CAPITAL |
| 24 | GF SECURITIES |
| 25 | GUOYUAN SECURITIES |
| 26 | SEALAND SECURITIES |
| 27 | CHANGJIANG SECURITIES |
| 28 | CENTRAL CHINA SECURITIES |
| 29 | SINOLINK SECURITIES |
| 30 | CHINA CINDA ASSET MANAGEMENT |
| 31 | GUOSEN SECURITIES |
| 32 | ZUOLI KECHUANG MCRFIN. |
| 33 | SHENWAN HONGYUAN GROUP |
| 34 | DONGXING SECS. |
| 35 | ORIENT SECS. |
| 36 | GUOTAI JUNAN SECS. |
| 37 | GUOLIAN SECURITIES |
| 38 | LUZHENG FUTURES |
| 39 | JUPAI HOLDINGS ADR 1:796 |
| 40 | HENGTAI SECURITIES |
| 41 | CHINA HUARONG ASTMGMT. |
| 42 | CHINA INTL.CAP. |
| 43 | YIREN DIGITAL ADR 1:792 |
| 44 | GUANGDONG JOIN-SHARE FNG.GTEE.INV. |
| 45 | YINTECH INV.HDG.ADR 1:810 |
| 46 | FIRST CAPITAL SECS. |
| 47 | HUAAN SECURITIES |
| 48 | CSC FINANCIAL |
| 49 | CHINA RAPID FINANCE ADR |
| 50 | ZHESHANG SECURITIES |
| 51 | QUDIAN ADR 1:791 |
| 52 | CAITONG SECURITIES |
| 53 | HEXINDAI ADR |
| 54 | FINVOLUTION GROUP ADR 1:795 |
| 55 | JIANPU TECHNOLOGY ADR 2:795 |
| 56 | LEXINFINTECH HDG. ADR 1:792 |
| 57 | HUAXI SECURITIES |
| 58 | JIANGSU FINANCIAL LEASING |
| 59 | NANJING SECURITIES |
| 60 | X FINANCIAL ADR 1:792 |
| 61 | TIANFENG SECURITIES |
| 62 | CHINA GREATWALL SECURITIES |
| 63 | CNFINANCE HDG.ADR 1:810 |
| 64 | WEIDAI ADR1:791 |
| 65 | 1150 FINANCE ADR 1:2 |
| 66 | CHINALIN SECURITIES |
| 67 | UP FINTECH HOLDING ADR 1:805 |
| 68 | SHANGHAI DONGZHENG AUTOMOTIVE FINANCE |
| 69 | JIAYIN GROUP ADR 1:794 |
| 70 | HAUN.INTL.LSG. |
| 71 | HONGTA SECURITIES |
| 72 | 9F ADR 1:791 |
| 73 | NANHUA FUTURES |
| 74 | RUIDA FUTURES |

**Table A.4**
List of real estate finance services.

| # | Real estate finance services name |
|---|---|
| 1 | SHANGHAI SHIMAO |
| 2 | METRO LAND CORP |
| 3 | JINAN HIGH-TECH DEVELOPMENT |
| 4 | GZH.PER.RVR.IND.DEV. |
| 5 | SHANGHAI GUIJIU |
| 6 | CHINA ENTERPRISE |
| 7 | CINDA REAL ESTATE |
| 8 | BEIJING ELECTRONIC ZONE HIGH-TECH GROUP |
| 9 | DONGGUAN WINNERWAY INDL. ZONE |
| 10 | ZHONGTIAN FINL.GP. |
| 11 | JINYUAN EP CO LTD |
| 12 | LANDER SPORTS DEV |
| 13 | WEDGE INDUSTRIAL |
| 14 | TIANJIN GUANGYU DEV |
| 15 | HAINAN JINGLIANG HOLDINGS |
| 16 | ZHONGRUN RES.INV. |
| 17 | CHONGQING YUKAIFA |
| 18 | RONGAN PROPERTY |
| 19 | XIAMEN UNIGROUP XUE |
| 20 | LVJING HOLDING |
| 21 | TANDE COMPANY LTD |
| 22 | SHAI.CHENGTOU HLDG |
| 23 | SHANGHAI FUKONG INTACT. ENTM. |
| 24 | SHANGHAI NEW HUANG PU INDUSTRIAL GROUP |
| 25 | SHANGHAI CHNGTU.HDGCO. |
| 26 | SHANGHAI WANYE ENTS. |
| 27 | SHANGHAI FENGHWA GP. |
| 28 | SHANXI GUOXIN ENERGY |
| 29 | SHANGHAI TIANCHEN |
| 30 | EVERBRIGHT JIABAO |
| 31 | GUANGHUI LOGISTICS |
| 32 | SHANGHAI SHIBEI HI-TECH |
| 33 | GREENLAND HOLDINGS |
| 34 | TUNGHSU AZURE RENEW.EN. |
| 35 | SHENZHEN CENTRALCON INV. HLDG. |
| 36 | CHIN.MRCH.PR.OPRTN. & SER. |
| 37 | OCEANWIDE HOLDINGS |
| 38 | CHINA UNION HDG. |
| 39 | GRANDJOY HOLDINGS GROUP |
| 40 | SHAHE INDUSTRY |
| 41 | SHENZHEN PROPS.& RES. DEV |
| 42 | CHINA BAOAN GP. |
| 43 | SHN.ZHENYE (GROUP) |
| 44 | SHN.FOUNTAIN |
| 45 | CHINA VANKE |
| 46 | HAINAN HAIDE IND. |
| 47 | SHAI.LJZ.FN&T.ZONE DEV. |
| 48 | SHAI.TONGJI SCTC.INDL. |
| 49 | SHANGHAI LINGANG HOLDINGS |
| 50 | TIANJIN REALITY DEV. |
| 51 | NANJING CHIXIA DEV. |
| 52 | ZHONGCHANG BIG DATA |
| 53 | SICHUAN LANGUANG DEVELOPMENT |
| 54 | BLACK PEONY (GP.) |
| 55 | BEIJING CAPITAL DEV. |
| 56 | GUANGZHOU YUETAI |
| 57 | GEMDALE |
| 58 | DELUXE FAMILY |
| 59 | HUBEI WUCHANGYU |
| 60 | BEIJING VANTONE RLST. |
| 61 | BEIJING CAPITAL LAND |
| 62 | SHENYANG PUBLIC UTILITY HOLDINGS |
| 63 | LUSHANG HEALTH INDUSTRY DEVELOPMENT |
| 64 | TIANJIN SONGJIANG |
| 65 | TIANJIN TIANBAO INFR. |

(*continued on next page*)

**Table A.4** (*continued*).

| # | Real estate finance services name |
|---|---|
| 66 | YINYI |
| 67 | HUAFA INDUSTRIAL ZHUHAI |
| 68 | GUANGDONG SHIRONGZHAOYE |
| 69 | YIHUA HEALTHCARE |
| 70 | GUANGZHOU R&F PROPS. |
| 71 | SHN.CAPSTONE INDL. |
| 72 | POLY DEVELOPMENTS AND HOLDINGS GROUP |
| 73 | JIANGSU DAGANG A' SUSP — SUSP.29/04/810 |
| 74 | COSMOS GROUP |
| 75 | RISESUN REAL ESTATE DEV. |
| 76 | XINYUAN RLST.ADR 1:792 |
| 77 | HEFEI URBAN CON.DEV. |
| 78 | HANGZHOU BJ.RLST.GP. |
| 79 | WUHAN ET.LK.HI.TECH.GP. |
| 80 | WUHAN DDMC CULTURE & SPORTS |
| 81 | SICHUAN JINYU AUTMB.CITY (GROUP) |
| 82 | CHINA SPORTS IND.GP. |
| 83 | BEIJING DALONG WEIYE RLST.DEV. |
| 84 | SHENZHEN HEUNGKONG HLDG. |
| 85 | GUANGDONG HIGHSUN GP. |
| 86 | BBMG 'H' |
| 87 | SHENZHEN WORLDUNION GROUP |
| 88 | LANGOLD RLST. |
| 89 | BEJ.URBAN CON.INV.DEV. |
| 90 | CHINA WLD.TRD.CENTER |
| 91 | WOLONG RLST.GP. |
| 92 | TIANJIN JINBIN DEV. |
| 93 | GREE REAL ESTATE |
| 94 | XINHU ZHONGBAO |
| 95 | BEJ.CENTERGATE TECHS. (HLDG.) |
| 96 | CHINA CALXON GROUP |
| 97 | LANGFANG DEVELOPMENT |
| 98 | YUNNAN MET.RLST.DEV. |
| 99 | FANG ADR 1:791 |
| 100 | WENFENG GT.WLD.CHN.DEV. |
| 101 | FINANCIAL STR.HLDG. |
| 102 | JIANGSU PHOENIX PR.INV. |
| 103 | ZHE JIANG DONG RI |
| 104 | YANGO GROUP |
| 105 | LEJU HOLDINGS ADR 1:791 |
| 106 | SHN.WONGTEE INTL. ENTER. |
| 107 | FUJIAN START GROUP |
| 108 | SUZHOU NEW DISTRICT HI-TECH INDL. |
| 109 | SHANGHAI AIKO SOLAR ENERGY |
| 110 | BEIJING QIANFENG ELECTRONIC |
| 111 | YANG GUANG |
| 112 | HUA YUAN PROPERTY |
| 113 | CRED HOLDING |
| 114 | SHAI. ZHANGJIANG |
| 115 | SHANGHAI INDL.DEV. |
| 116 | FJN.ORNTL.SIS.INV. |
| 117 | BEIJING ZODI INVESTMENT |
| 118 | MACROLINK CRNT.DEV. |
| 119 | TIBET URBAN DEV.& INV. |
| 120 | HNA INV.GP. |
| 121 | WINSAN SHAI.MED.SCTC. |
| 122 | CHENGDU HIGH-TECH DEV. |
| 123 | SHUNFA HENGYE |
| 124 | VANFUND URB.INVDV. |
| 125 | JINKE PROPERTY GROUP |
| 126 | MYHOME RLST.DEV.GP. |
| 127 | RONGFENG HOLDING GROUP |
| 128 | BEH-PROPERTY |
| 129 | HAINAN YATAI INDL.DEV. |
| 130 | SUNING UNIVERSAL |
| 131 | ZHEJIANG GUANGSHA |
| 132 | KUNWU JIUDING INVESTMENT HOLDINGS |
| 133 | CCCG REAL ESTATE |
| 134 | BEIJING NORTH STAR |
| 135 | TIANJIN HI-TECH DEV. |
| 136 | CASIN REAL ESTATE DEVELOPMENT GROUP |

(*continued on next page*)

**Table A.4** (*continued*).

| # | Real estate finance services name |
|---|---|
| 137 | NANJING GAOKE |
| 138 | CHINA WU YI |
| 139 | SANXIANG IMPRESSION |
| 140 | RED STAR MACALLINE GROUP |
| 141 | SEAZEN HOLDINGS |
| 142 | CHINA MRCH.SHEKOU INDL. ZONE |
| 143 | NACITY PROPERTY SERVICE GROUP |
| 144 | SIC.LANGUANG JUSTBON SSGP. |
| 145 | CHNG.NEW DAZHENG PR.GP. |
| 146 | POLY PROPERTY DEVELOPMENT |
| 147 | CHINA–SINGAPORE SZH. INPK.DEVGP. |

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