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Michael Funke - Andrew Tsang - Linxu Zhu

Not All Cities are Alike: House  
price heterogeneity and  
the design of macro-prudential  
policies in China



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## Not all cities are alike: House price heterogeneity and the design of macro-prudential policies in China

### Abstract

This paper investigates the implementation of regionally differentiated macro-prudential policies in China. To assess the relative intensity of the city-level macro-prudential policies over time, we construct a time-varying city-level macro-prudential policy intensity indicator for 70 Chinese cities from 2010-2017. The empirical evidence shows China's macro-prudential toolbox has gradually evolved toward city-level policies tailored to granular local conditions to mitigate risks.

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# 1 Introduction

The empirical literature highlights the importance of macro-financial linkages in examining the range of deep changes triggered by the global financial crisis. Claessens et al. (2012), using a comprehensive cross-country database for a large sample of advanced and emerging market economies over many years to characterize macro-financial linkages, report three main results. First, business cycles are more closely synchronized with credit and house price cycles than equity price cycles. Second, financial cycles appear to play an important role in determining recessions and recoveries. Third, recessions associated with house price busts tend to be deeper, last longer, and cost more than recessions unaccompanied by a house price bust.

A major lesson from the global financial crisis is the importance of housing in the balance sheets of households and financial institutions. A fall in house prices triggered the subprime mortgage crisis and a flood of distressed or defaulted low-quality subprime mortgages. Notably, two-thirds of housing price booms have ended in recessions (Cerutti et al., 2015). This, in turn, has fueled interest in the study of the macro-prudential policy in shaping the transmission of shocks and policies, as well as in determining asset prices and economic activity within and across countries.<sup>1</sup>

Turning to China, the Chinese house price increase began in the early 2000s and was further boosted in 2009 by China's huge financial crisis stimulus package. In the aftermath of the global financial crisis in 2008–2009, the Chinese government eased overall credit conditions in the face of slowing domestic demand. Increasing rates of urbanisation, rising income, and rapid economic growth have also contributed to high real estate demand. Furthermore, the expansionary monetary policy stance has not only boosted real estate prices but has also generated a shift in house price expectations and spurred excessive risk-taking in the banking sector. As a result, property in many cities has become unaffordable for broad sections of the population. This growth has led the Chinese authorities to become more concerned about housing affordability. Furthermore, this has led to the concern that housing prices, having gone up and up, might someday crash. Two further characteristics of the Chinese house price evolution are noteworthy. First, property prices in China have displayed a strong cyclical pattern. These price cycles have coincided with a range of government policies aimed at stimulating or dampening housing market activity. Second, the rates of price growth have varied considerably across cities.

Against the background of these challenges, China is trying new ways to calm the housing market.<sup>2</sup> It is particularly worth mentioning that since then China leaves macro-prudential policy implementation relating to

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<sup>1</sup> It is worthwhile to consider the evolution of the macro-prudential *Zeitgeist*, e.g. by comparing the discussion in Arslan et al. (2015) against the views in Bernanke and Gertler (2001) and Gilchrist and Leahy (2002).

<sup>2</sup> Macro-prudential policy was first posited as China's formal policy choice in the People's Bank of China (PBoC) (see China Financial Stability Report 2010, PBoC, 2010). The macro-prudential policy framework was rolled out in 2011 (see China Financial Stability Report 2012, PBoC, 2012) and extended to a macro-prudential assessment (MPA) system in 2016 (see China Monetary Policy Report 2016 Q1, PBoC, 2016).

housing to cities. As a first step, we will analyse the design of this globally exemplary city-level macroprudential policy approach. With the help of our newly developed macro-prudential policy intensity indicator for 70 Chinese cities from 2010–2017, we subsequently analyse how decentralised macro-prudential policies have evolved across cities and how their intensity has changed over time. To the best of our knowledge, this is the first paper to develop a city-level macro-prudential intensity index rich in detail for China.

The roadmap for the rest of the paper is as follows. Section 2 displays and evaluates the geographical variation of the granular Chinese macro-prudential housing policy toolbox. Section 3 describes a methodology to aid in implementing regionalized macro-prudential policies in a manner that avoids financial instability from recurring housing bubbles. Section 4 concludes with a discussion of the implications of our research.

## 2 City-level house price dynamics and development of macro-prudential policies in China

China's authorities have emphasized differentiated adjustment in macroprudential housing policies since 2010, when the State Council called city-level macro-prudential policies.<sup>3</sup> As has been the case several times in the past, the central government was ready to devolve considerable power in order to promote experiments with reform.<sup>4</sup> Our goal here is to investigate the economic rationale behind the implementation of decentralized city-level macro-prudential policies, and discover possible linkages between economic fundamentals and city-level macro-prudential policies. We start the discussion with an empirical review of Chinese housing-related macro-prudential policies.

### 2.1 Major developments in Chinese housing prices

The different movements of house prices across markets provide a natural economic rationale for decentralized macro-prudential policies. As a first step, we analyze the trends in movements of house price growth across 70 major Chinese cities. The house price trends in 70 cities are calculated using house price data released by China's National Bureau of Statistics from July 2005.<sup>5</sup> The cities are classified into three tiers according to levels of

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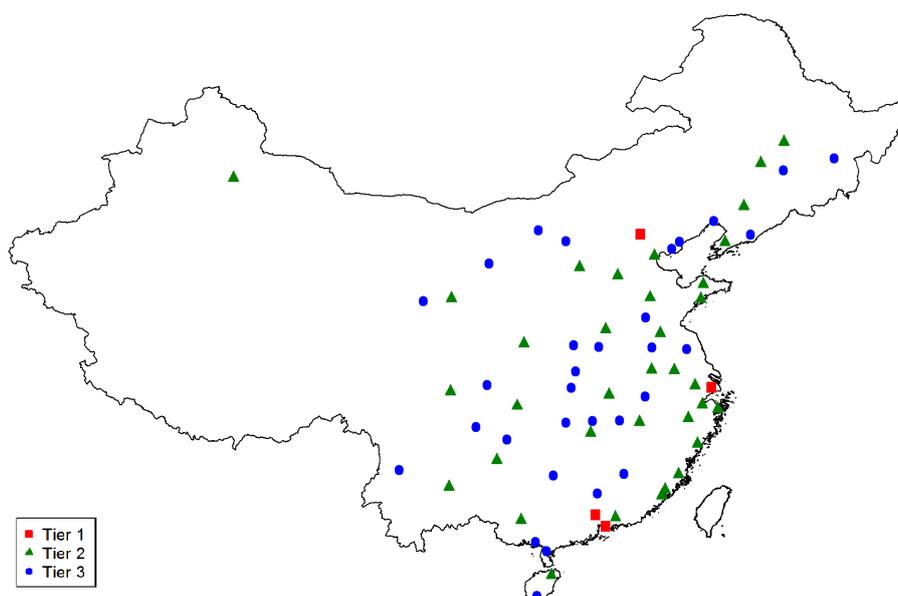
<sup>3</sup> China is by no means an isolated case. At a later time, other countries have also added city-level instruments to their macro-prudential toolkits to increase precision, and therefore effectiveness, of their macro-prudential policies. New Zealand introduced tighter macro-prudential measures for the Auckland metropolitan area. (<https://www.rbnz.govt.nz/financial-stability/macro-prudential-policy>). Norway introduced tighter macro-prudential policies to temper house prices in Oslo, and Denmark moved similarly for Copenhagen. ([http://www.esrb.europa.eu/pub/pdf/reports/esrb.report180425\\_review\\_of\\_macroprudential\\_policy.en.pdf](http://www.esrb.europa.eu/pub/pdf/reports/esrb.report180425_review_of_macroprudential_policy.en.pdf)). Korea put in place a differentiated application of LTV ratios according to zip codes to tighten policy more quickly in areas more prone to overheating (Igan and Kang, 2011).

<sup>4</sup> Take the “special economic zones”, which the communist party set up along the southern coast in the 1980s. In these, local officials were given considerable leeway to approve foreign investments, grant tax breaks and waive price controls. Their experiments succeeded in producing rapid economic growth. They were, in effect, the pilot projects for the market-oriented policies that helped China become the economic giant it is today.

<sup>5</sup> The IMF and BIS rely on housing price data released by China's National Bureau of Statistics in their analyses of Chinese

development. Tier 1 cities include the traditional four megalopolises (Beijing, Shanghai, Guangzhou, and Shenzhen). These cities enjoy the highest level of development and serves as regional centers. Tier 2 cities include most provincial capitals and larger prefectural cities in Eastern China. These cities enjoy a high level of development and connectedness with surrounding regions. The remaining cities are classified as Tier 3 cities. The details about the construction of the house price indices and the classification of tiers of cities are provided in Appendix A. Figure 1 shows the location of the 70 major cities and the three-tier classifications.

Figure 1 Map of 70 mainland Chinese cities



**Tier 1:** Beijing, Shanghai, Guangzhou, and Shenzhen;

**Tier 2:** Tianjin, Shijiazhuang, Taiyuan, Shenyang, Dalian, Changchun, Harbin, Nanjing, Hangzhou, Ningbo Hefei, Fuzhou, Xiamen, Nanchang, Jinan, Qingdao, Zhengzhou Wuhan, Changsha, Nanning, Haikou, Chengdu, Guiyang, Kunming Chongqing, Xi'an, Lanzhou, Urumqi, Wuxi, Xuzhou, Wenzhou Jinhua, Quanzhou, Yantai, and Huizhou;

**Tier 3:** Hohhot, Xining, Yinchuan, Tangshan, Qinhuangdao, Baotou, Dandong, Jinzhou, Jilin, Mudanjiang Yangzhou, Bengbu, Anqing, Jiujiang, Ganzhou, Jining, Luoyang Pingdingshan, Yichang, Xiangyang, Yueyang, Changde, Zhanjiang, Shaoguan Guilin, Beihai, Sanya, Luzhou, Nanchong, Zunyi, and Dali.

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property prices (Scatigna et al., 2014). Unfortunately, the reliability of such data and other official statistical data from China is questionable. While a thorough discussion of the issue of these data quality problems is beyond the scope of this article, we note that, despite their imperfections and susceptibility to manipulation (particularly at the city level), Chinese statistics are broadly informative. Moreover, Alder et al. (2016) find satellite night-time light data to be highly correlated with official statistics at the city level.

Figure 2 City-level house prices across city tiers

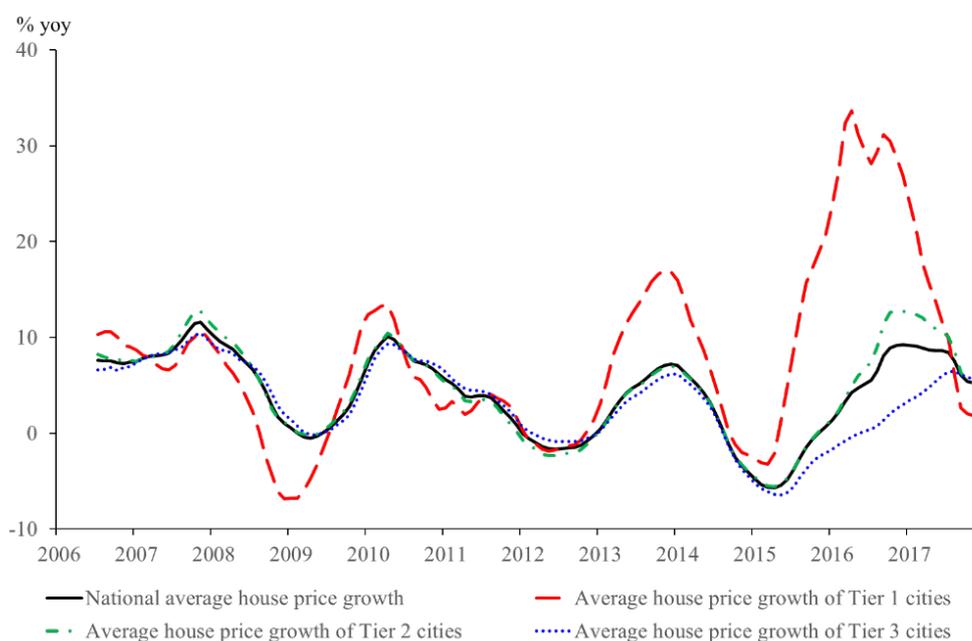


Figure 2 shows the averages of house price growth in nationwide and tiers of cities. At the local level, the pattern is uneven, with house prices in major Chinese cities rising faster than in the rest of China. As a rule, Tier 1 cities show the largest and most volatile house price development. During the global financial crisis of 2008–2009, Tier 1 cities experienced a deeper correction than other cities. The house price growth in Tier 1 cities accelerated faster than other cities in late 2009 to early 2010. The house price growth in Tier 1 cities synchronized with other cities during late 2011 to late 2012, but surged and deviated from other cities again in 2013 and during 2015 to 2017. House price trends were largely similar for the second and third tiers of major Chinese cities before 2015. In 2015–2017, the variety in house price growth increased. The price surge in some cities at that time was not evenly spread around China, but concentrated in markets with desirable locations. Places that fell within the gravitational pull of the most prosperous cities, particularly in the east and south, fared best.

Ultimately, the increase in China's house prices at the national level masks tremendous variation at the city level, a feature that has been largely overlooked in the macro-prudential literature. There is little doubt that common forces affected the dynamics of house prices in most cities, but idiosyncratic factors amplified their effects in some cases and offset them in others.<sup>6</sup>

<sup>6</sup> Following Wood (2003), one explanation for spatial heterogeneity could be that some regions respond more rapidly to national economic shocks than others as their housing market is more liquid and new information is reflected more quickly in housing prices.

Given this diversity, it is self-evident and natural to implement regionally differentiated macro-prudential policies.<sup>7</sup> The IMF recognizes the significant divergence in China's housing markets (IMF, 2017, p. 51), recommending macro-prudential policies tailored to local conditions as a first line of defense.

## 2.2 Development of city-level macro-prudential policy

Chinese authorities first introduced housing-market-specific policy in 2004.<sup>8</sup> The change recognized that heterogeneity in China's regional housing markets, so national macro-prudential policies were likely to be inefficient if they implicitly assumed all local markets to be similar. The central government conceded the wisdom of decentralizing and devolving its macro-prudential governance to local governments. In this spirit, the Chinese State Council, China's cabinet, issued new rules designed to cool house prices under the auspices of No. 10 National Notice on April 17, 2010. Under these new rules, city governments experiencing abnormal house price increases were requested to rein in house prices by restricting the number of houses a household could purchase, raise the maximum LTV ratio and increase the mortgage loan rate for some or all properties. Macro-prudential policies to cool down over-heated housing markets were formally localized.

Throughout this period, there were two main characteristics of China's macro-prudential policy: high heterogeneity across cities and strong cyclical movement.<sup>9</sup> Given the different socio-economic structure of cities, the details of the restrictions varied from city to city. For instance, tighter restrictions on non-resident home-buyers were imposed in some cities, but not in others. The restrictions could be relaxed as needed. From 2010 to 2017, there were two major rounds of tightening measures in the macro-prudential policy across cities, (i) April 2010 to May 2014, and (ii) September 2016 to December 2017. City-level macro-prudential policy was eased or abolished in most of the cities between these two rounds of tightening. A list of macro-prudential policy actions related to the housing market imposed by China's authority during 2004 to 2017 are presented in Appendix B.

The first round of tightening of the city-level macro-prudential policies started in Beijing in April 2010. Housing purchasing restrictions were first imposed on third properties of Beijing residents and non-local buyers. Similar tightening measures were then applied in Shenzhen in September 2010, and in Shanghai in October 2010.

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<sup>7</sup> What are the challenges to monetary policy when regional markets differ? When regional house price divergences are significant, then this may matter for the efficacy of monetary policy. For example, the policy response to a regional housing shock depends on the region where the shock originated. Similarly, the response to a policy tightening depends on issues such as whether the most rapidly expanding regions are also the most interest sensitive. More generally, the aggregate effects of monetary policy depend on the distribution of regional sensitivities and the initial distribution of regional economic conditions at the time of tightening.

<sup>8</sup> The policy measures focused on the restrictions on the bank loans. The policies included limiting the loan-to-value ratio (LTV) and debt-service-to-income ratio (DSTI) and imposing a discount or premium on the mortgage interest rate. Finally, these measures became part of the macro-prudential policy framework formally introduced by PBoC in 2011 (see China Monetary Policy Report, 2011 Q4).

<sup>9</sup> Using counterfactual analyses, Bai et al. (2014) and Du and Zhang (2015) evaluate the impact of administrative house purchase restrictions and property taxes on house prices in China. Du and Zhang (2015) find that, for the period from May 2010 to November 2011, purchase restrictions reduced the annual growth rate of housing prices in Beijing by 7.69 %, the property tax of Chongqing reduced the annual growth rate of housing prices by 2.52%, and the property tax of Shanghai had no significant effect on house prices.

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Although some cities imposed the tightening measures in 2010, the Chinese authorities still saw housing markets as overheated. In January 2011, the State Council announced that four types of cities should introduce purchasing restrictions. These cities included (i) direct-controlled municipalities, (ii) cities under separate state planning, (iii) capital cities of provinces (except Lhasa), and (iv) cities with already high house prices or soaring housing prices. After the policy announcement by the State Council, most cities introduced and strengthened their tightening measures in early 2011 according to the requirements of the State Council. By the end of 2011, at least 46 cities had tightened their city-level macro-prudential policies.<sup>10</sup> Cities generally imposed tightening measures according to their administrative level, except in Tier 1 cities, where tightening measures imposed in 2011 were kept without further strengthening until the abolition of these measures in June 2014 (even if the central government and local governments continued to emphasize policy tightening subsequently). The Tier 1 cities tightened twice in 2013, in March and at the end of the year.

The major policy measures in this period included housing purchase restrictions, loan restrictions and increased taxes and fees. The variety of city-level macro-prudential policy was still quite monochromatic. Most cities used the same measures, particular with regard to loan restrictions and the requirements on taxes and fees, which merely followed national specifications. The policy variations began to emerge in housing purchase restrictions, particularly in the number of properties allowed the buyer.

As prices stalled from 2014 to mid-2016, cities largely abandoned housing purchase restrictions, except Beijing, Shanghai, Shenzhen, Guangzhou, and Sanya. In the meantime, some relaxations on the loan restrictions, and the requirements on taxes and fees were applied at the national level, particularly in cities without housing purchase restrictions.

The second round of city-level macro-prudential policy tightening began in late summer 2016. Sharp increases in urban property prices caused some cities to re-impose housing purchase restrictions. 20 cities tightened their housing market policies in September-October 2016.<sup>11</sup> Nevertheless, property prices continued to increase, so Shenzhen and other cities with housing purchase restrictions had to tighten further. The property price surge, with the other policy needs, more and more cities introduced or tightened their macro-prudential policy further in March-April 2017 and September 2017.<sup>12</sup> Unlike in the previous round of the tightening, city was specifically required to impose the city-level macro-prudential policies by the central government. The tightening measures were gradually strengthened in most of the cities during 2016 to 2017, instead of a one-off tightening.

At first glance, the development of city-level macro-prudential policies is consistent with the house price growth in the three tiers of cities shown in Figure 2. Before the start of the two rounds of tightening, housing

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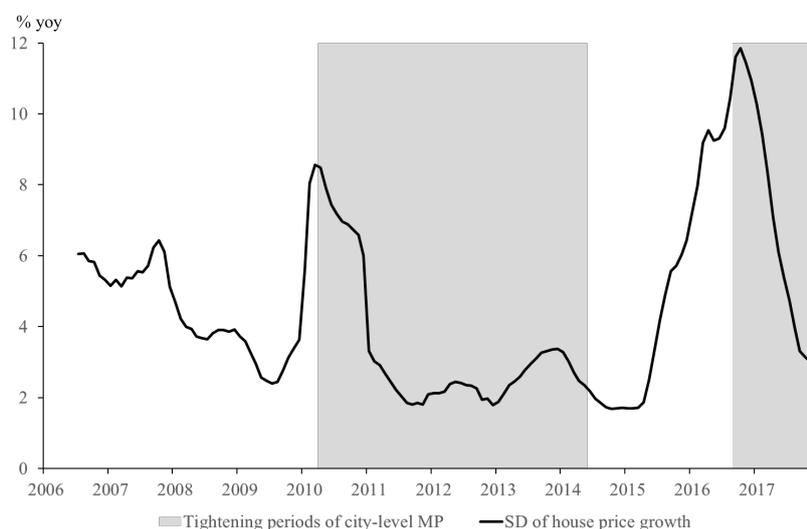
<sup>10</sup> The 46 cities included are Beijing, Changchun, Changsha, Chengdu, Dalian, Foshan, Fuzhou, Guangzhou, Guiyang, Haikou, Hangzhou, Harbin, Hefei, Hohhot, Jinan, Jinhua, Kunming, Lanzhou, Nanchang, Nanjing, Nanning, Ningbo, Qingdao, Quzhou, Sanya, Shanghai, Shaoxing, Shenyang, Shenzhen, Shijiazhuang, Suzhou, Taiyuan, Taizhou, Tianjin, Urumqi, Wenzhou, Wuhan, Wuxi, Xiamen, Xi'an, Xining, Xuzhou, Yinchuan, Zhengzhou, Zhoushan, and Zhuhai. Foshan, Quzhou, Shaoxing, Suzhou, Taizhou, Zhoushan and Zhuhai are not included in the statistics of the 70 major cities.

<sup>11</sup> Given the surge in city level property prices in late 2015 and early 2016, Shenzhen and Shanghai tightened their housing purchase restrictions by lowering the LTV ratio for second-home buyers and tightening the restrictions on non-local buyers.

<sup>12</sup> For the restrictions on Langfang, Guan County, Hualai County, Laishui County, Zhangjiakou and Zhuozhou, these was due to the policy associated with the founding of Xiong'an New Area, a state-level new area in Baoding, Hebei, China established April 1, 2017.

prices were generally rising. When prices surged, particularly in Tier 1 cities in 2013, those cities tightened their macro-prudential policies. Figure 3 provides the standard deviation of house price growth among 70 cities each month.

Figure 3 Standard deviation of housing price growth among 70 cities



Note: Standard deviations of the year-on-year growth rates of nominal house prices are calculated for each month. The details of the tightening periods are presented in the next sub-section.

The light and dark areas in Figure 3 show when city-level macro-prudential policy switches on and off. The two dark bars indicate the localized macro-prudential policy sub-periods. The line gives the time-varying standard deviation of housing price growth among the 70 cities. Prior to the introduction of localized macro-prudential policies, we see the heterogeneity across cities' housing markets was increasing, while policy-tightening leads to a higher degree of synchronicity.

The synchronization of housing prices across major Chinese cities was high for most of the past decade, except for two periods. Notably, the short-term co-movement in housing prices also sharply increased around the time of global financial crisis in 2008–2009. Shortly thereafter, the variation of house price growth among cities rose, i.e. in the period just before the introduction (and the first round of tightening) of city-level macro-prudential policies. The synchronization in house price growth resumed from late 2011 to mid-2015. Another enlargement in the variation of city-level house price growth occurred between late 2015 and late 2016, just before the second round of tightening.

The major tightening in policy measures appeared in housing purchase restrictions and loan restrictions. The introduction of an embargo period on resale of residences was a main feature of this round of tightening. Besides some removal of subsidies, the change in the requirement of taxes and fees was not the main measure for the tightening. In contrast to the previous round of the tightening, there was variation in housing purchase restrictions, loan restrictions, and sales restrictions. In addition, the national authorities (State

Council and PBoC) imposed two-tier national specifications for housing market macro-prudential policy measures for cities with and without housing purchase restrictions after 2014. Comparing with the previous round of tightening, the requirements on downpayment, taxes and fees were generally lower in this round. Table 1 compares the key differences between the two rounds of city-level macro-prudential policy tightening.

Table 1 Key characteristics of two rounds of city-level macro-prudential policy tightening

	<b>First tightening round (April 2010 – May 2014)</b>	<b>Second tightening round (September 2016 – December 2017)</b>
Coverage	Four types of cities (mainly according to the administrative level of the cities)	No specific requirement (mainly according to the housing market situation)
Key measures	<ul style="list-style-type: none"> <li>i. Housing purchase restrictions</li> <li>ii. Loan restrictions</li> <li>iii. Taxes and fees</li> </ul>	<ul style="list-style-type: none"> <li>i. Housing purchase restrictions</li> <li>ii. Sales restrictions</li> <li>iii. Loan restrictions</li> </ul>
Variety	<ul style="list-style-type: none"> <li>i. Uniformity in demanding national specifications for mortgage loans, taxes and fees</li> <li>ii. Most variety is in housing purchase restrictions</li> </ul>	<ul style="list-style-type: none"> <li>i. Two-tier and low national specifications on mortgage loans, taxes and fees</li> <li>ii. Large variation in types of measures used</li> </ul>
Implementation	Mainly one-off tightening	Mainly multi-stage and gradual tightening

In conclusion, there was a remarkable variation in the use of macro-prudential policies across Chinese cities and over time.<sup>13</sup> A wide range of city-level macro-prudential policy measures were employed between 2010 and 2017. Table 2 summarizes these policy measures.

<sup>13</sup> There is also a broader cross-national lesson here. Del Negro and Otrok (2007) consider whether heterogeneous increases in US house prices reflect a national phenomenon or constitute sub-national bubbles driven by local factors. For 2001 to 2005, they find that the increase in US house prices was a national phenomenon, while house prices before that were mainly driven by local components. The study by Gao et al. (2009) also provides a systematic analysis of geographical heterogeneity in US housing markets. The shared insight is that house price dynamics and their drivers vary significantly across local markets.

Table 2 Key measures of city-level macro-prudential policy in China

<b>Transaction restrictions</b>
Ban on purchases of second or third residences (the different restrictions are applied to household and individual in some cities) mitigates demand and thus puts pressure on house prices.
Restriction on non-local residents on purchasing residence mitigates demand.
An embargo period on resale of residences (sales restriction) discourage the resale of properties and speculative investment.
<b>Loan restrictions</b>
Limits on LTV ratios (increases in the downpayment requirement) introduced in a regionally-targeted manner prevents excessive indebtedness of borrowers and increases the resilience of commercial banks. In addition, stricter limits on LTV ratios and loan application are applied to non-local loan applicants. To this end, the LTV limits are connected to the geographical location of the collateral rather than the permanent residence of the loan applicant.
Halt in the issuance of mortgage loans (essentially a lending prohibition) for third residences.
Limits on LTV ratios for the House Provident Fund (HPF) mitigate demand. The HPF provides mortgages with lower interest rates to home-buyers. Local governments impose tighter downpayment requirements for HPF as a further tightening measure.
<b>Taxes and fees</b>
Transaction taxes (buyer/seller stamp duties or reduction in first-home buyer subsidies) discourage the resale of properties and speculative investments.
Recurrent property taxes reduce speculative housing demand and benefit of home ownership.
Taxes on imputed rents and capital gains reduce indirect benefits of home ownership and housing demand.

### 2.3 Construction of city-level macro-prudential policy intensity indicator

To assess the relative intensity of the city-level macro-prudential policies across the city over time, we construct a city-level macro-prudential policy intensity indicator. The construction of the indicator follows the procedures below:

1. We select ten specific policy measures (in three types), according to the major macro-prudential policy measures summarized above.
2. We classify the relative intensity of each of policy measures in a particular month and in a specific city. The relative intensity is determined by comparing the strength of a specific policy measure in a different month and among 70 cities during the sample period from April 2010 to December 2017.  
The detailed definitions of each measure and the classification of their relative strength are described in Appendix C. The detailed summary of the macro-prudential policies and the monthly intensity for 70 cities are provided in an online Appendix.
3. We standardize the relative policy intensity of each measure into the range from 0 to 1.
4. We aggregate the overall macro-prudential policy intensity indicator by calculating the weighted average of the policy intensity of 10 specific measures. The weights are determined according to the relative importance of each policy measures. The relative importance is judged with taking into account for the policy objectives,

the market opinion, and the length of the implementation time.<sup>14</sup> The weights of each measure appears in Table 3 below.

Table 3 Weights of various macro-prudential policy measures in calculating macro-prudential policy intensity

Type	Measure	Weight
Transaction restrictions	Purchase restriction on local household (number of residential properties)	15.0%
	Purchase restriction on local individual (number of residential properties)	15.0%
	Purchase restriction on non-locals (residence requirement)	15.0%
	Sales restriction (embargo period on resale)	5.0%
Loan restrictions	Loan restrictions (minimum downpayment, %)	25.0%
	Mortgage on primary residence for non-local buyers (no restrictions, restrictions, not allowed)	5.0%
	Mortgage on second residence for non-local buyers (no restrictions, restrictions, not allowed)	2.5%
	Mortgage on third residence (allow or not)	2.5%
	Housing Provident Fund (minimum downpayment, %)	5.0%
Taxes and fees	Taxes and fees (classified into categories with scores from -1 to 3)	10.0%
<b>Total</b>		<b>100.0%</b>

Note: The key criteria for deciding the relative strength of a specific policy appear in parentheses. The detailed definitions of each measure and the classification of their relative strength are described in Appendix C.

For the intensity indicator for each of specific policy measure, “0” means the measure in that city in that month was the loosest measure among all cities in the whole sample period, while a “1” value means the tightest measure among the sample is imposed. The overall macro-prudential policy intensity indicator ranges from 0 to 1, indicating overall macro-prudential policy relating to the housing market (the aggregate of policy measures) ranging from loosest to tightest.

Constructing a panel dataset for the macro-prudential policy intensity indicator provide an empirical basis for assessing the relative strength of the city-level macro-prudential policy. In particular, we can (i) assess the relative strength of the macro-prudential policy of a specific city over time, and (ii) compare the relative strength of the macro-prudential policies among cities in a particular period.

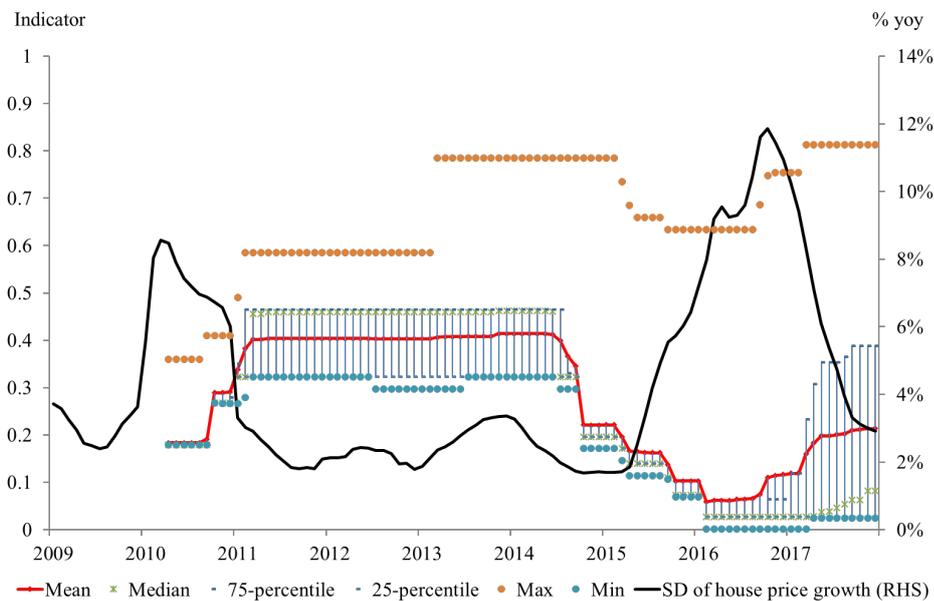
<sup>14</sup> As is customary in the literature, we have chosen a predefined weighting scheme (see Decancq and Lugo, 2013). As a robustness check, we have also calculated indices with equal weights for all policy measures. We find that this approach delivers comparable results to the weighting scheme in the paper. Furthermore, we have also employed the Wald exclusion test suggested by Akinci and Olmstead-Rumsey (2015). The test consists of regressing the house price on the equally weighted indicator (the sum of the indicators for all  $n$  individual policy measures) and the  $(n-1)$  individual policy measures. The hypothesis that all coefficients on the  $(n-1)$  individual policy measures are zero is rejected for a panel of all 70 city-level policy indices, suggesting that weights are not statistically equal and thus a weighted index is appropriate.

## 2.4 Coherence between city-level housing prices and macro-prudential policy intensity

Macro-prudential policy intensity increased and remained at a high level during the tightening periods (April 2010 to May 2014, and September 2016 to December 2017). Comparing the macro-prudential policy intensity in each round of tightening, we see macro-prudential policy intensity was generally lower in the second round with respect to lower downpayment requirements, taxes and fees. The variations in macro-prudential policy intensity increased in these periods, but the variation during the second round of tightening was larger than in the first round.

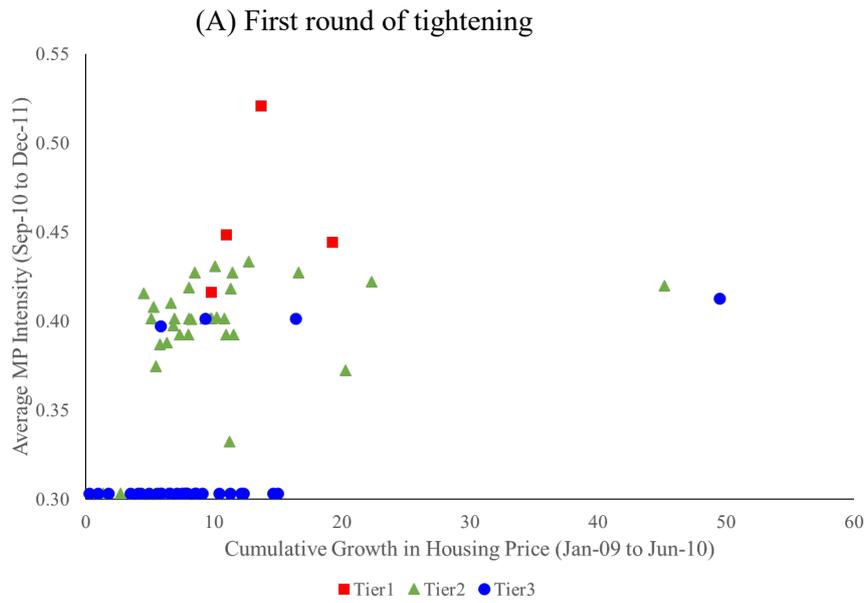
Figure 4 shows the distribution of the macro-prudential policy intensity across 70 cities and the standard deviation of housing price growth. The graph is an extension of Figure 3, incorporating information about the configuration and heterogeneity of macro-prudential policies. The standard deviation of housing price growth shows clearly that housing market dynamics varied from city to city just ahead of each tightening round. The graphical evidence supports our observation in section 2.1 that the high differentials in the house price growth could be an economic rationale to explain why there was the implementation of the decentralized city-level macro-prudential policies.

Figure 4 Standard deviation of house price growth and city-level macro-prudential policy intensity

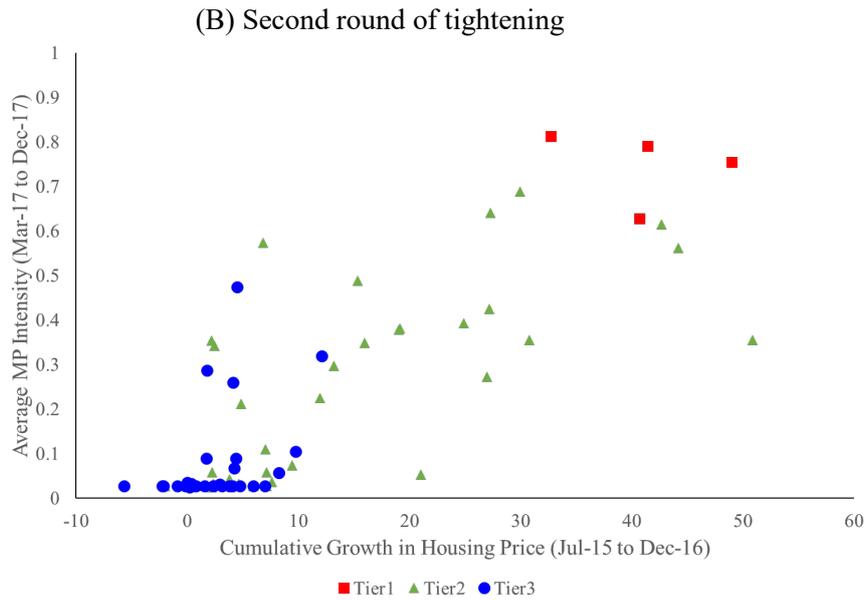


It is hardly surprising that macro-prudential policy tightening is the response to a rapid in housing prices or that variations in housing price growth partly explains the variety of city-level macro-prudential policies. If the macro-prudential policy implementation fit the housing price trend appropriately, we expect that cities with higher house price growth should have a tighter macro-prudential policy.

Figure 5 City-level macro-prudential policy intensity and accumulated house price growth



Notes: The cumulative growth in housing price is the growth from Jan-09 to Jun-10, comparing the price in Jun-10 with that in Dec-08 (the lowest price during 2008-2009). The two outliers are Haikou and Sanya in Hainan Province. Spearman’s rank correlation coefficient: 0.4698 (*t*-statistics: 4.3887, *p*-value: 0.0000).



Note: The cumulative growth in housing price is the growth from Jul-15 to Dec-16, comparing the price in Dec-16 against that of Jun-15 (the lowest price during 2015–2016). Spearman’s rank correlation coefficient: 0.7614 (*t*-statistics: 9.6845, *p*-value: 0.0000).

Figure 5 illustrates the relationship between housing price growth and macro-prudential policy tightening in the two tightening periods. We compare the macro-prudential policy intensity ranking implemented with the cumulative housing price growth three months prior. A positive Spearman’s rank correlation occurs between recent house price growth and the macro-prudential policy intensity, suggesting that a city with higher housing

price growth experienced tighter macro-prudential policies. The value of positive Spearman's rank correlation in the second round of tightening was much higher than that in the first round of tightening, which implies a stronger relationship between recent housing price growth and macro-prudential policy intensity.

There are two possible explanations for the increasing correlation between housing price development and macro-prudential policy intensity. First, the policy arrangement. As discussed in section 2.2, during the first round of tightening, a number of cities tightened their macro-prudential policies due to their administrative levels according to the proposal of the State Council, rather than in accordance with local economic conditions. In the second round of tightening, the central government increased the discretion and flexibility of local governments in macro-prudential policies related to their housing markets. The outcome was an increasing intensity of macro-prudential policies tailored to local conditions. Second, the time required for the learning process. Given the city-level macro-prudential policies only introduced in April 2010, the city-level governments did not have experience in implementation of the city-level macro-prudential policies. They simply applied national guidelines. After several years of implementation and the end of macro-prudential policy tightening, city governments had acquired a modicum of experience in implementation and policy shaping suited to their specific needs.

In this section, we established that macro-prudential measures in China are regionally differentiated. While this is interesting in itself, it also raises the question of whether such city-level macro-prudential policy design is just a patchwork of unrelated individual measures or a coherent strategy implemented in a verifiable way based on empirical data. To this end, we next explore whether the city-specific intensity of macro-prudential policies have been used in a targeted manner to contain speculative house price bubbles.

### 3 Econometric approach

The activation or deactivation of macro-prudential measures necessitates an assessment of financial vulnerabilities. To aid in this assessment, we draw on recent econometric research relevant to implementing regionalized macro-prudential policies in a transparent and traceable manner. To achieve this, policymakers must be able to differentiate from a good boom and a bad boom, because not all credit booms end badly.

Escalating house prices in major Chinese cities might well be justified by fundamentals and help the Chinese economy to grow and prosper. If policymakers “lean against the wind” in a good boom, they might impose costs on the economy from lower growth.<sup>15</sup> Furthermore, the housing market may hold the key to where China's economy is headed. Other than housing, there are few investment options available to most Chinese citizens, which helps explain why home prices keep rising, despite the government's efforts to contain the speculative frenzy.<sup>16</sup>

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<sup>15</sup> According to the IMF (2017, p. 51), a reduction of house prices by 10–15 % (roughly the magnitude in previous cycles) would reduce GDP growth by around 0.9 percentage points.

<sup>16</sup> Home buyers have developed a sort of psychological resilience to more restrictive policies, viewing them as “buy signals.”

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A deeper reason may be China's restrictive financial system. As long as financial repression is in place, money will continue to flow into housing. Financial repression makes homeowners reluctant to cut prices in order to sell their homes because the alternatives for their savings are so unattractive. Beyond this, capital controls, progressively tightened by the Chinese authorities in recent years, play a role in the house price dynamics. After the stock market collapse in 2015, housing became the most appealing asset. All the more so, given that the Chinese authorities began encouraging banks to increase their mortgage lending to boost the economy.

The econometric literature reminds us that identifying a bubble in real time can be challenging. A nuanced and persuasive approach to identification and dating multiple bubbles in real time has recently been pioneered by Phillips et al. (2011, 2014, 2015).<sup>17</sup> They have developed a new recursive econometric methodology interpreting mildly explosive unit roots as a hint for bubbles. If we consider the typical difference of stationary versus trend stationary testing procedures for a unit root, we usually restrict our attention to a stationary autoregressive process. In contrast, Phillips and Yu (2011) model mildly explosive behavior by an autoregressive process with a root that exceeds unity, but is still in the neighborhood of unity. The basic idea of their approach is to recursively calculate right-sided unit root tests to assess evidence for mildly explosive behavior in the data. Phillips and Yu (2011) argue that their tests have discriminatory power as they are sensitive to changes that occur when a process undergoes a change from a unit root to a mildly explosive root or vice versa.

Bubbles usually collapse periodically. Therefore, standard unit root tests have limited power in detecting periodically collapsing bubbles.<sup>18</sup> To overcome this drawback, Phillips and Yu (2011) have suggested using the supremum of recursively determined augmented Dickey-Fuller (ADF) statistics. The estimation is intended to identify the time period when explosiveness becomes dominant in the price process. The test is applied sequentially on different subsamples. The first subsample contains observations from the initial sample. It is then extended forward until all observations of the complete sample are included. The beginning of the bubble is estimated as the first date when the ADF statistic is greater than its corresponding critical value of the right-sided unit root test. The end of the speculative bubble will be determined as the first period when the ADF statistic is below the aforementioned critical value. Phillips and Magdalinos (2007, 2012) provide a large-sample asymptotic theory for this class of mildly explosive processes that enables econometric inference. The associated finite sample critical values and prob-values are calculated via Monte Carlo methods.

In addition to the supADF (SADF) test, Phillips et al. (2011, 2014, 2015) have suggested employing the 'generalized' supADF (GSADF) test as a dating mechanism. The GSADF diagnostic is also based on the idea of sequential right-tailed ADF tests, but the diagnostic extends the sample sequence to a more flexible range.

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<sup>17</sup> The diagnostic for multiple speculative bubbles modifies a previous method for identifying one-off bubbles suggested in Phillips et al. (2011). Below we provide a concise and informal review of the estimation technique and key concepts employed in this paper, but make no pretense about providing an exhaustive survey of the literature.

<sup>18</sup> Busetti and Taylor (2004), Kim et al. (2002) and Leybourne et al. (2006) have shown that traditional unit root tests have low power in the case of gradually changing persistence and/or the existence of persistence breaks. Homm and Breitung (2012) compare several time series based tests for the detection of bubbles. They find that the Phillips et al. (2011, 2014, 2015) strategy performs relatively well both in detecting periodically-collapsing bubbles and in real-time monitoring.

Instead of fixing the starting point of the sample, the GSADF test changes the starting point and ending point of the sample over a feasible range of windows. Phillips et al. (2015) demonstrate that the moving sample GSADF diagnostic results in substantial power gains, consistent with multiple and periodically-collapsing episodes of explosiveness in the data. The SADF and GSADF procedures can also be used as a date-stamping strategy that consistently estimates the origination and termination of bubbles. Thus, this approach gives an indication of where macro-prudential policies should excel and where they are inappropriate. In the next section, we apply this bubble dating algorithm to locate periodic explosive sub-periods.

As suggested in the previous section, different rates of housing price growth before the two rounds of tightening provide hints on the intensities of city-level macro-prudential policy. Therefore, it should be a strong economic rationale of implementing the city-level macro-prudential policy if the dates of city-level house price bubbles are consistent with the time of the policy tightening. The bubble dating algorithm could provide us the econometric evidence to evaluate the appropriateness of the process of implementing decentralized macro-prudential policies.

Figure D1 in Appendix D compares the city-level macro-prudential policy intensity with bubble periods for 70 cities. The blue lines stand for the policy intensity indicator and the shaded areas are the bubble periods. At first glance, the city-level macro-prudential policies are consistent with the bubble periods, displayed in the graphs of Figure D1 as the increases of indicator lines overlap some shaded areas, especially for Tier 1 and Tier 2 cities. For some cities in Tier 3 ( e.g. Luoyang, Xiangyang, and Guilin), the GSADF tests demonstrate that no bubbles occurred during the period of 2011 to 2014, and they did not experience additional city-level tightening measures beyond the nationwide policy measures.

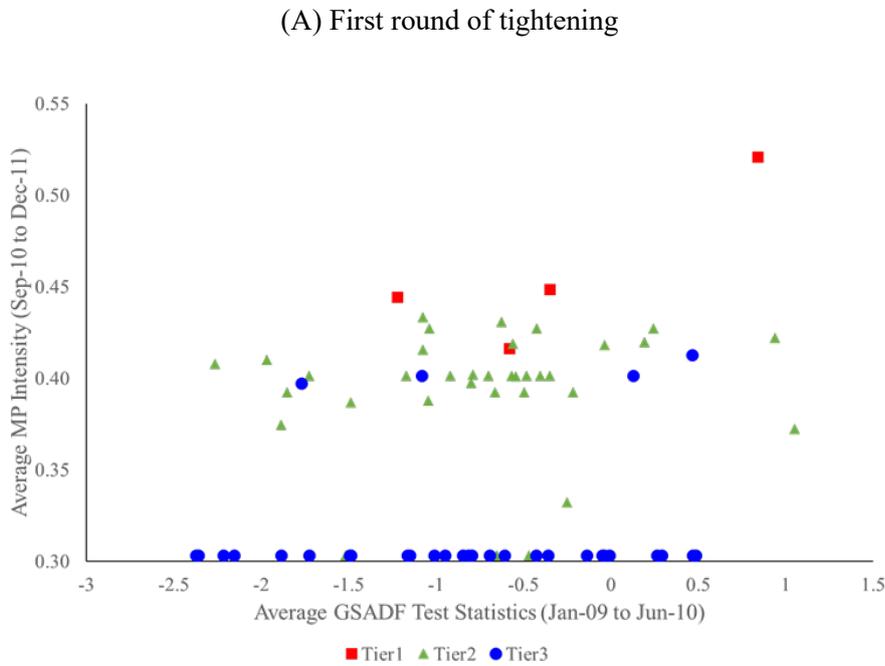
For most cities, the policy intensity indicators also highlight the two periods of policy tightening. 61 cities out of 70 experienced more than one bubble during the 2010–2017 period. Most cities in Tier 1 and Tier 2 displayed more bubbles than cities in Tier 3. Particularly for Tier 1 cities, multiple longer-lasting bubbles occurred, foreshadowing the risk of bubble collapse in these cities. Among Tier 2 cities, many provincial capital cities (e.g. Tianjin, Nanjing, Hangzhou, Fuzhou, Wuhan, and Chongqing) also experienced more than two bubbles during 2010–2017, which is associated with the increasing property prices in recent years among Tier 2 cities. However, the four Tier 2 cities in Northeast China, including three provincial capital cities (Shenyang, Changchun, Harbin, and Dalian), did not experience any bubble occurrence according to the GSADF test results. This can be explained by the fact that the economic situation in Northeast China has deteriorated over the last decade, with younger members of the labor force departing for China’s coastal areas. This trend has resulted in lower property price growth compared to provincial capital cities elsewhere in the country.

The dates of city-level house price bubbles are detected by conducting the GSADF test stated above. In order to assess the house price bubbles in different cities, we employed the real house price indices. The real house price indices are deflating the nominal house price indices for 70 cities by the corresponding provincial consumer price inflation, given the lack of the city-level inflation data. The relative house prices over the consumer prices are used as a proxy the fundamental value of the house prices. We next identify the house price bubble periods

when the GSADF test statistics exceed the critical values at the 95 % significance level. The time-varying GSADF test results for all 70 cities are displayed in Figure D2 in Appendix D. In all 70 charts, the red solid lines stand for the GSADF test statistics and the blue dashed lines stand for the critical values at the 95 % significance level.

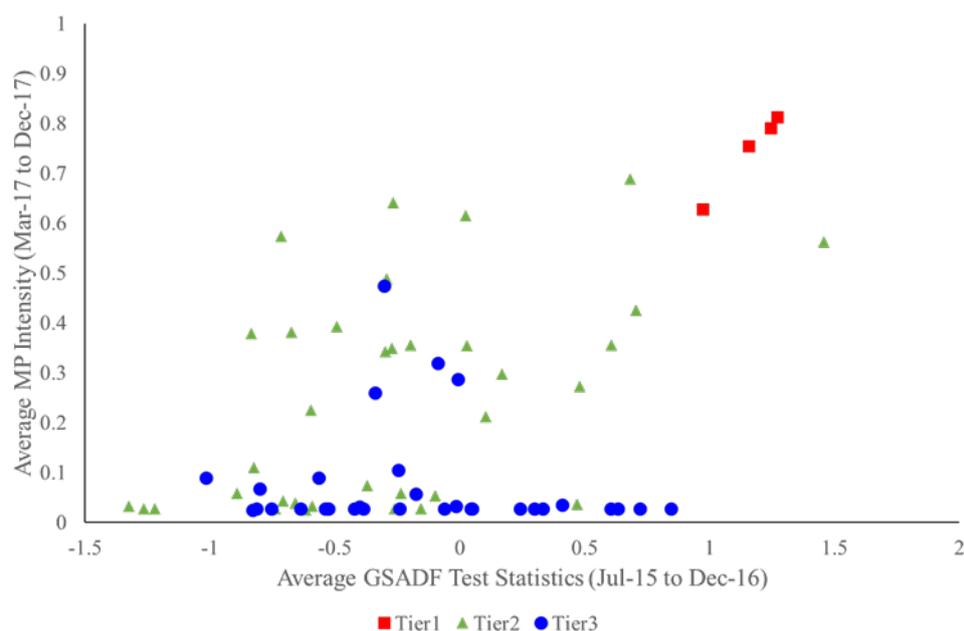
Figure 6 presents the correlation of city-level macro-prudential policy intensity and the GSADF test statistics in two periods that the tightening policies were implemented. Each point represents a correlation for one city. The GSADF test statistics are the average of the GSADF test statistics over the period prior to the policy tightening periods. Higher GSADF test statistics represent a greater likelihood of forming a house price bubble. As before, in order to provide a causal relationship between policy intensity and bubble occurrence, we compare the macro-prudential policy implemented with the average GSADF test statistics up to three months prior.

Figure 6 City-Level macro-prudential policy intensity and the GSADF test statistics for two rounds of tightening



Notes: The GSADF test statistics are calculated by using the data of real housing prices (deflated by provincial CPI), and the number of lags are selected by SIC. The GSADF test statistics shown are the average of GSADF test statistics for each city between Jan-09 to Jun-10. Spearman's rank correlation coefficient is 0.1521 (t-statistics: 1.2688, p-value: 0.2088).

## (B) Second round of tightening



Note: The GSADF test statistics are the average of GSADF test statistics for each city between Jul-15 to Dec-16. Spearman's rank correlation coefficient is 0.2590 (t-statistics: 2.2111, p-value: 0.0304).

The correlation between the macro-prudential policy intensity and the GSADF statistic in Figure 6 follows a similar qualitative pattern in both tightening periods. However, the Spearman's rank correlation coefficient in the first round is much lower than that in the second round and not significant. The higher and significant Spearman's rank correlation coefficient in the second round of tightening implies that the stronger relationship between macro-prudential policy intensity and bubble indications occurred during this round of tightening. In other words, the policy tightening in different cities was more adapted to local conditions. This supports the finding in the previous section that the policies have become more granular over time. It remains to be seen whether this will also apply in the future. As a result of president Xi Jinping's current hardline rule unswerving loyalty to himself as the leadership's "core", officials show less enthusiasm for creative experiments.<sup>19</sup>

The bubble detecting technique provides an econometric ground for local authorities to decide how much they need to tighten city-specific macro-prudential policy. Furthermore, with the nature of housing stability risks changing over time, we see macro-prudential policy needs to be sufficiently flexible to address shifting vulnerabilities. The estimates in this paper contribute to this.

<sup>19</sup> Heilmann (2016) has shown that the number of provincial-level policy pilots in China has declined significantly since 2012. Over the same period, the share of national regulations with experimental status dropped from nearly 20% to about 5%.

## 4 Conclusions

Our investigation has methodological and substantive contributions. Methodologically, this paper presented an approach to calculating the intensity of city-level macro-prudential policies across Chinese cities starting in 2010 after the global financial crisis. Our first substantive finding is that there exists a sizable heterogeneity in the strength of macro-prudential policies across cities and over time. The second insight is that over time the decentralized macro-prudential policy measures are more precisely targeting the respective housing market situation and the associated financial stability concerns.

Considering the potential direct and indirect effects of housing markets on the stability of the financial system, as demonstrated during the global financial crisis, national authorities are placing increasing emphasis on the monitoring of housing markets. Consequently, house prices are closely monitored. Since the global financial crisis, the Chinese housing market is characterized by a multiple-speed recovery. There is a moderate increase of house prices in some metropolitan areas, but overheating in other metropolitan areas at the same time.

Policymakers should be alert to this difference and the associated trade-offs. In such an outset situation, there is no one-size-fits-all national macro-prudential policy. Obviously, the monetary authority sets macro-prudential policy for the country, but housing price dynamics vary significantly across the country, so policy may be too tight in some regions and too loose in others relative to policy set optimally for each region. Here, city-specific policies may be advisable. The Chinese authorities have embarked in 2010 on this very reasonable policy approach. The start was bumpy. In the first tightening period, we see that many city-level policies were misaligned and often defaulted to conformity with national guidelines, i.e. the available statutory macro-prudential leeway that cities had been granted was not used. This was particularly true for many Tier 3 cities. In the second tightening period, we see city officials taking a more hands-on approach and implementing well-targeted policies.

Measured vulnerabilities are always associated with uncertainty, so determining the appropriate macro-prudential policy action is not clear-cut.<sup>20</sup> This is an inherent feature of measuring systemic risk; housing crises emerge infrequently and often in new and unexpected ways. In practice, macro-prudential policies can be implemented by discretion or follow pre-specified rules.

Discretionary policies increase policy flexibility and limit the room for policy errors. Rule-based policies, in contrast, require a sufficient degree of confidence that the predefined variables would always correctly perform as intended without noisy signals. Rule-based policies can also act as a commitment device.<sup>21</sup> Notably, a less disciplined discretionary framework addresses this issue by allowing policymakers to learn. However,

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<sup>20</sup> One may be concerned that the classification of cities is technocratic, highly dependent upon some econometric modelling techniques with little space for alternative approaches and perspectives. In response, we argue, that the suggested decision-making does not require governance that is more technocratic than other existing monetary policy endeavors.

<sup>21</sup> Much of the literature on housing and macro-prudential policy has built on DSGE models with limited heterogeneity. Funke et al. (2018) recently presented a DSGE modelling framework that allows for out-of-sync house prices. The findings suggest that there is beneficial scope for region-specific macroprudential policies in slowing down hot spots without affecting cold spots.

flexibility and adaptability of discretion do not come without costs. They entail limited predictability of decisions as well as an incentive for policymakers to postpone unpopular decisions. Given the trade-off between ex-ante efficiency of discretion and ex-post efficiency of rules, the Bank of England (2009) proposed a constrained discretion macro-prudential regime. It is discretionary, but still systematic, transparent, and accountable due to pre-defined numerical objectives, decision-making frameworks, and accountability measures.

Put differently, implementing a regionally differentiated macro-prudential policies requires a transparent, well-signaled and well-understood policy process. One obvious reason is that preferences for city-specific macro-prudential policies most likely vary far more than views of what constitutes adequate national macroeconomic policy. Thus, a great degree of transparency of macro-prudential policy through the city governments' communication with the public about its plans, objectives and policy decisions is needed.<sup>22</sup> For example, clarifying the local authorities' judgments about the appropriate path of policy and the conditions that might warrant significant adjustments to that path would hold substantial benefits. Furthermore, analysis of alternative scenarios may be a valuable tool for examining key financial stability risks and formulating contingency plans aimed at mitigating such risks. In other words, the implementation of localized macro-prudential risk management policies requires "outside-the-national-box" thinking and problem-solving. Arguably, accountability measures are needed to establish legitimacy for this initiative. We leave the exploration of the questions of how to implement granular macro-prudential policies in a transparent and traceable way and other avenues to future work.

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<sup>22</sup> Communication should include information on how macro-prudential policies are complemented by other interventions to increase the elasticity of the housing supply to yield desired effects.

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## Appendix A. House price indices and tiers of cities in China

### Construction of house price indices

The Chinese housing price indices for 70 cities (all are prefectural-level cities, except Dali) surveyed in this paper are the price indices of all residential buildings ( $PA$ ). The city-level indices combine the two housing price indices released by China's National Bureau of Statistics: i) price indices of newly constructed residential buildings ( $P1$ ) and ii) price indices of second-hand residential buildings ( $P2$ ) by the formula  $PA = P1^{0.5}P2^{0.5}$ . The details of the official data can be found in the annotations in the press release:

[http://www.stats.gov.cn/english/PressRelease/201801/t20180118\\_1574960.html](http://www.stats.gov.cn/english/PressRelease/201801/t20180118_1574960.html)

Both housing price indices cover 70 major cities in China, but only the housing prices in the urban area of each prefectural-level city is included. Housing in in county-level administrative areas (if any) are excluded. The dataset begins in July 2005.

### Classification of tiers of cities

There are few classifications of the tiers of cities in China, e.g. iFeng News (by Phoenix Satellite Television Holdings), CBN Weekly, and South China Morning Post. The classification of the tiers of cities used in this paper is modified from the "Commercial Appeal Ranking of Chinese Cities" list released by the financial magazine CBN Weekly (CBN = China Business News). CBN began releasing its list in 2013. The classification uses survey results from approximately 400 enterprises on the distributions of branches and the focus of development among cities. The survey also measures the perceived attractiveness of other cities based on feedback from over a thousand young professionals based in traditional Tier 1 cities (Beijing, Shanghai, Guangzhou, and Shenzhen). CBN also collects the data of city-level GDP, per-capita income, number of branches of Fortune Top 500 enterprises, number of top universities, number of international flights, number of legal counsels, and volumes of freight carriers. The list is updated annually, with the latest list released in April 2018.

Given our house prices dataset is ended at December 2017, we used the classification in 2017 (broadly the same as the one in 2018). The classifications were refereed by experts, who reviewed the city data, including the business data of 160 large enterprises, the user data of 17 Internet firms and the big data of the cities. The vetted data are used to produce a so-called City Fascination Index, which is compiled from scores in five categories: (i) Business Resource Concentration (weight: 0.24); (ii) Connectedness (weight: 0.18); (iii) Activeness of Urban Population (weight: 0.18); (iv) Diversification of Lifestyle (weight: 0.20) and (v) Potentials (weight: 0.20). The detailed weighting of the sub-categories of data is calculated with principal component analysis.

Tier 1 cities include the traditional four megalopolises (Beijing, Shanghai, Guangzhou, and Shenzhen). These cities enjoy the highest business resource concentration and function as regional centers. They also have the highest and most diversified consumption, as well as the highest potentials. They are cities with rich offerings in education, culture, and lifestyle. Tier 2 cities, which are combined with "New Tier 1 cities" and Tier 2 cities in the CBN classification, include most of the provincial capitals and larger prefectural cities in Eastern China. They also have high business resource concentration, connectedness with surrounding regions, high levels of consumption, as well as diversified consumption patterns and high potentials. The remaining cities are classified as Tier 3 cities in this discussion.

## Appendix B. Timeline of key macro-prudential policies related to the housing market by Chinese authorities

Date	Coverage	Stance	Policy
Sep 2004	Nationwide	Tightening	PBoC imposes maximum LTV ratio of 80 % for loans for purchasing homes, while the maximum debt-service-to-income (DSTI) ratio of 50 % for borrowers to purchase homes.
Mar 2005	Nationwide	Tightening	PBoC lowers the maximum LTV ratio from 80 % to 70 % for properties in cities and areas where the price of real estates are believed to be rising too fast.
Mar 2005	Nationwide	Neutral	PBoC imposes a reform on the mortgage lending interest rate. The different interest rates for mortgage and other loans are coupled to the benchmark lending interest rate. However, a lower limit of 0.9 times the benchmark lending rates of the corresponding maturities is imposed on the mortgage rate. (The actual level of actual mortgage rate is determined by commercial banks based on internal pricing methodology).
Aug 2006	Nationwide	Easing	To promote the market-based reform of the individual mortgage rate, the lower limit of the rate is changed from 0.9 times the benchmark lending rate to 0.85 times the benchmark lending rate.
Sep 2007	Nationwide	Tightening	PBoC imposes maximum LTV ratio of 60 % for those borrowers applying for the second mortgage loans.
Oct 2008	Nationwide	Easing	PBoC raises the maximum LTV ratio to 80 %.
Oct 2009	Nationwide	Tightening	CBRC issues draft rules tightening the use of personal loans for speculation on stock and property markets.
Dec 2009	Nationwide	Tightening	The authorities tighten the policies on house market by: 1) revising the resale lock-up period from 2 to 5 years; 2) reimposing a 5.5 % tax on property transactions involving residential property held for less than five years; and 3) setting the maximum LTV ratio for land purchases at 50 % with the full amount of downpayment made within one year of the date of purchase.
Jan 2010	Nationwide	Tightening	PBoC lowers the maximum LTV ratio to 60 % for second mortgage loans.
Apr 2010	Nationwide	Tightening	PBoC lowers the maximum LTV ratio on first homes for apartments over 90 square meters from 80 % to 70 %, and lowers the ratio on second homes from 60 % to 50 %. The minimum mortgage rate is raised from 85 % to 110 % of the base lending rate for second-home buyers.
Apr 2010	City-level	Tightening	The State Council announces that banks may temporarily halt the release of mortgage loans (equivalence to loan prohibition) for third homes in regions with overheated prices and restricts purchases by non-residents. These restrictions are imposed for Beijing in end-April 2010, Shenzhen in September 2010, and Shanghai in October 2010. By the end of 2011, at least 46 cities have imposed these restrictions (some set to expire by the end of 2011). This policy is known as “city-level housing purchase restrictions.”
Sep 2010	Nationwide	Tighten	PBoC and CBRC jointly advise commercial banks to stop lending (loan prohibition) to third-home buyers altogether, or raise the downpayment to 60 % (i.e. LTV ratio of 40 %) and the mortgage rate to 1.5 times the base rate.
Sep 2010	Nationwide	Tighten	PBoC lowers the maximum LTV ratio to 70 % for all first-home buyers.
Jan 2011	Nationwide	Tightening	The authorities tighten the policies on house market by: 1) further lowering the maximum LTV ratio on purchase of second homes to 40 %; 2) setting the minimum mortgage rate at 110 % of the benchmark rate; 3) implementing housing purchase restrictions in all municipal cities and overheated cities; and

			4) unifying business tax calculation to 5.5% of total sales amount.
Dec 2011	City-level	Tightening	State Council requests that cities that have set a deadline to terminate housing purchase restrictions to extend their deadlines.
Feb 2013	City-level	Tightening	State Council requests that cities with high property price growth continue with housing purchase restrictions.
Oct 2013	City-level	Tightening	Tier 1 cities (Beijing, Shanghai, Shenzhen, and Guangzhou) announce further tightening measures.
May 2014	Nationwide	Easing	PBoC suggests that banks increase individual mortgage lending.
Jun 2014	City-level	Easing	Hohhot announces it is lifting all housing purchase restrictions. In the following months, over 90 % of cities besides Beijing, Shanghai, Shenzhen, Guangzhou, and Sanya, lift their housing purchase restrictions.
Sep 2014	Nationwide	Easing	PBoC allows increase in the LTV ratio for the second home and without other mortgage loans (from 40 % to 70 %, as the LTV ratio applied to the first home) in the cities that did not impose restrictions on housing purchases.
Mar 2015	Nationwide	Easing	PBoC raises the LTV ratio on purchasing second homes (with other mortgage loans) for self-use to 60 %. PBoC lets several financial institutions cut their home mortgage interest rates.
Sep 2015	Nationwide	Easing	PBoC raises the LTV ratio to 75 % for all first-home buyers in cities that did not impose restrictions on housing purchases. The move is an enhancement to the differentiated adjustments in the real-estate market.
Feb 2016	Nationwide	Easing	PBoC raises the LTV ratio to 80 % for all first-home buyers in cities that did not impose restrictions on housing purchases.
Mar 2016	City-level	Tightening	Shenzhen and Shanghai tighten their housing purchase restrictions, lower the LTV ratio for second-home buyers, and tighten restrictions on non-local buyers.
Sep 2016	City-level	Tightening	Over the summer of 2016, some cities re-impose housing purchase restrictions. The number of cities with housing purchase restrictions hits nine in September 2016 and 20 in October 2016.
Mar 2017	City-level	Tightening	Shenzhen and other cities with housing purchase restrictions continue to tighten, while the number of cities with housing purchase restrictions increases to over 30 by end-April 2017. Some cities introduce sale restrictions, i.e. an embargo period for the resale of residences.
Sep 2017	City-level	Tightening	More cities tighten their macro-prudential policies with the introduction the sale restrictions.

Sources: Shim *et al.* (2013), Wang and Sun (2013), various issues of PBoC's Quarterly Monetary Policy Reports and news.

## Appendix C. Macro-prudential policy intensity indicators

As noted in section 2.4, the overall macro-prudential policy intensity indicator is the weighted average of the policy intensity of ten indicators. Each indicator is standardized by the formula

$$\frac{X_{it}^k - \text{Min}X^k}{\text{Max}X^k - \text{Min}X^k}$$

where  $X_{it}^k$  is the relative strength of a specific indicator ( $X^k$ ) for city  $i$  at time  $t$ ,  $\text{Min}X^k$  is the loosest level of the indicator  $X^k$  among 70 cities during the sample period from April 2010 to December 2017, and  $\text{Max}X^k$  is the tightest level of the indicator  $X^k$ . After standardization, the relative macro-prudential policy intensity of each indicator is translated to a value in the range from 0 to 1. This appendix provides the details of the definition and the classification of the relative strength for these ten indicators.

### Transaction restrictions

1. **Purchase restriction for the local household (number of residential property).** Local government imposes purchase restriction for different groups of residents in the city. In all the cities imposing the purchase restriction, local governments limit the number of residential property purchased by the local registered household. China uses a rigid household registration system. The formal name for the system is “*hukou*”. Only the original household can be registered as a local household with the local government. Some cities have relaxed the requirement of local household registration for some professionals, but the number of the exceptional cases is limited. The number of the residential property purchase is restricted between 1 and 3. If there is no restriction, a value of “4” is assigned. Some cities restricted the local household to purchase a new residential property in 2010, but without restriction on the total number of properties. For this case, a value of “2.5” is assigned. For the classification of this policy measure, the lower number represents the tighter measure.

2. **Purchase restriction for the local individual (number of residential properties).** Some local government impose a stricter purchase restriction for individuals with local household registration. The number of the individual’s residential property purchase is restricted between 1 and 2. If there is no restriction, a value of “3” is assigned. Similarly, for the classification of this policy measure, the lower number represents the tighter measure.

3. **Purchase restriction for the non-locals (residence requirement).** In almost all the cities imposing the purchase restriction, the local governments only allow non-local households (households present in the city without local household registration) to buy one residential property. There is also a residence requirement, i.e. minimum number of years of paying contributions to the social security fund or income tax. If there is no restriction, a value of “0” is assigned. For the classification of this policy measure, the higher number represents the tighter measure.

4. **Sales restriction (embargo period for resale).** Since 2017, some cities have imposed a temporal sales restriction, i.e. an embargo period on resale the residences. The embargo period is between 2 and 5 years. If there is no restriction, a value of “0” is assigned. The higher number represents the tighter measure.

### Loan restrictions

5. **Minimum downpayment (%).** Local government requires a minimum percentage for the down- payment of all mortgage loans provided by the commercial banks equivalent to the LTV requirement. The minimum downpayment requirements vary depending on the type of mortgage. We assign the weights for the minimum downpayment requirements for different types of mortgage loans and calculate the weighted average for the aggregate minimum downpayment requirement. The weights are summarized as follows:

Type of mortgage loan	Weight
<b>A) Primary property</b>	<b>70%</b>
No mortgage leading before	49%
Ordinary property	34%
Non-ordinary (luxury) property	15%
With mortgage leading before	21%
Ordinary property	15%
Non-ordinary (luxury) property	6%
<b>B) Second property</b>	<b>30%</b>
No mortgage leading before or loan settled	21%
Ordinary property	15%
Non-ordinary (luxury) property	6%
With mortgage loan not yet settled	9%
Ordinary property	6%
Non-ordinary (luxury) property	3%

According to the downpayment requirements, the minimum aggregate downpayment ratio ranged from 20.9 % to 51.5 % among 70 cities during the sample period. A higher number represents tighter measures.

6. **Mortgage on primary residence for non-local buyers (no restrictions, with restrictions, not allowed).** Some cities impose restrictions on non-local households on mortgage loan applications for any housing. A value of “1” is assigned for the non-local buyers prohibited from applying for mortgage loans, a value of “0.5” is assigned to those non-local buyers allowed to apply for mortgage loans with restrictions, and a value of number “0” is assigned if there are no restrictions.

7. **Mortgage on second residence for the non-local buyers (n no restrictions, with restrictions, not allowed).** Some cities impose restrictions on non-local households on mortgage loan applications for a second residence. A value of “1” is assigned for the non-local buyers prohibited from applying for mortgage loans, a value of “0.5” is assigned to those non-local buyers allowed to apply for mortgage loans with restrictions, and a value of number “0” is assigned if there are no restrictions.

8. **Mortgage on third property (allowed or prohibited).** Some cities block access to mortgage loans (i.e. lending prohibition) for a third property (applies to all local and non-local households). A value of “1” is assigned for the lending prohibition, and “0” for no restriction.

9. **Housing Provident Fund (minimum downpayment, %).** HPF is policy of providing mortgages with lower interest rates to homebuyers. Some local governments require a minimum percentage for the downpayment for the mortgage loans from the HPF as a further policy measure on top of the downpayment requirements for the mortgage from a commercial bank. Like the commercial bank mortgage, minimum downpayment requirements vary depending on the type of mortgage loan. We assign the weights for different types of HPF mortgage loans. The weights are summarized as follows:

Type of mortgage loan	Weight
<b>A) First residence</b>	<b>70%</b>
No mortgage lending before	49%
With mortgage lending before	21%
<b>B) Second residence</b>	<b>30%</b>
No mortgage lending before or loan settled	21%
With mortgage loan not yet settled	9%

The minimum aggregate downpayment ratio ranged from 20 % to 45.3 % across the 70 cities during the sample period. A higher value represents tighter measures.

## Taxes and fees

10. **Taxes and fees (scored from -1 to 3).** There is a wide variety of requirements governing property-related taxes and fees. A five-value indicator is assigned for different requirements on property-related taxes and fees. The relative strength indicators have 5 values, with the higher value representing a tighter measure. The meaning of the value of the indicator is summarized as follows:

<b>Strength</b>	-1	0	1	2	3
<b>Meaning</b>	Easing	Neutral	Slightly Tightening	Tightening	Heavily Tightening

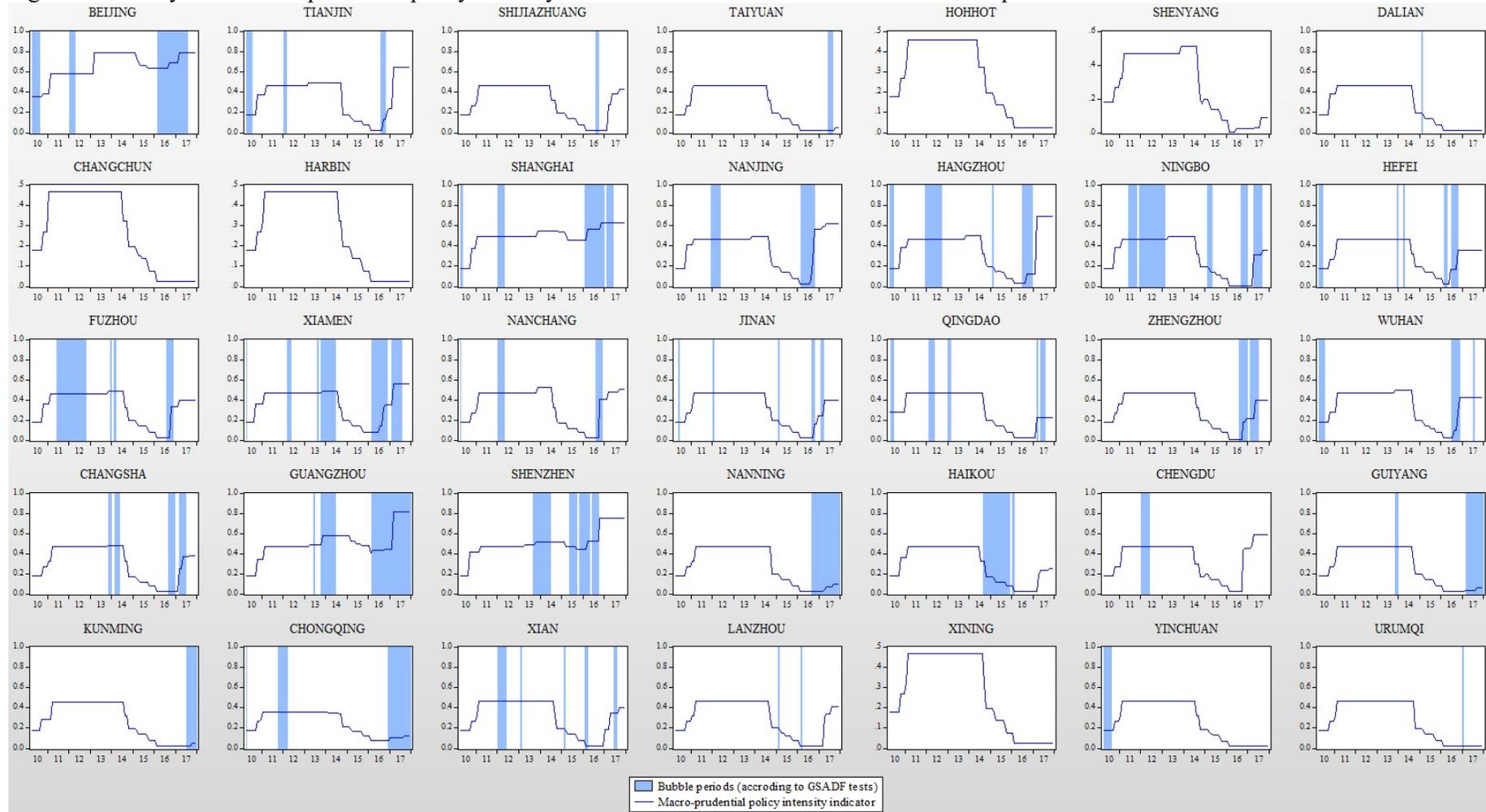
The indicator is decided based on the corresponding measures as follows:

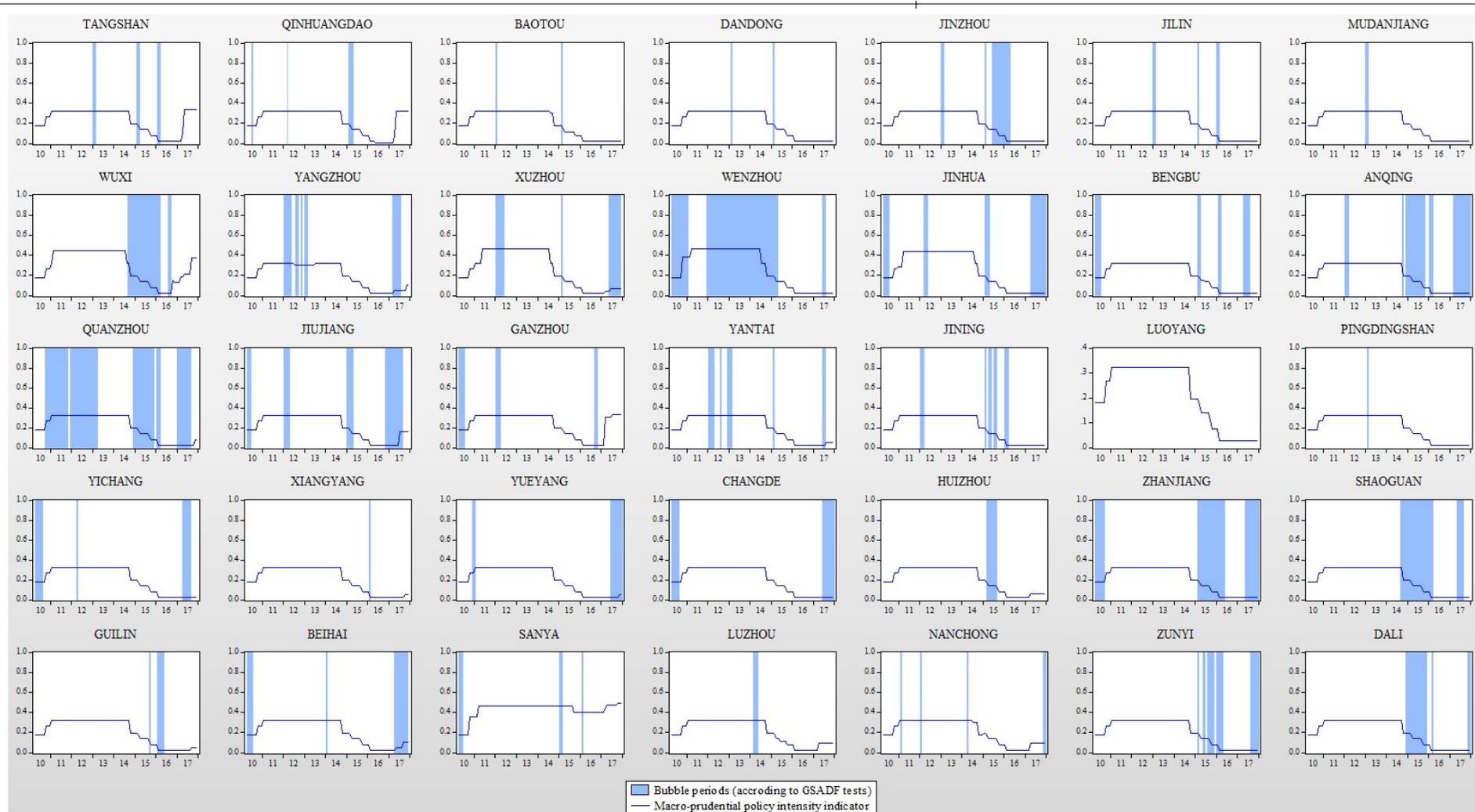
Measures	Strength
Full sales tax for property transaction within 2 years of purchase but no sales tax for transaction more than 2 years of purchase; lower transaction tax and fee; with subsidy	-
Full sales tax for property transaction within 2 years of purchase; with some fee reduction	1
Full sales tax for property transaction within 2 years of purchase; with some fee reduction and subsidy	0
Full sales tax for property transaction within 2 years of purchase; with some tax reduction	0
Full sales tax for property transaction within 2 years of purchase; with some tax reduction and fee reduction	0
Full sales tax for property transaction within 2 years of purchase; with some tax reduction and subsidy	0
Full sales tax for property transaction within 2 years of purchase; with subsidy	0
Full value-added tax for property transaction within 2 years of purchase; lower transaction tax and fee	0
Full sales tax for property transaction within 2 years of purchase but no sales tax for transaction after 2 years of purchase; lower transaction tax and fee	0
Full value-added tax for property transaction within 2 years of purchase but no value-added tax for transaction more than 2 years of purchase; lower transaction tax and fee	0
No specific measure	0
Differentiated tax on property transaction: Tax reduction for self-used owner-occupied property?	1
Property tax & full sales tax for property transaction within 2 years of purchase; lower transaction tax and fee	1
Property tax & full value-added tax for property transaction within 2 years of purchase; lower transaction tax and fee	1
Full sales tax for property transaction within 2 years of purchase	1
Full sales tax for property transaction within 5 years of purchase, with some tax reduction	1
Full sales tax for property transaction within 5 years of purchase, with subsidy	1
Property tax & full sales tax for property transaction within 2 years of purchase; higher property income tax	2
Property tax & full value-added tax for property transaction within 2 years of purchase; higher property income tax	2
Full sales tax for property transaction within 5 years of purchase	2
Full sales tax for property transaction within 5 years of purchase; higher property income tax	3
Higher property tax & full value-added tax for property transaction within 2 years of purchase; higher property income tax	3
Property tax & full sales tax for property transaction within 5 years of purchase	3
Property tax & full sales tax for property transaction within 5 years of purchase; higher property income tax	3

Note: Since 2011 two trials of a property tax in Shanghai and Chongqing exist. The expectation is that the tax will be rolled out to other cities later. One reason is that legislation could take up years to implement. The annual property tax rate in Shanghai is 0.6% of value of the taxable area of the property (some tax exemption is applied) for luxury housing (the price is 200% or above of the average transaction price in the previous year) and 0.4% for other housing. In Chongqing, the annual tax rate is 0.5% - 1.2% of value of the taxable area of the property.

## Appendix D. Bubble test results

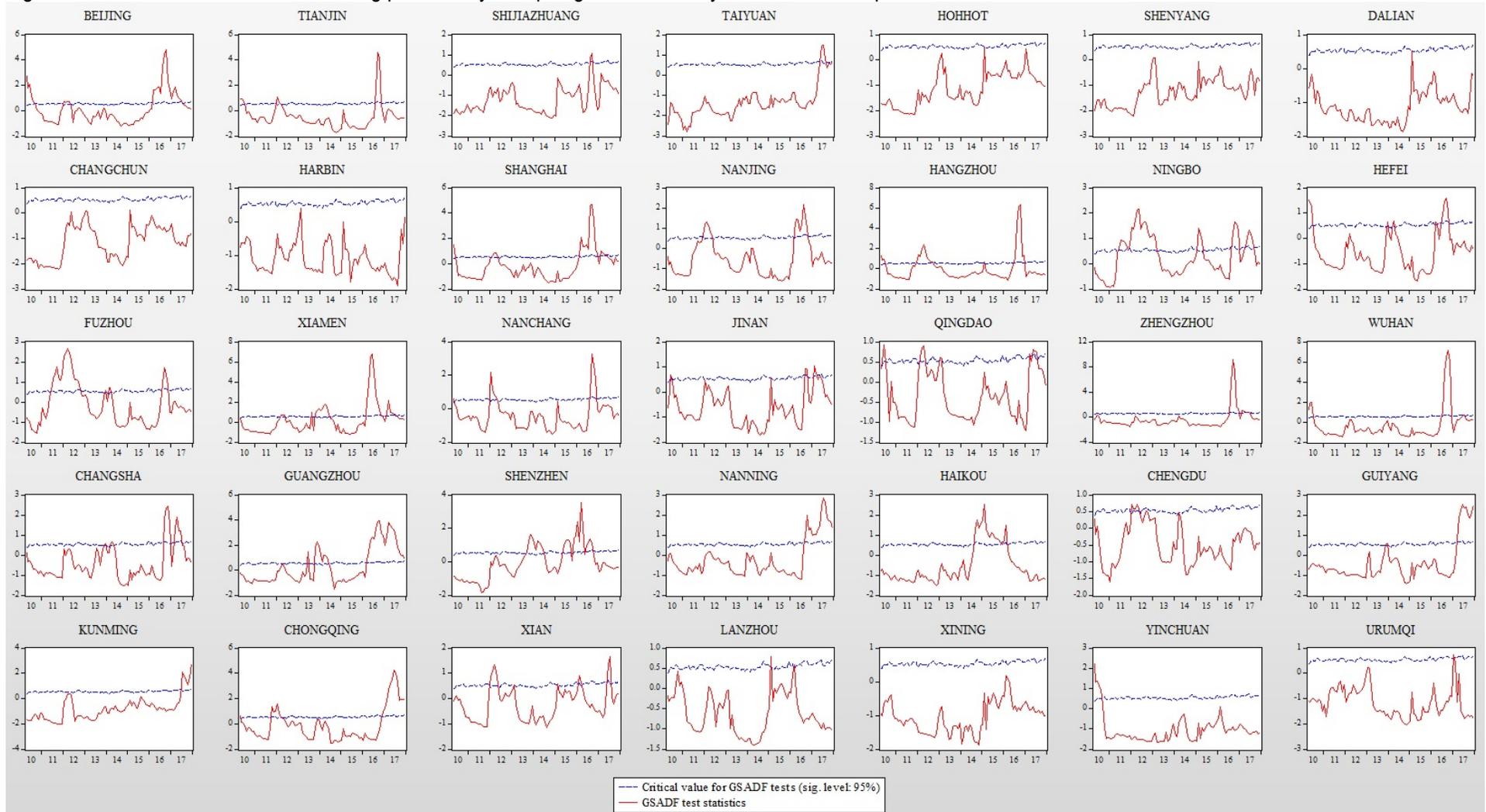
Figure D1 City-level macro-prudential policy intensity and GSADF bubble test results for real house prices

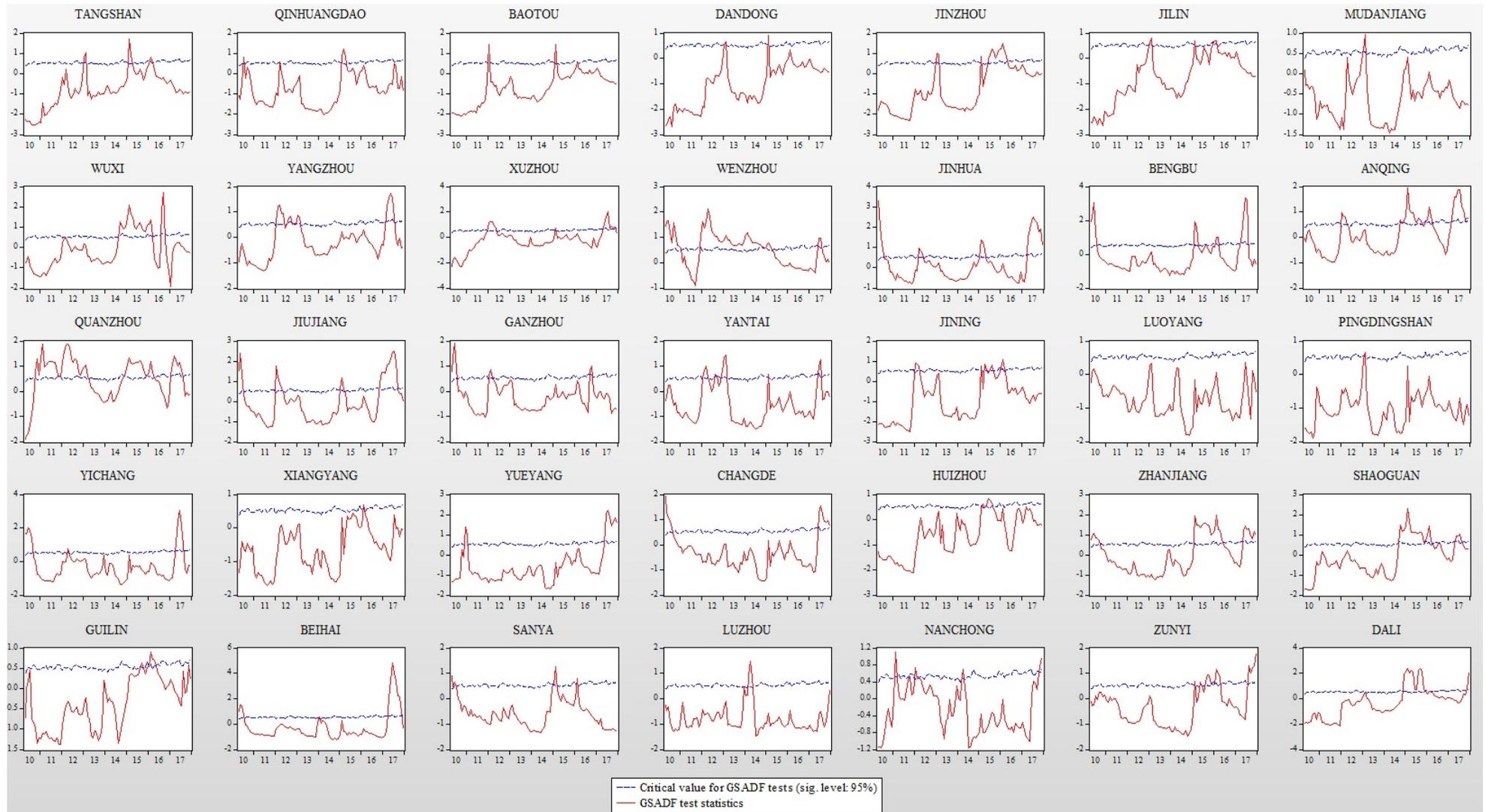




Note: Shaded areas in blue are the bubble periods detected by GSADF tests for real house prices (deflated by provincial CPI) with significance level at 95 %, and the number of lag is selected by SIC.

Figure D2 GSADF tests for detecting periodically collapsing bubbles of city-level real house prices





Note: The GSADF test stat (red solid line) is calculated by using the data of real house prices (deflated by provincial CPI), and the number of lag is selected by SIC. The critical values (blue dashed line) are at 95 % of significance level.

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