Inflation-hedging properties of regional Chinese real estate Market: evidence from 35 cities in China

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Abstract: The housing markets in China have been gaining considerable interest from investors, but the inflation-hedging characteristics of housing remain ambiguous. Based on China city-level data, this study evaluates different inflation-hedging properties in eastern, middle, and western real estate markets using Panel Vector Autoregressive (PVAR) models. Findings suggests middle real estate markets afford the best hedging opportunities for expected inflation, this is robust considering housing market heterogeneity, financial crisis, and the 2010 purchase restriction order. Moreover, hedging efficacy of anticipated inflation differs between markets with low and high supply-demand ratio.

Key words: Inflation-hedging, Chinese regional real estate, PVAR model, Difference-in-Difference

I. Introduction

The large-scale 1998 housing reform in China substantially changed the landscape of Chinese urban real estate markets, swiftly transforming China into a country with one of the highest house ownership rates in the world. China's rate of house ownership increased from 55% in early 1990's to over 89.68%,[3] compared to approximately 66.1%[4] in the U.S for 2011. As Figure 1 illustrates, average annual growth rates of housing prices was about 3% points higher than inflation during 2010 to 2013 time period. Domestic loans for real estate investment and personal disposable income also increased, outpacing both housing and inflation rate changes. In 2010 the Chinese government placed regulatory constraints on the purchase of multiple residential properties to curb overheating in real estate markets and limit speculative investment by imposing restrictions.

Connectivity between housing price appreciation and soaring inflation in China has attracted considerable research interest. The efficacy of real estate inflation-hedging properties has been widely documented in many countries (see for example, Barkham, 1996; Tarbert, 1996; Ganesan, 1998; Stevenson, 2000; Hoesli, 2008,). In China, results are ambiguous, as some scholars find real estate has short-term hedging inflation characteristics but not long-term, differing from many developed countries (Qiu, 2011; and Di, 2012), however, analogous to Hong Kong real estate markets (Glascock, Fen, Fan and Bao, 2010; Qiao and Wong, 2015). Some studies fail to find evidence of short- or long-term hedging characteristics (e.g., Chou and Tien, 2004; and Zhou and Clements, 2010).

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3 Data: Chinese Household Finance Survey (CHFS)
4 Data: American Community Survey (ACS)

This ambiguity may be attributed to local factors contributing to regional peculiarities in real estate markets. For example, Zhang (2013) finds housing prices cannot significantly counteract inflation in Beijing, but they do in Shanghai. Regional differences also occur in developed countries. In the U.S, for example, Daniel (2002) and Jud (2002) examine the dynamics of house price appreciation in 130 metropolitan areas and inflation hedging efficacy varied geographically, because local factors contribute to house price variance (Zhang, Gerlowski and Ford, 2014). Furthermore, Baffoe-Bonnie (1998) provides evidence that regional residential markets are sensitive to local economic variables, allowing for regional differences. Stevenson (1999) also finds substantial regional differences in British residential markets, with North West Scotland, and Yorkshire being the only markets to consistently hedge inflation.

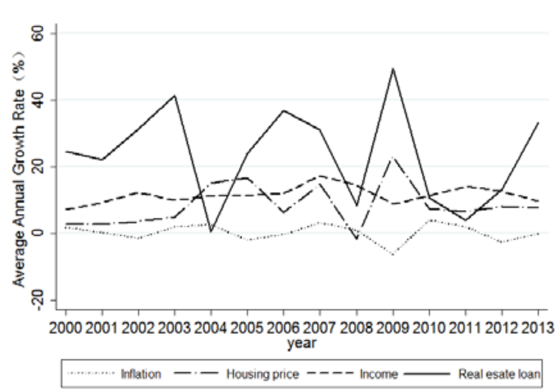

Fig.1. Historical plots of inflation rate, change in housing prices, domestic loans for real estate investment, and real personal disposable income. Source: Calculated based on statistics published by the National Bureau of Statistics of China (NBSC).

This study explores the relationship between Chinese housing markets and inflation during pre- and post-financial crisis time periods, conditional on regional markets rather than the country in aggregate, and an intervention effect of government policy restricting property speculation in some markets. This allows us to identify and test factors that influence inflation hedging characteristics in diverse Chinese real estate markets.[5] We include regional supply- and demand-side factors in our analysis, as the spatial structure in Chinese cities can become distorted by local differentials in capital cost and income. We focus on local personal disposable income as our demand-side indicator variable and total housing mortgage loans outstanding as a percentage of domestic loans for real estate investment as a supply-side indicator. The latter increased from 3.9% in 2000Q1 to 13.2% in 2012Q4.[6] We expect regional inflation hedging disparities can be explained by regional real estate market heterogeneity.

5 City samples are geographically divided into three regions according to the official partition method of the statistical bureau in China, namely: the Eastern region, the Middle region and the Western region.
6 Data source: WIND database. We use domestic loans for regional real estate investment rather than Loan to Value ratio to explore the monetary policy factors in influencing the ability of hedging inflation among regional real estate markets. Adjusting loan to value ratio (LTV) is one of the targeted macro prudential policies of the central bank to contain risk of a real estate boom. But LTV ratios are relatively constant, ranging from 50% to 60% on residential real estate loans.

We employ panel data for 35 cities representing eastern, middle, and western regions in China, and highlight potential anticipated and unanticipated inflation hedging characteristics considering supply- and demand-side factors. To our knowledge we are first to use PVAR models[7] to evaluate inflation hedging properties of Chinese real estate. This study documents the following contributions, (1) inflation hedging efficacy, particularly anticipated inflation, of Chinese regional housing markets in the pre-and post-financial crisis sub-samples, (2) hedging differentials among regional markets, and (3) these differences are robust considering regional supply- and demand-side factors. (4) We also document pricing effects of the 2010 government imposed "purchase restriction order". This study provides insight for international and domestic real estate investors, helping with their understanding of the robust and varied Chinese regional real estate economies.

The paper is organized as follows. Section 2 reviews the literature; Section 3 presents the estimation methods and defines model variables; Section 4 provides empirical results; in Section 5 robustness checks are discussed; Section 6 concludes.

II. Literature Review

According to classical asset pricing theory, real estate has traditionally been regarded as an investment with inflation hedging properties. For example, Fama and Schwert (1977) use conventional Ordinary Least Square (OLS) to study inflation hedging characteristics of various assets and find that only private residential real estate completely hedges against both expected and unexpected inflation in the US (see also Brown, 1991; Tarbert, 1996). Although the calculation of housing price indices may vary, previous research offers evidence that inflation hedging characteristics of real estate persist in many countries: UK (Limmack and Ward,1988; Matysiak, 1996; Barkham, 1996, and Stevenson, 2000), Australian (Newell ,1996), Greece (Apergis and Rezitis ,2003), Singapore (Sing and Low, 2000), Thailand (Amonhaemanon, 2013) and Malaysian (Lee, 2014). But in China, Chou and Tien, 2004; Zhou, 2010; Qiu, 2011 and Di, 2012 study inflation hedging properties of real estate at the aggregate national level and find that the Chinese real estate market is not an effective hedge against inflation, lacking consistent results in the short- and long-term.

The literature features two major research threads regarding inflation hedging characteristics of real estate. The first focus is on the short-term, while the second tests long-run hedging characteristics of real estate (e.g. Anari and Kolari, 2000; Stevenson, 2000; Hoesli,,*et al*., 2008, Sousa, 2012). Most Chinese scholars apply cointegration models for long-run analysis and short-run effects; the focus has primarily been at an aggregate national level or in some cases a few select cities, e.g., Hong Kong, Beijing and Shanghai (Glascock *et al*.,2010; Qiu,2010; Di,2012; Zhou,2010). The few existing empirical studies on this issue in China have led to ambiguous conclusions. Duan (2007) finds a positive feedback mechanism between housing prices and inflation. However, using quarterly real estate price index of four major Chinese cities from 1996 to 2002,

[7] PVAR models are selected because housing prices and inflation potentially share an endogenous relationship.

Chou and Tien (2004) find no evidence of inflation hedging in Chinese real estate. Whereas Qiu (2011) finds that Chinese real estate has inflation hedging characteristics in the short- but not long-term. Conversely Di (2012) finds long-term hedging opportunities, but not short-term. Zhang (2013) concludes that housing prices cannot significantly counteract the influence of inflation in Beijing, but in Shanghai house price is the main determinant of inflation. In summary, previous results are conflicting, regional analysis has been limited to only a select few cities in mainland China and Hong Kong; these studies reflect different time periods, price measure choice, and property data type. The empirical literature indicates that while property is likely to be a hedge against inflation, definitive agreement is absent.

This lack of consensus perhaps points to high levels of regional disparity in Chinese housing markets and illustrates the need to control for regional demand- and supply-side factors. Liang (2008) points out Chinese regional differences and shows the unbalanced economic growth in coastal and inland regions. Similarly, in the US, using a nonstructural estimation technique testing the effects of four key macroeconomic variables on housing prices, Baffoe-Bonnie (1998) shows that inflation has a larger impact on housing prices in the northwest compared to the south. In another US study, housing price returns were found to vary across geographic areas because of location-specific fixed-effects (Jud and Winkler, 2002).

In addition to regional factors, housing markets are well known for being heterogeneous (Clayton, Miller and Peng, 2010), particularly in terms of fundamentals causing substantial regional differences in house prices (Oikarinen and Engblom, 2015). The aggregate demand and supply for housing is elastic (Clayton, Miller and Peng, 2010). In fact, Smith (1976), Hanushek and Quigley (1980), DiPasquale and Wheaton (1994), and Malpezzi and Maclennan (2001) provide evidence of negative price elasticity of housing demand and positive price elasticity of housing supply. Regional differentials in observed price patterns reflect differences in the correlation of demand shocks, as well as the elasticity of supply responses (Titman, Wang and Yang, 2014). Chow and Niu (2015) show that the rapid increase in urban residential housing prices can be explained by the economics of supply and demand - with income contributing to demand and cost of construction affecting supply. So that, housing Prices in urban real estate markets reflect the intersection of supply and demand (Deng, Gyourko and Wu, 2015).

We use domestic loans for real estate investment as an indicator of supply and personal disposable income for demand, as house prices have been linked to income (Capozza, Hendershott, Mack and Mayer, 2002), and housing price appreciation is strongly influenced by changes in real income (Jud and Winkler, 2002). However, the supply of real estate is also susceptible to influences wielded by national policies, as Demary (2009) documents in all ten OECD countries.[8]

8 Ten OECD countries. Australia, Denmark, Finland, France, Germany, Japan, Netherlands, Spain, UK and USA.

In the transmission mechanism of monetary policy, housing prices are important considerations (Bjornland *et al*, 2010), as they are sensitive to policy changes (Iacoviello and Neri, 2010). Monetary policy decisions tend to have persistent influence on housing wealth (Sousa, 2014), and on housing investment. In China, Chou and Tien (2004) explore the relationship between regional real estate prices and monetary policy and contend that monetary policy significantly influences housing prices. Extending the sample of Chou and Tien (2004), Liang and Gao (2007) find that the efficacy of monetary policy is not consistent, as only east and west regional Chinese real estate markets are significantly impacted. Zhang and Li (2013) suggest that the effectiveness of monetary policy is dependent on regional inflation hedging characteristics.

While most of the previous studies relied on aggregate level data, our paper uses city-level data to document a link between real estate price, and anticipated and unanticipated inflation considering demand- and supply-side local market fundamentals, financial crisis and compulsory housing policy changes.

III Data and Empirical Strategy

Data and preliminary test

Data is collected from the national statistical bureau, the state council development research center, and China Center for Economic Research (CCER). This study employs quarterly data representing 35 cities[9] in China using time periods recognizing a diverse economic conditions, considering regional real estate heterogeneity, financial crisis and controlling for the 2010 housing purchase restrictions. City samples are geographically divided into three regions according to the official partition method of the statistical bureau in China (eastern, middle, and western regions).[10] Descriptive statistics are presented in Table 1.

We use housing sales price index data for the percentage change in housing prices as calculated and reported by the National Bureau of Statistics of China (NBSC).[11] R_{it} is the growth rate of regional i housing price index at quarter t, i.e., regional real estate market return. This can be calculated as follows,

$$R_{it} = (HPI_{it} - HPI_{i,t-1}) / HPI_{i,t-1}$$

where HPI_{it} refers housing price index for region i in quarter t, and $HPI_{i,t-1}$ is quarter $t-1$.

Prior studies have employed a variety of methods to calculate expected inflation. Based on Brown (1991), Fama and Gibbons (1982), Limmack and Ward (1988), we use an autoregressive integrated moving average

9 The quarterly housing price index released by the National Bureau of Statistics covering 2000 to 2010 is only available for 35 cities. This is the earliest publicly available housing price index for China. See. Fu et al. (2008) for more discussion.

10 The eastern regions include sixteen cities (Beijing, Tianjin, Shijiazhuang, Shenyang, Dalian, Shanghai, Nanjing, Hangzhou, Ningbo, Fuzhou, Xiamen, Jinan, Qingdao, Guangzhou, Shenzhen, Haikou), the middle regions include eight cities (Taiyuan, Changchun, Haerbin, Hefei, Nanchang, Zhengzhou,Wuhan, Changsha) and the west regions include eleven cities (Hohhot, Nanning, Chengdu, Chongqing, Guiyang, Kunming, Xi'an, Lanzhou, Xi'ning, Yinchuan, Urumqi). See Appendix for detailed descriptions.

11 Data source: http://www.stats.gov.cn/

(ARMA) model to estimate anticipated inflation[12]. Accordingly, inflation in region i at quarter t is calculated as $INF_{it} = (CPI_{it} - CPI_{i,t-1})/CPI_{i,t-1}$ The unanticipated inflation rate is estimated as real inflation rate less anticipated inflation according to Fama and Schwert (1977) method: $INF_{it} - ANINF_{it}$.

Table 1 Descriptive statistics

Variable	Observations	Mean	Stdev	Min	Max
R_{it}	1540	0.00157	0.02565	-0.09928	0.36142
$ANINF_{it}$	1540	0.00391	0.01607	-0.21358	0.19996
$UNINF_{it}$	1540	0.00002	0.10282	-0.77512	2.69740

Notes: R_{it} is the growth rate of regional i housing price index at quarter t, $ANINF_{it}$ is the time-varying anticipated inflation rate and $UNINF_{it}$ is the unanticipated inflation rate estimated as the real inflation rate less the anticipated inflation rate according to the Fama and Schwert (1977) method.

The average growth rate of real estate prices in 35 cities during 2000Q1 to 2010Q4 is 0.00157, with a standard deviation of 0.02565. Anticipated inflation and unanticipated inflation follow similar growth pattern with a mean rate of 0.00391 and 0.00002, respectively. The mean value of anticipated inflation is greater than real estate returns, but unanticipated inflation is not.

We use the Pesaran (2007) test, Im, Pesaran and Shin test (IPS, 2003) and Levin, Lin and Chu (LLC, 2002) to test stationarity of the variables. Results tabulated in Table 2 show all variables are stationary at a 1% significance level.

Table 2 Unit Root Test

	Pesaran test		IPS test		LLC test	
Variable	t-statistics	Critical Value	t-statistics	Critical Value	t-statistics	Critical Value
R	-4.908***	-2.230	-4.913***	-1.810	-28.762***	-18.032
ANINF	-5.153***	-2.230	-5.193***	-1.810	-30.384***	-22.269
UNINF	-4.071***	-2.230	-5.426***	-1.810	-33.171***	-23.405

Note: ***indicates significance at 1% levels respectively.

Modeling Specification

Based on "Fisher effect" theory contending that nominal return on an asset should be equal to its expected real return plus expected inflation as developed by Fama and Schwert (1977).

$$R_{it} = \alpha_i + \beta_i ANINF + \gamma_i (INF - ANINF) + \eta_{it} \quad (1)$$

Most previous studies in this area use Vector Autoregressive Regression (VAR) primarily at an aggregate national level or in some cases a few select cities, e.g., Hong Kong, Beijing and Shanghai (Chou and Tien, 2004; Glascock et al., 2010; Qiu, 2010; Di, 2012; Zhou, 2010). The conventionally used models cannot cater properly for this regional heterogeneity, and may thereby lead to biased conclusions concerning regional

12 We use the Dickey-Fuller test to examine the inflation rate and find that there is no unit root for the inflation rate, which means the inflation rate is stationary. We use Akaike information criterion (AIC) and Schwarz criterion (SC) to determine the ARMA model orders at city level. Different cities have different orders of ARMA.

housing price dynamics.(Oikarinen and Engblom, 2015).

Econometrically, serial correlation and cross-sectional correlation are concerns. We test for serial correlation in the idiosyncratic errors of a linear panel-data model discussed by Wooldridge (2002). The Wald test is 18.947, significant at 1 percent level, suggesting first-order serial correlation. We further use Pesaran (2004) and Friedman (1937) tests to examine cross-sectional correlation in residuals of a fixed effect regression model. The results are significant at 1 percent level which rejects the null hypothesis of cross-sectional independence. Endogeneity is also a concern for possible reciprocal causation between housing prices and inflation rates (see, for example, , 2015; Kuang and Liu, 2015; Zhang, 2013; Adam, et al., 2011). Tillmann (2013) point out that an OLS estimator with fixed-effects is potentially biased in a dynamic panel setting if coefficients on the endogenous variables differ across areas.

Considering both endogeneity and serial correlation, we employ a Panel Vector Autoregressive Regression model (PVAR model). PVAR models are frequently used to construct average effects possibly-across heterogeneous groups of units and to characterize unit specific differences relative to the average (Canova and Ciccarelli, 2013) and to document dynamic linkages between endogenous variables (Calomiris, Longhofer and Miles, 2013). Panel VAR is efficient because it does not require an assumption that economic structures of cities in the panel are the same. Such heterogeneity, if disregarded in estimating procedure, can bias the estimates. In particular, it is likely to lead to implausible estimates of persistence of shocks (Assenmacher and Gerlach, 2008). Moreover, Bordo and Landon (2013) find it useful to employ PVAR models to analyze relationships between inflation and house prices, to identify orthogonalized shocks and their effect on house prices.

Regional housing prices, anticipated inflation, unanticipated inflation, are part of a three-variable system of equations. PVAR models capture a dynamic link among all three variables, as they are treated as mutually endogenous and allows for unobserved individual heterogeneity. We use GMM (system linear generalized method of moments) estimators to avoid potential bias from including lagged endogenous variables. The model can be expressed as follows:

$$Z_{it} = \Gamma_0 + \Gamma(L) Z_{i,t-n} + f_i + d_{c,t} + \varepsilon_t \quad (2)$$

where, Z_{it} is a three-variable vector $\{R, \text{ANINF}, \text{UNINF}\}$; f_i is the city fixed effect, reflective of individual heterogeneity. We use forward Helmert de-meaning of observations to avoid biased coefficients, so we lose the last observation.[13] Our model also allows for city-specific time dummies, $d_{c,t}$, to capture aggregate city-

13 This process was first proposed by Arellano and Bover (1995) and adopted by Love and Ziccino (2006).

specific macro shocks that may affect all cities at the same time, we eliminate the need for these dummies by subtracting the means of each variables calculated for each city-quarter. We further use impulse-response functions to describe a reaction of one variable to innovations to another variable in the system. We use Choleski decomposition of variance-covariance matrix of residuals, equivalent to transforming the system in a "recursive" VAR for identification purposes.

IV Empirical Results

Baseline model:

Based on AIC, BIC and HQIC selection criterion tests, we find a one quarter lag is necessary to measure fully the relationships among the modeled variables. We follow the PVAR literature by employing the 'Helmert procedure' (see, Arellano and Bover, 1995) using lagged regressors as instruments and estimate coefficients by using system linear generalized method of moments (GMM).[14] PVAR regression results based on equation (2) are presented in Table 3.[15]

The response of anticipated inflation to real estate return is positive in estimated coefficients at one lag levels, only significant in the middle region. This result supports findings of Chou and Tien (2004) and Tarbert (1996), however it is contrary to findings of Barkham et al (1996), Matysiak et. al. (1996), and Stevenson (2000).

Table 3 PVAR model-Baseline model

	ALL	EAST	MIDDLE	WEST
R(t)				
R(t-1)	0.255***	0.335***	0.159**	0.196***
	(6.40)	(5.30)	(2.28)	(2.63)
ANINF(t-1)	0.210*	0.080	0.739***	0.563
	(1.94)	(1.07)	(3.95)	(1.24)
UNINF(t-1)	0.003	-0.040	0.130	0.004*
	(1.44)	(-1.29)	(1.55)	(1.84)

Note: ***, ** and * indicates significance at 1%, 5% and 10% levels respectively.

We also employ panel granger causality tests with one lags; results are presented in Table 4. Nationally, we find anticipated inflation and real estate returns have bidirectional Granger causation. Regionally, however, we find that anticipated inflation only significantly Granger causes real estate returns in the middle region – consistent with PVAR findings.

14 The estimator augments Arellano–Bond (1995) by making an additional assumption that first differences of instrument variables are uncorrelated with fixed effects. This allows more instruments and can dramatically improve efficiency. It builds a system of two equations—the original equation and the transformed one—and is known as system GMM. See (Oikarinen and Engblom, 2015) for discussion.

15 We experiment with various possible orderings among the three variables and find results regarding different relationships between regional real estate returns and inflation among the three regions are robust to orderings selected.

Table 4 Panel Granger Causality Test-Baseline model

Null Hypothesis	Wald-Stat.	P-value
Anticipated inflation does not Granger Cause Real estate return overall	3.750*	0.053
Real estate return does not Granger Cause Anticipated inflation overall	8.781***	0.003
Anticipated inflation does not Granger Cause real estate return in Eastern region	1.155	0.283
Real estate return does not Granger Cause Anticipated inflation in Eastern region	18.496***	0.000
Anticipated inflation does not Granger Cause real estate return in Middle region	15.575***	0.000
Real estate return does not Granger Cause Anticipated inflation in Middle region	0.018	0.894
Anticipated inflation does not Granger Cause real estate return in Western region	1.534	0.216
Real estate return does not Granger Cause Anticipated inflation in Western region	6.575***	0.010
Unanticipated inflation does not Granger Cause Real estate return at average overall	2.072	0.150
Real estate return does not Granger Cause Unanticipated inflation overall	0.299	0.584
Unanticipated inflation does not Granger Cause Real estate return in Eastern region	1.653	0.199
Real estate return does not Granger Cause Unanticipated inflation in Eastern region	0.068	0.794
Unanticipated inflation does not Granger Cause Real estate return in Middle region	2.405	0.121
Real estate return does not Granger Cause Unanticipated inflation in Middle region	1.537	0.215
Unanticipated inflation does not Granger Cause Real estate return in Western region	3.393*	0.065
Real estate return does not Granger Cause Unanticipated inflation in Western region	0.408	0.523

Note: *** and * indicates significance at 1% and 10% levels respectively.

In order to generate impulse responses and variance decompositions, we employ Choleski decomposition. The following graphs are reported based on impulse-response functions and report 5% error bands generated by Monte Carlo simulations. Figures 2, present graphs of impulse responses comparing regional real estate returns with anticipated and unanticipated inflation shocks, respectively.

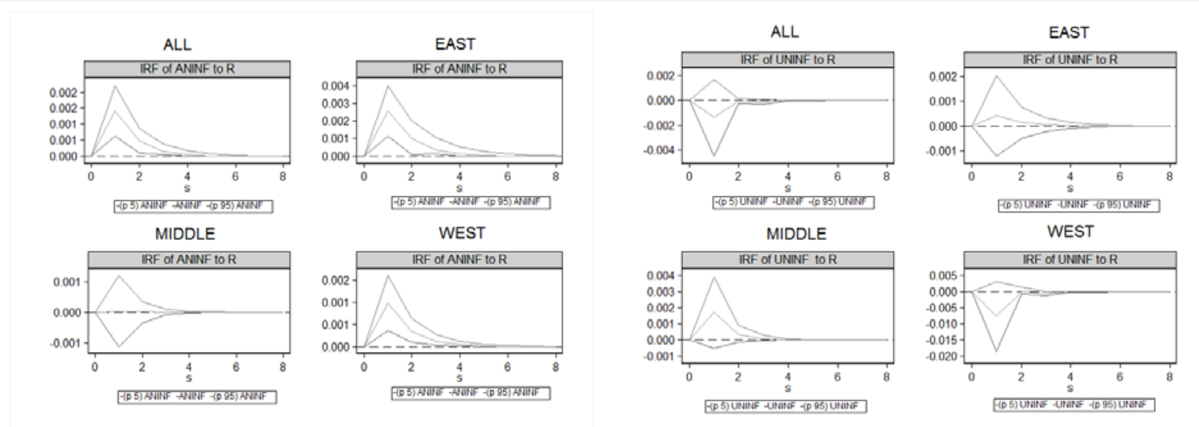

Fig 2 Impulse response functions of real estate returns to anticipated and unanticipated inflation rate shocks**.** Errors are 5% on each side generated by Monte-Carlo with 500 reps

Return of real estate increases in response to an anticipated inflation shock for all three regions, lasting up to 4 quarters. Some regional disparities are noted as the Middle regional markets tend to have a stable response to anticipated inflation compared to Eastern and Western regions, and responds positively with unanticipated inflation shocks. The returns in Eastern and Western regions also respond (positively) to shocks in anticipated inflation, responses to unanticipated inflation were not uniform however little long-term persistence is noted.

Table 5 Variance decompositions-Baseline model

Region	ALL	EAST	MIDDLE	WEST
Variable	R	R	R	R
Forecast Horizon	20	20	20	20
R	0.989	0.994	0.956	0.958
ANINF	0.011	0.001	0.039	0.041
UNINF	0.000	0.005	0.005	0.001

Notes: Entries in this table show percent of row variable's error variance explained by shocks to column variable at specified lag.

The variance decompositions presented in Table 5 measures covariate magnitudes or contributions to gauge economic importance. After lagged real estate returns, anticipated inflation contributes the most to forecast variance of real estate returns, both nationally and regionally. Anticipated inflation shocks explain nearly 4.1% of the 20-lag forecast variance of real estate returns in the western region and about 3.9% in middle region cities. Unanticipated inflation explains 0.5% in the both eastern and middle regions, compared with only 0.1% in the western region. Comparing with eastern and western regional real estate markets, the sum of anticipated and unanticipated inflation in middle markets account for 4.4% of housing price variation, more than eastern and western regions, 0.6% and 4.2% respectively.

V Robustness

Housing market heterogeneity

Price elasticity with respect to fundamentals substantially varies across distinct regional housing markets

(Capozza et al., 2004; Davis and Heathcote, 2007). To understand possible heterogeneity in regional real estate inflation hedging characteristics and confirm the robustness of our previous analysis, we re-estimate by parceling our sample into two city groups, (1) above and (2) below median supply-demand ratios.

$LOAN_{it}$ is the growth rate of domestic loans for regional real estate investment and is an indicator of supply activity which is calculated as follows.

$$LOAN_{it} = \ln(loan_{it} / loan_{i,t-1})$$

Where $loan_{it}$ refers to the amount of domestic loans for real estate investment at quarter t in region i and $loan_{i,t-1}$ is at quarter $t-1$.

Variable Y_{it} is the growth rate of personal disposable income, an indicator of demand, and is calculated as follows.

$$Y_{it} = \ln(y_{it} / y_{i,t-1})$$

Where y_{it} is personal disposable income in region i at quarter t and $y_{i,t-1}$ is quarter $t-1$

We construct an indicator variable of the supply-demand ratio by taking the average $LOAN$ and Y during 2000Q1 to 2010Q4.

$$ratio_i = LOAN_i / Y_i$$

If the supply-demand ratio of city i is beyond the median supply-demand ratio in our sample, we classify the real estate market of city i as a "buyer market" and a "seller market" is when the supply-demand ratio is less than the median. Sub-sample results are presented in Table 6.

Table 6 PVAR model **-** Subsample of economic market conditions

	ALL	EAST	MIDDLE	WEST
Panel A: Buyer market				
R(t)				
R(t-1)	0.247***	0.324***	0.071	0.123
	(5.01)	(4.97)	(0.85)	(0.96)
ANINF(t-1)	0.156	0.080	0.494***	0.872
	(1.45)	(1.07)	(2.64)	(0.59)
UNINF(t-1)	0.003	-0.038	0.103	0.004*
	(1.39)	(-1.20)	(1.41)	(1.68)
Panel B: Seller Market				
R(t)				
R(t-1)	0.244***	0.721***	0.183**	0.259***
	(3.56)	(4.06)	(2.00)	(3.41)

Table 6 Continued

ANINF(t-1)	0.663***	-0.019	1.683***	0.449***
	(4.57)	(-0.06)	(3.06)	(3.29)
UNINF(t-1)	0.086	-0.297	0.205	0.073
	(0.91)	(-1.61)	(0.84)	(0.82)

Note: ***, ** and * indicates significance at 1%, 5% and 10% levels respectively.

The middle market has significant anticipated inflation hedging characteristics in both economic market types and confirms the robustness of our baseline results. We also find western real estate markets have unexpected inflation hedging properties in "buyer market" and expected inflation hedging properties in "seller market". Panel Granger Causality Test presented in Table 7 further complements our PVAR results. Anticipated inflation Granger causes real estate returns in the Middle real estate market for both "seller" and "buyer" markets. The unanticipated inflation does not generally Granger Cause real estate returns except in the Western region "seller" market.

Table 7 Panel Granger Causality Test- Subsample of economic market conditions

Null Hypothesis	Wald-Stat.	P-value
Panel A: Buyer Market		
Anticipated inflation does not Granger Cause Real estate return overall	2.101	0.147
Real estate return does not Granger Cause Anticipated inflation overall	9.395***	0.002
Anticipated inflation does not Granger Cause real estate return in Eastern region	1.146	0.284
Real estate return does not Granger Cause Anticipated inflation in Eastern region	17.167***	0.000
Anticipated inflation does not Granger Cause real estate return in Middle region	6.974***	0.008
Real estate return does not Granger Cause Anticipated inflation in Middle region	.0554	0.814
Anticipated inflation does not Granger Cause real estate return in Western region	0.348	0.555
Real estate return does not Granger Cause Anticipated inflation in Western region	3.778*	0.052
Unanticipated inflation does not Granger Cause Real estate return at average overall	1.924	0.165
Real estate return does not Granger Cause Unanticipated inflation overall	0.573	0.449
Unanticipated inflation does not Granger Cause Real estate return in Eastern region	1.430	0.232
Real estate return does not Granger Cause Unanticipated inflation in Eastern region	0.107	0.744

Table 7 Continued

Unanticipated inflation does not Granger Cause Real estate return in Middle region	1.995	0.158
Real estate return does not Granger Cause Unanticipated inflation in Middle region	14.675***	0.000
Unanticipated inflation does not Granger Cause Real estate return in Western region	2.814*	0.093
Real estate return does not Granger Cause Unanticipated inflation in Western region	0.443	0.506
Panel B: Seller Market		
Anticipated inflation does not Granger Cause Real estate return overall	20.902***	0.000
Real estate return does not Granger Cause Anticipated inflation overall	0.26905	0.604
Anticipated inflation does not Granger Cause real estate return in Eastern region	0.003	0.953
Real estate return does not Granger Cause Anticipated inflation in Eastern region	0.474	0.491
Anticipated inflation does not Granger Cause real estate return in Middle region	9.360***	0.002
Real estate return does not Granger Cause Anticipated inflation in Middle region	1.159	0.282
Anticipated inflation does not Granger Cause real estate return in Western region	10.804***	0.001
Real estate return does not Granger Cause Anticipated inflation in Western region	1.486	0.223
Unanticipated inflation does not Granger Cause Real estate return at average overall	0.834	0.361
Real estate return does not Granger Cause Unanticipated inflation overall	0.684	0.408
Unanticipated inflation does not Granger Cause Real estate return in Eastern region	2.591	0.107
Real estate return does not Granger Cause Unanticipated inflation in Eastern region	5.443**	0.020
Unanticipated inflation does not Granger Cause Real estate return in Middle region	0.708	0.400
Real estate return does not Granger Cause Unanticipated inflation in Middle region	0.017	0.897
Unanticipated inflation does not Granger Cause Real estate return in Western region	0.674	0.412
Real estate return does not Granger Cause Unanticipated inflation in Western region	2.186	0.139

Impulse responses of real estate returns to anticipated and unanticipated inflation are generally similar to prior findings. However, anticipated and unanticipated inflation seems to produce more persistent effects during seller markets. Results from Variance decompositions confirm that anticipated and unanticipated inflation explain a substantial amount of real estate returns for both market conditions in middle real estate market.

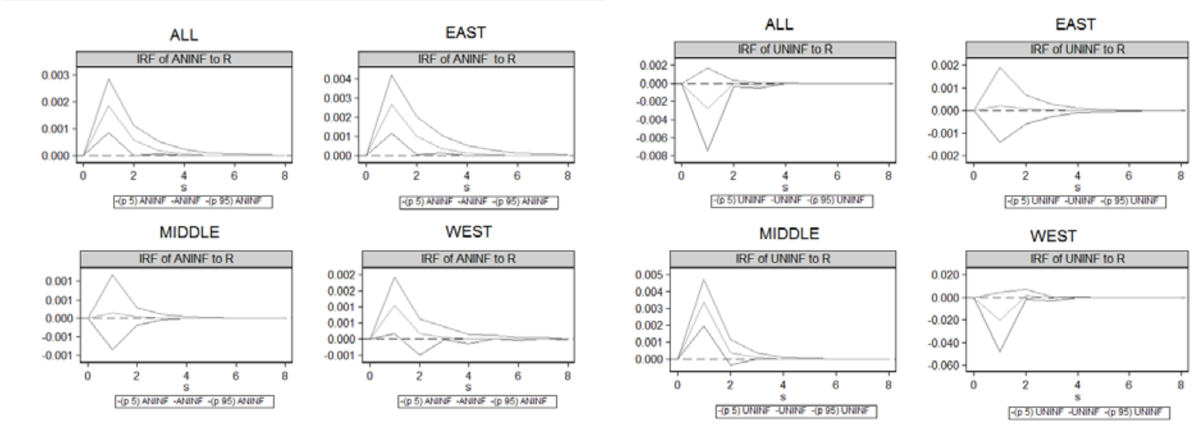

Fig 3 Impulse response functions of real estate returns to anticipated and unanticipated inflation rate shock in Buyer Market conditions.

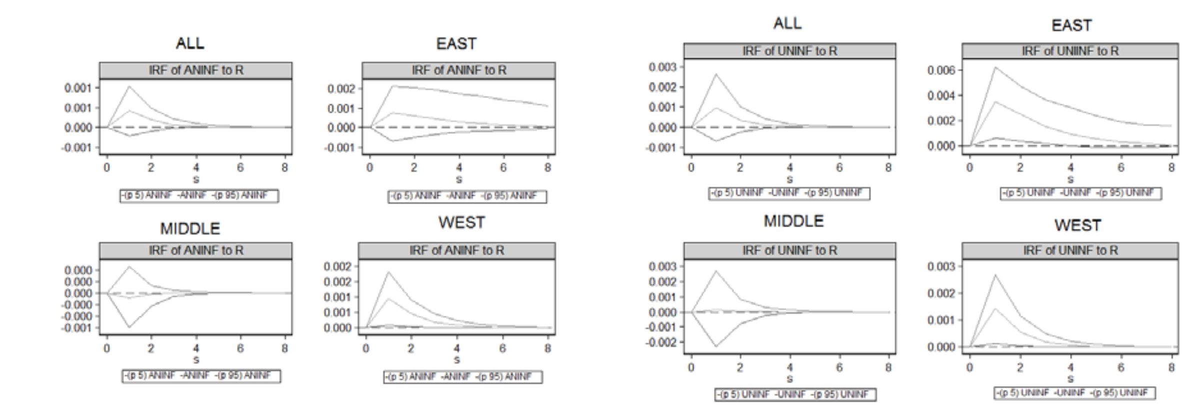

Fig 4 Impulse response functions of real estate returns to anticipated and unanticipated inflation rate shock in Seller Market conditions.

Table 8 Variance decompositions- Subsample of economic market conditions

Region	ALL	EAST	MIDDLE	WEST
Variable	R	R	R	R
Forecast Horizon	20	20	20	20
Panel A : Buyer Market				
R	0.992	0.994	0.958	0.945
ANINF	0.008	0.001	0.036	0.053
UNINF	0.000	0.005	0.005	0.001
Panel B : Seller Market				
R	0.958	0.923	0.926	0.957
ANINF	0.038	0.003	0.061	0.039
UNINF	0.004	0.074	0.013	0.005

Notes: Entries show the percent of row variable's error variance explained by shocks to column variable at specified lag.

Structural break-Substantial of financial crisis

To test for potential influences of the financial crisis, we parceled the time period into two sub-samples. We define the beginning of the crisis as second quarter 2007, following Ryan (2008). Prior to 2007Q2, we define as pre-financial crisis and vice versa.

Table 9 PVAR model-Subsample financial crisis

	ALL	EAST	MIDDLE	WEST
Panel C: Pre-Financial Crisis				
R(t)				
R(t-1)	-0.071*	-0.010	-0.137**	-0.104
	(-1.67)	(-0.13)	(-2.07)	(-1.40)
ANINF(t-1)	-0.041	0.020	0.053	-0.483
	(-0.45)	(0.26)	(0.21)	(-1.06)
UNINF(t-1)	0.002	-0.010	0.013	0.003
	(1.00)	(-0.25)	(0.16)	(1.19)
Panel D: Financial Crisis				
R(t)				
R(t-1)	0.637***	0.815***	0.372**	0.542***
	(4.45)	(12.30)	(2.06)	(2.71)
ANINF(t-1)	0.158	-0.102*	1.293***	0.769
	(0.74)	(-1.66)	(4.13)	(1.21)
UNINF(t-1)	-0.027	-0.028	0.020	0.018
	(-0.33)	(-0.29)	(0.05)	(0.07)

Note: ***, ** and * indicates significance at 1%, 5% and 10% levels respectively.

Results from sub-sample models reveal that eastern, middle and western regions did not show significant inflation hedging potential prior to the financial crisis. And, as shown in Table 9, middle real estate markets are the only regional markets acting as a potential hedge for anticipated inflation during and after the financial crisis. Similarly, prior to the financial crisis, inflation does not Granger cause real estate returns. Rather, real estate returns seem to Granger cause inflation. However, during- and post-financial crisis, anticipated inflation and real estate returns tend to have a bidirectional relationship in Eastern markets. And the anticipated inflation significantly Granger cause real estate return in Middle regional market.

Table 10 Panel Granger Causality Test-Financial Crisis

Null Hypothesis	Wald-Stat.	P-value
Panel C: Pre-financial crisis		
Anticipated inflation does not Granger Cause Real estate return overall	0.201	0.654
Real estate return does not Granger Cause Anticipated inflation overall	0.895	0.344

Table 10 Continued

Anticipated inflation does not Granger Cause real estate return in Eastern region	0.068	0.795
Real estate return does not Granger Cause Anticipated inflation in Eastern region	9.174***	0.002
Anticipated inflation does not Granger Cause real estate return in Middle region	0.044	0.833
Real estate return does not Granger Cause Anticipated inflation in Middle region	1.623	0.203
Anticipated inflation does not Granger Cause real estate return in Western region	1.123	0.289
Real estate return does not Granger Cause Anticipated inflation in Western region	0.061	0.806
Unanticipated inflation does not Granger Cause Real estate return at average overall	1.008	0.315
Real estate return does not Granger Cause Unanticipated inflation overall	1.495	0.221
Unanticipated inflation does not Granger Cause Real estate return in Eastern region	0.063	0.802
Real estate return does not Granger Cause Unanticipated inflation in Eastern region	0.720	0.396
Unanticipated inflation does not Granger Cause Real estate return in Middle region	0.025	0.875
Real estate return does not Granger Cause Unanticipated inflation in Middle region	7.181***	0.007
Unanticipated inflation does not Granger Cause Real estate return in Western region	1.415	0.234
Real estate return does not Granger Cause Unanticipated inflation in Western region	1.469	0.226
Panel D: Post-financial crisis		
Anticipated inflation does not Granger Cause Real estate return overall	0.543	0.461
Real estate return does not Granger Cause Anticipated inflation overall	7.325***	0.007
Anticipated inflation does not Granger Cause real estate return in Eastern region	2.772*	0.096
Real estate return does not Granger Cause Anticipated inflation in Eastern region	9.431***	0.002
Anticipated inflation does not Granger Cause real estate return in Middle region	17.046***	0.000
Real estate return does not Granger Cause Anticipated inflation in Middle region	0.057	0.812
Anticipated inflation does not Granger Cause real estate return in Western region	1.475	0.225
Real estate return does not Granger Cause Anticipated inflation in Western region	1.399	0.237

Table 10 Continued

Unanticipated inflation does not Granger Cause Real estate return at average overall	0.109	0.741
Real estate return does not Granger Cause Unanticipated inflation overall	1.157	0.282
Unanticipated inflation does not Granger Cause Real estate return in Eastern region	0.084	0.772
Real estate return does not Granger Cause Unanticipated inflation in Eastern region	0.243	0.622
Unanticipated inflation does not Granger Cause Real estate return in Middle region	0.003	0.956
Real estate return does not Granger Cause Unanticipated inflation in Middle region	0.091	0.763
Unanticipated inflation does not Granger Cause Real estate return in Western region	0.005	0.945
Real estate return does not Granger Cause Unanticipated inflation in Western region	5.573**	0.018

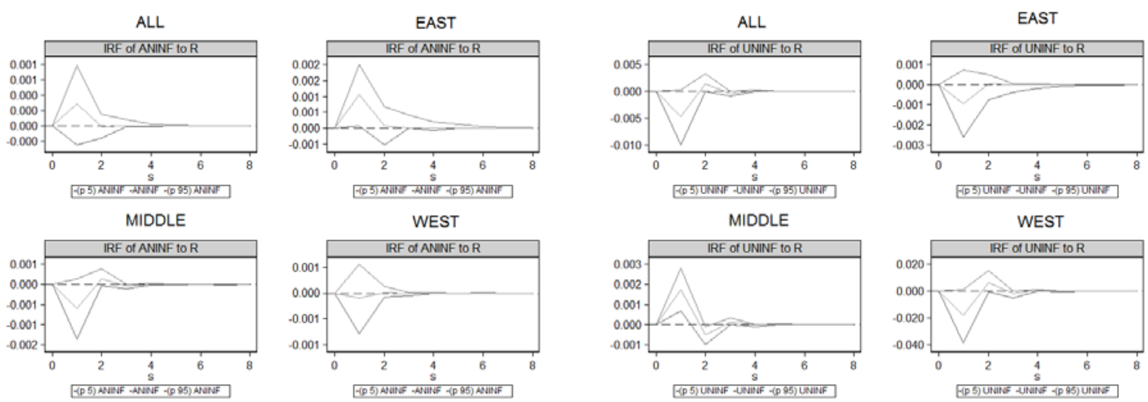

Fig 5 Impulse response functions of real estate returns to anticipated and unanticipated inflation rate shocks before financial crisis.

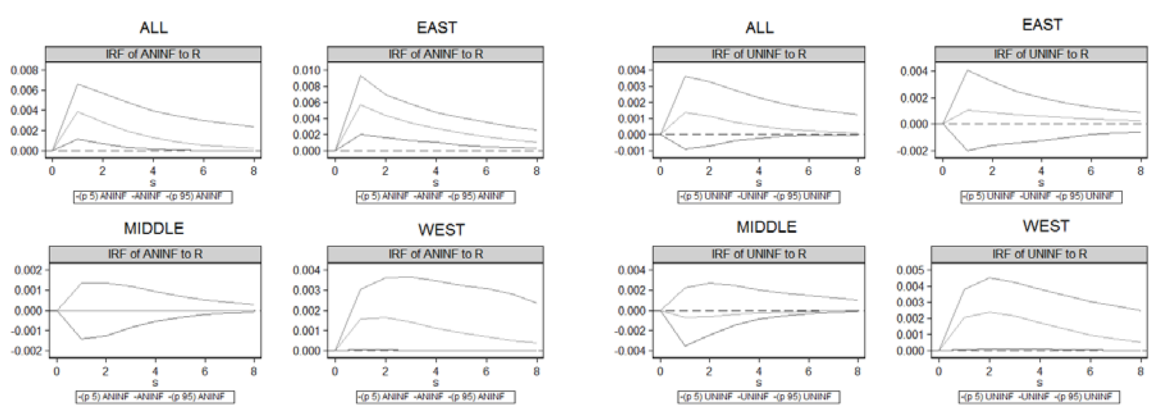

Fig 6 Impulse response functions of real estate returns to anticipated and unanticipated inflation rate shock after the financial crisis.

As shown in Figures 5, prior to the financial crisis, real estate returns do not have a persistent response to anticipated inflation shocks. During and subsequent financial crisis, regional real estate responds positively inflation shocks and response time is persistent during the 8 quarters following. Table 11 confirms that real estate return is not substantially explained by inflation prior to the financial crisis. Subsequently, both anticipated and unanticipated inflation impact real estate returns, especially in middle and western regions accounting for 12.5% and 15.7% respectively.

Table 11 Variance decompositions-Financial crisis

Region	ALL	EAST	MIDDLE	WEST
Variable	R	R	R	R
Forecast Horizon	20	20	20	20
Panel A : Pre-financial crisis				
R	0.999	1.000	1.000	0.972
ANINF	0.000	0.000	0.000	0.027
UNINF	0.000	0.000	0.000	0.001
Panel B : Post-financial crisis				
R	0.993	0.996	0.875	0.843
ANINF	0.003	0.003	0.120	0.150
UNINF	0.004	0.001	0.005	0.007

Notes: Entries in this table show percent of row variable's error variance explained by shocks to column variable at the specified lag.

Policy effects

The Chinese government implemented a "purchase restriction order" on April 30th 2010. This policy change limited purchases of multiple residential properties - to curb overheating real estate markets and limit speculative investment. Normally, citizens registered in hukou system can own a maximum of two houses in their names, while those relying on effective proof in the city can buy only one house. This policy was implemented in a few select cities. We want to test the efficacy of this exogenous policy, and also test whether this policy impacted regional real estate inflation hedging characteristics. We use a fixed effect model, as these models are widely used to test policy effects (Cao, Huang and Lai, 2015). A difference-in-difference method (DID) is as follows,

$$R_{it} = \beta\ ANINF_{it} + \lambda UNINF_{it} + DID_{it} + \zeta_i + \gamma_t + \delta X' + \varepsilon_{it} \qquad (3)$$

$Treatment_i$ equals one when a city implemented the policy during May 2010 to January 2011 time period[16]; $Post_{it}$ denotes post-policy period, taking a value of 1 after the date of implementation for cities and 0 otherwise. We consider a time lag for the policy effect, if announced before the middle of the month, city is classified in the treatment group for that month. If announcement date is after the middle of the month, the city is classified as treated the following month. DID is the interaction of $Treatment_i$ and $Post_{it}$. ζ_i is the city fixed

16 The cities that implemented the policy before January 2011 are Beijing, Tianjing, Taiyuan, Shanghai, Nanjing, Hangzhou, Hefei, Fuzhou, Xiamen, Jining, Qingdao, Zhengzhou, Guangzhou, Shenzhen, Haikou and Kunming,.

effect, controlling for time invariant differences across cities; γ_t is the month fixed effect, controlling for monthly macroeconomic shock to cities; X' is a control variable potentially impacting housing returns, here we use the growth rate of domestic real estate loans. ε_{it} is an error term.

Considering regulatory policy changes within regions, the coefficients of DID are negative in three real estate markets confirming that enactment of the "purchase restriction" policy decreased local real estate returns. Hedging anticipated inflation properties of regional real estate markets remain in the Middle markets. Although the growth rate of middle regional real estate returns decreased by 21.6%, it still hedges inflation as documented in Table 12.

Table 12 Results of difference-in-difference models based on monthly data from 2010June to 2014 December

Region	EAST	MIDDLE	WEST
$ANINF_{it}$	-26.199**	27.233*	0.019
	(-2.40)	(1.92)	(0.07)
$UNINF_{it}$	-3.501	-4.507	-0.844**
	(-0.29)	(-0.48)	(-2.55)
DID	-0.318	-0.216	-0.179
	(-0.84)	(-0.51)	(-1.01)
Control variables	Yes	Yes	Yes
City fixed effect	Yes	Yes	Yes
Month fixed effect	Yes	Yes	Yes

Note: Standard errors, clustered at city level, are in parentheses. ***, ** and * indicates significance at 1%, 5% and 10% levels respectively.

In summary, positive expected inflation-return connectivity we observe for the whole sample period is generally robust for the middle regional real estate market.

VI Conclusion

This study highlights anticipated and unanticipated inflation hedging characteristics of regional real estate markets in China. We use city-level panel data on 35 Chinese cities, grouped into regions. Regional real estate inflation hedging properties are calculated using PVAR, impulse response functions, variance decompositions and granger causality test. Our key results provide insight into hedging characteristics of heterogeneous real estate markets pre- and post- financial crisis. We also consider the 2010 policy restricting multiple house purchases.

We find Chinese real estate markets provide a limited hedging opportunity for expected and unexpected inflation. However, regional differentials emerge with middle real estate markets outperforming western and eastern regions. PVAR results also show that although lags in anticipated and unanticipated inflation do not consistently forecast real estate returns for all three regional real estate markets, marginal significance is found in the middle region.

Disparities between three regional real estate markets in hedging inflation can potentially be explained by supply and demand factors in various markets. We confirm the robustness of results considering real estate market heterogeneity based on a calculated supply-demand ratio. Additionally, examination of subsample time periods reveal potential impacts of the financial crisis, as we cannot document consistent hedging estimates during both pre- and post- financial crisis, prior to the financial crisis real estate prices were influencing inflation while during and post financial crisis the relationship seems to shift to bidirectional causality.

In addition to contributing to literature on inflation hedging characteristics, we document effects from the 2010 Chinese government “purchase restriction order”. This policy limiting multiple housing purchases seems to have the intended effect of slowing down growth in real estate prices. And, middle market real estate remains an inflation hedge.

Perhaps middle market cities are particularly better suited to hedge inflation because rates of gross domestic product are increasing in the middle market creating more job opportunities; also housing prices are less expensive compared with eastern real estate markets, and middle market areas do not suffer from pollution caused by manufacturing in the western area. The pace of housing price increases in middle regional cities is larger than those in eastern or western markets, potentially affording middle market investors a better inflation hedging opportunity.

These findings enhance our understanding of Chinese real estate markets and related policy. Investors interested in Chinese real estate markets should consider regional differentials, as middle real estate markets provide inflation hedging opportunities and effects are generally robust to the 2010 documented regulatory restrictions. These findings should be of interest to domestic and international investors and speculators in the Chinese housing markets.

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Appendix:

Map: Cities and Locations

The graph shows the location of the thirty-five cities in our data sample. Eastern regions include sixteen cities (Beijing, Tianjin, Shijiazhuang, Shenyang, Dalian, Shanghai, Nanjing, Hangzhou, Ningbo, Fuzhou, Xiamen, Jinan, Qingdao, Guangzhou, Shenzhen, Haikou), middle regions include eight cities (Taiyuan, Changchun, Haerbin, Hefei, Nanchang, Zhengzhou, Wuhan, Changsha) and west regions include eleven cities (Hohhot, Nanning, Chengdu, Chongqing, Guiyang, Kunming, Xi’an, Lanzhou, Xi’ning, Yinchuan, Urumqi).

Appendix Descriptive data on 35 Chinese cities from 2000 to 2012

Region	City	Average growth rate of GDP (%)	Population Density (person/sq.km)	Average Amount of Real Estate Investment (million dollars)	Average personal disposable income (dollars)
East	Beijing	10.7	727	2.9	3354.7
	Tianjin	14.9	804	0.8	2615.2
	Shijiazhuang	11.9	596	0.4	2202.1
	Shenyang	14.6	543	1.2	2408.0
	Dalian	14.7	455	0.7	2577.3
	Shanghai	10.7	2159	2.1	3632.8
	Nanjing	13.5	911	0.7	3264.9
	Hangzhou	12.4	400	0.9	3562.4
	Ningbo	11.8	585	0.5	3736.5
	Fuzhou	12.4	502	0.6	2781.2
	Xiamen	14.1	1019	0.4	3567.0
	Jinan	13.5	726	0.4	3011.9
	Qingdao	14.3	676	0.6	2979.2
	Guangzhou	13.2	1025	1.1	3964.5
	Shenzhen	14.0	1013	0.7	4918.1
	Haikou	12.2	1111	0.1	2130.0
Average		13.1	828	0.9	3169.1
Middle	Taiyuan	11.0	493	0.2	2200.8
	Changchun	14.2	357	0.4	2181.5
	Haerbin	13.0	183	0.4	2152.5
	Hefei	15.6	645	0.6	2281.6
	Nanchang	14.2	643	0.2	2212.0
	Zhengzhou	13.6	1015	0.6	2304.9
	Wuhan	13.6	946	0.9	2467.4
	Changsha	14.1	530	0.6	2755.3
Average		13.7	602	0.5	2319.5
West	Hohhot	18.6	127	0.2	2870.6
	Nanning	13.5	304	0.3	2170.0
	Chengdu	13.6	892	1.2	2484.2
	Chongqing	13.2	389	1.4	1994.5
	Guiyang	14.0	439	0.3	2100.6
	Kunming	11.8	246	0.4	2334.7
	Xi’an	12.8	271	0.7	2451.0
	Lanzhou	11.7	239	0.1	1775.3
	Xi’ning	15.7	271	0.1	1772.7
	Yinchuan	13	184	0.1	1946.5
	Urumqi	13	165	0.1	1969.2
Average		13.7	321	0.5	2169.9

Source: Chinese Statistical Yearbook