

When Cointegration Misleads: Regional Evidence on the Determinants of Housing Prices in China

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Abstract

Using data from 29 regional housing markets in China, this study examines the long-run relationships between housing prices and key macroeconomic variables. Conventional cointegration methods can be misleading, as estimated coefficients often contradict standard demand–supply theory even when statistical tests indicate cointegration. Among the variables, only real income consistently explains regional housing price dynamics, whereas real interest rates and building costs fail to do so consistently across markets. Region-specific models reveal substantial heterogeneity and are both statistically robust and economically meaningful. Panel cointegration tests that account for cross-sectional dependence fail to detect cointegration when such heterogeneity is ignored. These findings highlight the limitations of uniform national approaches and underscore the need for tailored, region-specific housing policies.

Keywords: Housing Market; Cointegration; Dynamic Ordinary Least Squares; Panel Cointegration Test with CSD; Disaggregated Regional Data

JEL Classification: R30; E00; C51

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Compliance with Ethical Standards

The authors certify that this research was conducted in accordance with all applicable institutional and national ethical guidelines. The study did not involve human participants, personal data, or animal experimentation. As such, no institutional review board (IRB) or equivalent ethical approval was required. The authors affirm adherence to accepted norms of responsible research and publication practice.

Conflict of Interest

The authors declare that they have no conflicts of interest—financial or non-financial—related to the content of this manuscript.

Data Availability Statement

The data used in this study consist of publicly available and anonymized sources. All datasets can be obtained from the referenced providers or are available upon reasonable request from the authors. No proprietary or confidential data were used.

1 Introduction

The dynamics of housing prices in China have received considerable academic attention, reflecting the sector’s pivotal role in driving the country’s economic expansion. Over the past few decades, China’s real estate sector has experienced a sustained housing boom, triggering debates on price misalignments and regional supply-demand imbalances.

Building on earlier research, numerous studies have highlighted the distinctive features of China’s housing market, particularly regarding its susceptibility to asset bubbles.¹ For instance, [Fang et al. \(2016\)](#) claim that the observed housing price appreciation is largely supported by robust household income growth, thereby reducing the likelihood of a financial crisis akin to that of the 2008 U.S. subprime mortgage market crisis. In contrast, by estimating supply-demand fundamentals, [Chivakul et al. \(2015\)](#) identify potential mismatches in China’s real estate markets. [Chen and Wen \(2017\)](#) also interpret China’s housing boom as a rational bubble that emerged during the country’s economic transition, highlighting a phenomenon where housing prices have grown substantially faster than disposable income despite high vacancy rates and sustained returns to capital. According to [Jiang et al. \(2022\)](#), rapid increases in housing prices in China may provide short-run benefits by stimulating infrastructure investment. However, [Rogoff and Yang \(2021\)](#) caution that an extended housing boom may expose China to macroeconomic vulnerabilities due to persistent supply-demand imbalances. More recently, [Xu et al. \(2024\)](#) highlight systemic vulnerabilities in the Chinese housing sector, emphasizing the potential for negative information to propagate across regional housing networks.

The literature on housing price determinants extends well beyond the macroeconomic fundamentals considered in most China-focused studies. In a cross-country setting, environmental quality has emerged as a significant factor: using a panel of high and low-polluting cities worldwide, [Das et al. \(2022\)](#) find that pollution levels are systematically associated with housing prices, pointing to environmental capitalization effects that operate alongside conventional demand and supply channels. Separately, a body of work has examined how fiscal policy, monetary policy, and governance quality jointly shape the inflationary environment within which housing markets operate. [Das and Mandal \(2022\)](#) document long-run and short-run linkages between corruption and inflation across a panel of countries, while [Das \(2026\)](#) shows that fiscal, monetary, and governance factors are significant drivers of inflation dynamics. Because inflation, in turn, affects real income and real interest rates, these institutional and governance channels represent an additional layer of housing price determination that has received relatively limited attention in the China-specific literature. While a

¹See [Piazzesi and Schneider \(2016\)](#) for a survey of the literature on housing markets in macroeconomics.

full treatment of pollution and governance factors lies beyond the scope of the present study — which focuses on regional heterogeneity in the income, interest rate, and construction cost channels — we note these as important complementary dimensions documented in the broader empirical literature.

We recognize that understanding the potential mismatch issues highlighted in the existing literature requires a careful assessment of the fundamental drivers of housing prices and the extent to which macroeconomic variables—such as income, interest rates, and construction costs—can fully account for regional housing market dynamics. In particular, we focus on the heterogeneity of housing markets across China’s diverse regions. Nationally aggregated models often obscure substantial regional variation arising from structural, demographic, and institutional differences. This concern is particularly relevant in the Chinese context, where local governments play a critical role in land allocation and the implementation of housing policies (see, among others, [Deng et al. 2012](#)). Moreover, regional disparities in income levels and credit market conditions further contribute to differentiated housing market behaviors that may elude detection in national-level analyses.

Our study addresses this gap by using a panel of annual data from 1994 to 2021 for 29 Chinese regions to examine the long-run relationships between real housing prices and key macroeconomic variables, including real GDP per capita (as a proxy for income), real interest rates, and real construction costs. We employ cointegration tests across alternative model specifications, followed by dynamic ordinary least squares (DOLS) estimation, to assess whether these variables are jointly cointegrated and whether the estimated coefficients align with standard economic theory. We show that relying on cointegration tests alone can produce misleading inferences, highlighting the importance of combining statistical evidence with theoretical expectations.

A key contribution of our analysis is the identification of statistically and economically valid models at the regional level, revealing substantial heterogeneity across markets. Unlike previous studies that impose a common specification across regions, our approach allows for structural variation in the underlying cointegrating vectors, offering a more nuanced understanding of regional housing market dynamics. The findings indicate that while income consistently plays a dominant role in explaining housing prices, the effects of real interest rates and construction costs are generally limited and vary considerably across regions. These results are further supported by panel cointegration tests accounting for cross-sectional dependence, which detect cointegration only when such heterogeneity is excluded from the specification.

The remainder of the paper is organized as follows. Section 2 provides historical background on China’s national real estate policies. Section 3 describes the data and presents

the preliminary analysis, followed by the cointegration tests and DOLS estimations for the benchmark model. We also report a set of second-generation panel test results to strengthen our findings. Section 4 identifies the model specifications that best fit each regional housing market. Section 5 concludes.

2 Evolution and Regional Challenges of China’s Housing Market Policies

2.1 Evolution of National Real Estate Policies

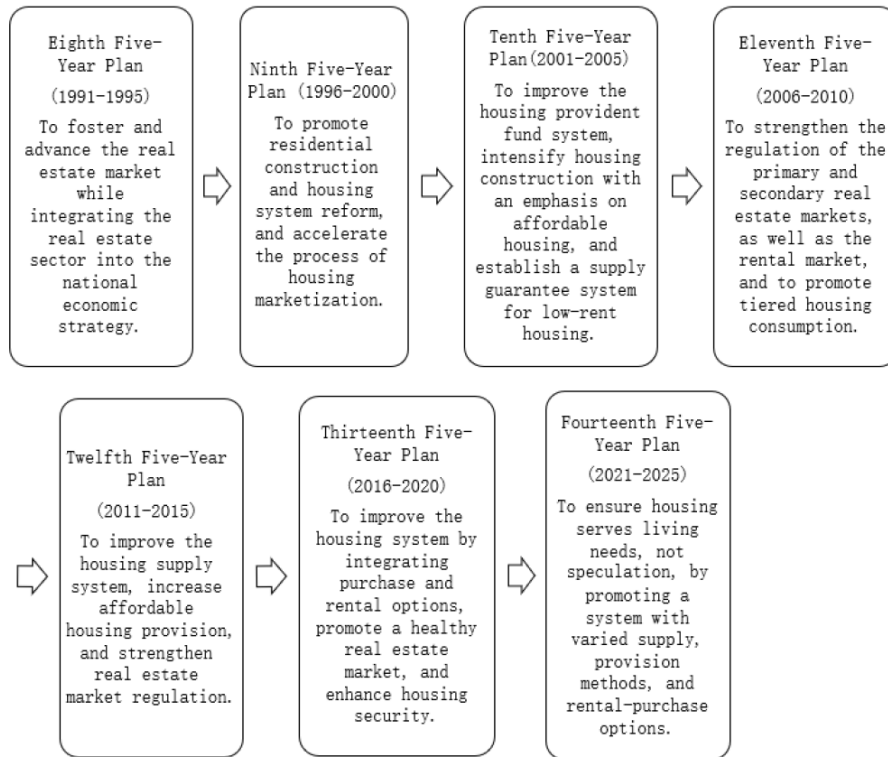
During the period from 1991 to 2025, China’s housing policy evolved from promoting the rapid expansion of real estate markets to establishing a more mature, balanced, and properly regulated market structure. In the early stage (1991–2005), corresponding to the 8th Five-Year Plan (see Figure 1), the real estate sector was designated as a key driver of national economic growth. Policy initiatives during this period promoted the commercialization of housing through market-oriented reforms, restructured the housing distribution system, and expanded residential construction, thereby integrating the property sector into the broader national development strategy. These efforts were subsequently reinforced and further developed through the implementation of successive Five-Year Plans.

From the mid-2000s through the early 2010s, policy priorities progressively shifted toward the strengthening of housing finance mechanisms, the expansion of access to affordable housing, and the enhancement of regulatory oversight across both primary and secondary markets, with the objective of fostering more stable and orderly market growth. Since 2011, policy orientation has increasingly focused on optimizing the housing supply structure, reinforcing market regulation, and expanding the provision of guaranteed housing.

The most recent phase (2016–2025) has been characterized by the institutionalization of a dual-track housing system integrating ownership and rental markets under the guiding principle that “housing is for living, not for speculation.” During this period, policymakers have sought to diversify housing supply channels, expand multi-tiered guarantee systems, and promote the sustainable and balanced development of the real estate sector.

¹Authors’ compilation based on China’s Five-Year Plans (1991–2021), issued by the National People’s Congress of the People’s Republic of China:

Figure 1: Evolution of China's Housing Market Policies



Source: Authors' compilation based on China's Five-Year Plans (1991-2021), issued by the National People's Congress of the People's Republic of China

2.2 Economic Impacts of Housing Market Policy Development

The evolution of housing policy has been closely aligned with the national Five-Year Plans. During the 8th through 11th Plans, the government actively promoted housing commercialization, expanded market-based construction, and encouraged private ownership. These initiatives stimulated rapid sectoral expansion and spurred the growth of related industries. Scholarly discussions during this period largely debated whether surging housing prices reflected market fundamentals or speculative dynamics. While some researchers emphasized demand-side drivers—such as urbanization, income growth, and demographic change (Wang et al. 2012, Deng and Chen 2019a, Gong and Yao 2022)—others pointed to speculative pressures indicated by vacancy rates, price-to-income ratios, and rental yields (Wu and Li 2007).

Since the 12th Plan, policy focus has shifted toward long-term market stability and sustainability. The 13th and 14th Plans have further strengthened institutional regulation and expanded the integration of ownership and rental systems, signaling the government’s intent to promote a more balanced and equitable housing framework. Recent research has reflected this policy transition by investigating the determinants of housing prices from both demand and supply perspectives (Chow and Niu 2015; Wu et al. 2016; Deng and Chen 2019b), which closely aligns with the objectives of our research.

2.3 Regional Heterogeneity and Policy Effectiveness

Despite the comprehensive scope of national housing policies, their effectiveness has varied significantly across regions. The heterogeneity of China’s housing markets—arising from differences in economic structures, population dynamics, and institutional capacities—poses major challenges to the uniform implementation of national plans.

Regional economic disparities lead to uneven policy impacts. For example, measures that effectively promote home-ownership or affordability in coastal cities may fail to achieve similar results in inland or less-developed regions. Housing market diversity also constrains policy effectiveness, as national supply-side expansions can worsen oversupply in declining areas while failing to ease shortages in rapidly growing cities. Urban–rural contrasts further complicate implementation. Urban areas overall tend to struggle with affordability and congestion, whereas rural regions tend to face depopulation and underutilized housing stock. Also, infrastructure and land constraints, variations in cultural and social preferences, and limited local policy flexibility have contributed to the uneven transmission of national policy objectives. These factors highlight the need for greater decentralization and adaptability in housing governance.

Taken together, while China’s real estate policy framework has become increasingly sophisticated and regulation-oriented, regional heterogeneity remains a major obstacle to its uniform effectiveness. Developing region-specific policy mechanisms that account for local market conditions, demographic trends, and institutional capacities will be essential to promoting the sustainable and equitable development of China’s housing markets. To this end, identifying the region-specific determinants of housing prices constitutes a crucial step toward formulating well-tailored policy designs.

3 China’s Institutional Framework

China’s housing market operates within a distinctive institutional framework that differs markedly from those prevalent in many market-oriented economies. Although monetary policy is implemented at the national level, housing finance conditions are simultaneously shaped by administrative lending policies, mortgage regulations, and mechanisms governing the allocation of bank credit. Regional disparities in effective financing conditions stem from variations in down payment requirements, lending standards, and the availability of mortgage credit, despite relatively uniform benchmark interest rates. On the supply side, urban land is primarily allocated through government-controlled land auctions, with local governments relying heavily on land transfer revenues, thereby creating a strong link between fiscal incentives and land supply decisions. Furthermore, the financing environment for property developers is influenced by their access to bank credit, bond markets, and regulatory frameworks, all of which affect housing investment and the introduction of new housing stock. Considerable regional differences in land availability, urban planning restrictions, and development intensity indicate that housing supply elasticities are unlikely to be consistent across regions. The effects of financing conditions and construction costs might be analyzed within the context of these institutional arrangements. The variables employed in this study are intended to capture broad macroeconomic and regional factors rather than to encompass the full complexity of local housing market dynamics.

4 The Empirics

4.1 Data Descriptions and Preliminary Analysis

We collected data on housing prices and key macroeconomic variables that are related to the housing market for China and its 29 regions. These variables include gross domestic product (GDP), construction costs of completed buildings, population, the consumer price

index (CPI), and real interest rates. Observations are annual frequency, spanning from 1994 to 2021.² We obtained the data from the World Bank and National/Provincial Statistical Yearbooks of China.

Housing prices and construction costs are expressed in Chinese yuan per square meter. Income variables are also expressed in Chinese yuan. The CPI, originally reported as year-over-year percent changes, was adjusted to a common base year and converted into an index. All nominal variables, including housing prices, GDP, construction/building cost, and lending interest rates, were transformed into corresponding real variables using the regional CPI. Real GDP was further adjusted into per capita terms utilizing regional population data.

To analyze regional real housing price ($hp_{i,t}$) dynamics, we focus on three key housing market variables: regional real GDP per capita ($ry_{i,t}$) and the real interest rate (rr_t) as demand shifters, and real building cost (bc_t) as a supply shifter. Note that housing prices ($hp_{i,t}$) whereas the real interest rate (rr_t) and real building cost (bc_t) are national variables. All quantity variables, housing prices, real GDP, and real building cost, were log transformed for consistency to capture percent changes. Figure 2 presents the graphs of housing prices $hp_{i,t}$ and real GDP per capita $ry_{i,t}$ for 29 regions, along with their respective national averages, hp_t and ry_t . Both $hp_{i,t}$ and $ry_{i,t}$ exhibit upward trends over time, suggesting the presence of stochastic trends. Moreover, the two variables tend to move together, with temporary short-run deviations, indicating potential cointegrating relationships.

To statistically test this possibility, we implemented the DF-GLS unit root test proposed by Elliott et al. 1996 with an intercept, which is asymptotically more powerful than the conventional augmented Dickey-Fuller test. The results, presented in Table 1, indicate that the null hypothesis of nonstationarity cannot be rejected at the 5% significance level for all 29 regional housing price series and for 27 of the regional real GDP per capita series. We also find strong evidence of nonstationarity in all national-level variables, including the real interest rate and real building cost. Given this strong evidence supporting the presence of integrated $I(1)$ processes, we proceed by modeling housing price dynamics within a cointegration framework³.

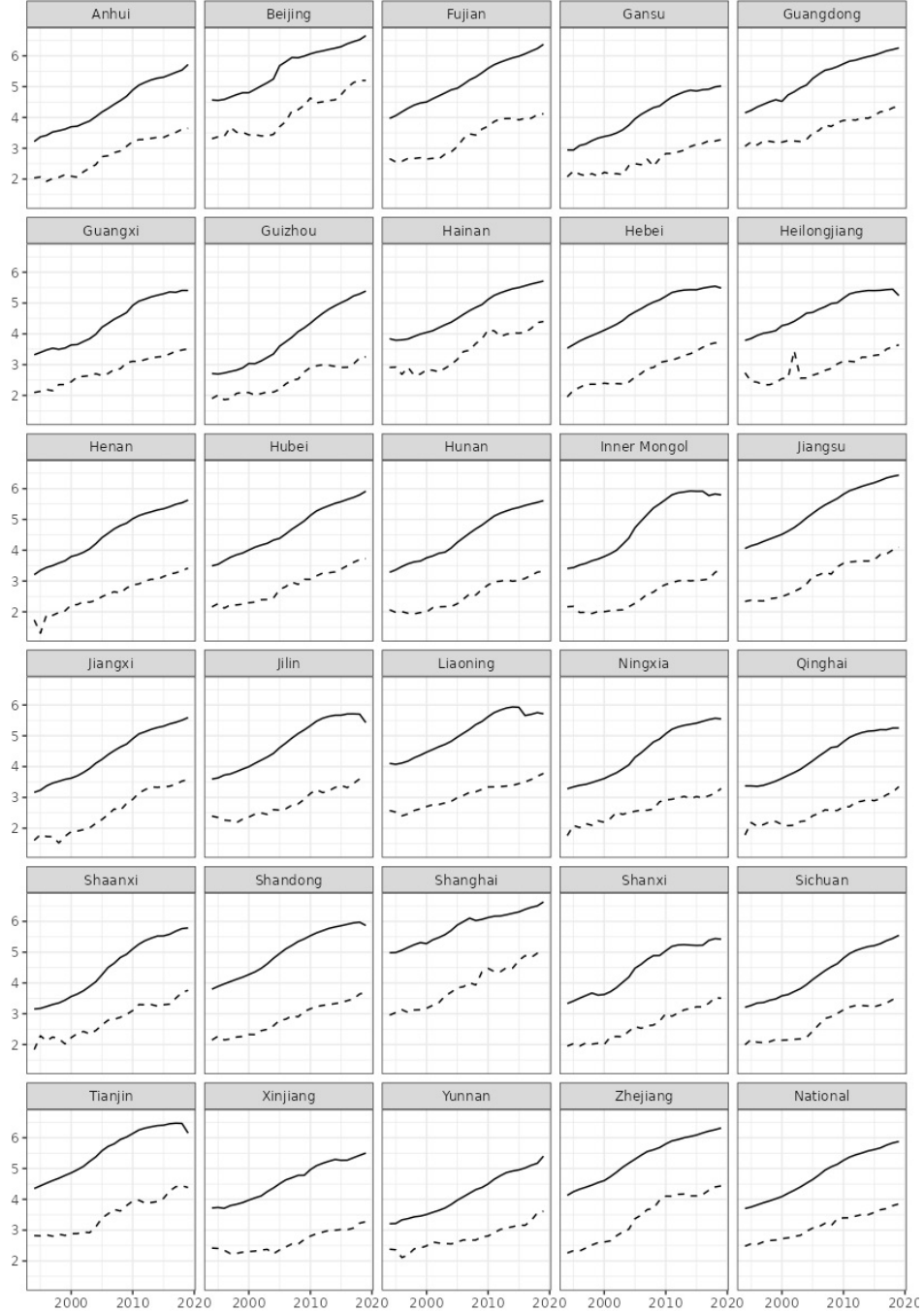
4.2 Cointegration Analysis

Let $\mathbf{y}_{i,t}$ denote a $k \times 1$ vector of endogenous variables of region i which obey an integrated $I(1)$ process. In the presence of a cointegrating relationship among the variables in $\mathbf{y}_{i,t}$, we

²In addition to GDP, we also collected alternative income measures, including urban disposable income per capita and rural per capita net income. Our main findings are based on real GDP, as the empirical results are overall similar when using these alternative income variables. The alternative results will be provided upon request.

³All materials required for the replication of our results will be made available upon request.

Figure 2: Regional Housing Prices and Per Capita Real GDP



Note: The solid lines are regional housing prices $hp_{i,t}$, while the dashed lines are real GDP per capita $ry_{i,t}$. The last panel displays the national averages of these variables across 29 regions, hp_t and ry_t . All data are log transformed.

Table 1: DF-GLS Test Results

Region	$hp_{i,t}$		$ry_{i,t}$	
	DFGLS	p-value	DFGLS	p-value
Anhui	-0.023	0.499	0.003	0.804
Beijing	-0.025	0.670	-0.011	0.725
Fujian	-0.021	0.545	0.007	0.501
Gansu	0.035	0.639	-0.007	0.630
Guangdong	-0.001	0.980	-0.005	0.813
Guangxi	0.002	0.957	-0.013	0.500
Guizhou	-0.018	0.693	-0.017	0.240
Hainan	-0.026	0.658	-0.012	0.266
Hebei	0.000	0.998	-0.013	0.225
Heilongjiang	-0.090	0.592	-0.034	0.195
Henan	0.035	0.259	-0.002	0.865
Hubei	-0.017	0.664	0.003	0.800
Hunan	-0.011	0.776	-0.006	0.586
Inner Mongolia	-0.021	0.519	-0.025	0.085
Jiangsu	-0.005	0.887	-0.010	0.106
Jiangxi	-0.006	0.883	0.001	0.956
Jilin	-0.001	0.988	-0.045 [†]	0.019
Liaoning	-0.019	0.566	-0.027	0.335
Ningxia	0.034	0.517	-0.021*	0.091
Qinghai	0.050	0.359	-0.024*	0.073
Shaanxi	0.019	0.725	-0.016	0.181
Shandong	-0.006	0.859	-0.021 [†]	0.041
Shanghai	0.022	0.667	0.003	0.932
Shanxi	0.013	0.815	-0.014	0.563
Sichuan	-0.015	0.571	-0.005	0.643
Tianjin	-0.021	0.639	-0.042*	0.052
Xinjiang	-0.001	0.988	-0.013	0.539
Yunnan	-0.004	0.957	0.016	0.349
Zhejiang	-0.017	0.548	-0.005	0.585
National Variables	DFGLS	p-value		
hp_t	0.008	0.839		
ry_t	-0.008	0.314		
bc_t	-0.901	0.264		
rr_t	-0.217	0.217		

Note: ‘DFGLS’ indicates the DF-GLS statistics proposed by [Elliott et al. \(1996\)](#). ‘p-value’ denotes the p values of the test with the null hypothesis of nonstationarity. * and † denote a rejection of the null hypothesis at the 10% and 5% levels, respectively.

may consider the following vector error correction model.

$$\Delta \mathbf{y}_{i,t} = \mathbf{a}_i + \alpha_i \beta' \mathbf{y}_{i,t-1} + \sum_{j=1}^p \mathbf{B}_j \Delta \mathbf{y}_{i,t-j} + \mathbf{u}_{i,t}, \quad (1)$$

where α_i is a $k \times 1$ vector of convergence rates, β is a $k \times 1$ cointegrating vector (and is therefore common across regions), $\beta' \mathbf{y}_{i,t-1}$ denotes the error correction term. $\mathbf{B}_j$ is a $k \times k$ coefficient matrix. $\mathbf{a}$ is a $k \times 1$ vector of constants and $\mathbf{u}_t$ is a $k \times 1$ vector of error terms.

For our housing market analysis, consider $\mathbf{y}_{i,t} = [\mathbf{z}_{i,t}' \ hp_{i,t}]'$, where $hp_{i,t}$ denotes the log of housing price in region i at time t , while $\mathbf{z}_{i,t}$ is a 3×1 vector of key macroeconomic variables. Specifically, $\mathbf{z}_{i,t}$ includes the log of real per capita income ($ry_{i,t}$), the real interest rate (rr_t), and the log of the real building cost index (bc_t), where rr_t and bc_t are common factors across all regions.

We first employ the Johansen cointegration testing procedure (Johansen (1991)), specifically the Johansen maximum eigenvalue test and the trace test. These are data-driven, sequential testing methods that allow for the possibility of multiple cointegrating relationship, which can make economic interpretation challenging. In what follows, we address this issue by applying an economic approach to interpret the estimated cointegrating relationship. We also supplement the testing procedure with the Engle-Granger test (Engle and Granger (1987)), which is based on a single equation specification for housing price.

Table 2 presents the cointegration test results with $\mathbf{y}_{i,t} = [ry_{i,t} \ rr_t \ bc_t \ hp_{i,t}]'$. The maximum eigenvalue test supports at least one cointegrating relationship for 28 out of 29 regions, except Heilongjiang, at the 10% significance level, while the trace test provides evidence of cointegration for all 29 regions. The Engle-Granger test, on the other hand, rejects the null of no cointegration for 21 out of 29 regions, possibly due to its weaker power relative to the Johansen procedure, which is based on a vector error correction model rather than a single equation framework. Overall, all tests indicate strong evidence of cointegrating relationships with the national average series. Taken together, the results provide robust evidence of a long-run relationship between $hp_{i,t}$ and $\mathbf{z}_{i,t}$, its demand and supply shifter variables.

In the next section, we critically examine the statistical evidence presented above that supports the conventional economic model based on demand and supply shifter variables by directly estimating the cointegration coefficients, highlighting the heterogeneity across the 29 regional housing markets in China.

Table 2: Cointegration Test Results

$$\mathbf{y}_{i,t} = [ry_{i,t} \ rr_t \ bc_t \ hp_{i,t}]'$$

Region	J_{MaxEig}	H_A	J_{Trace}	H_A	EG
Anhui	14.38*	$r > 2$	18.23*	$r > 2$	-2.572 [†]
Beijing	8.89*	$r > 3$	8.89*	$r > 3$	-1.924*
Fujian	31.2 [†]	$r > 0$	33.73*	$r > 1$	-1.739*
Gansu	8.93*	$r > 3$	8.93*	$r > 3$	-1.835*
Guangdong	8.46*	$r > 3$	8.46*	$r > 3$	-1.738*
Guangxi	37.37 [‡]	$r > 0$	68.07 [‡]	$r > 0$	-2.240 [†]
Guizhou	26.28 [†]	$r > 1$	39.48 [†]	$r > 1$	-2.884 [‡]
Hainan	30.94 [†]	$r > 0$	62.90 [‡]	$r > 0$	-2.622 [†]
Hebei	14.97*	$r > 2$	21.54 [†]	$r > 2$	-1.549
Heilongjiang	23.06	$r > 0$	52.75*	$r > 0$	-2.372 [†]
Henan	36.23 [‡]	$r > 0$	63.61 [‡]	$r > 0$	-3.287 [‡]
Hubei	23.81 [†]	$r > 1$	40.80 [†]	$r > 1$	-2.509 [†]
Hunan	23.33 [†]	$r > 1$	40.12 [†]	$r > 1$	-2.720 [†]
Inner Mongolia	7.92*	$r > 3$	7.92*	$r > 3$	-0.259
Jiangsu	25.28 [†]	$r > 1$	19.10*	$r > 2$	-3.071 [‡]
Jiangxi	20.38*	$r > 1$	35.05 [†]	$r > 1$	-3.524 [‡]
Jilin	8.53*	$r > 3$	8.53*	$r > 3$	-0.378
Liaoning	29.97 [‡]	$r > 1$	42.43 [‡]	$r > 1$	-0.267
Ningxia	29.48 [†]	$r > 0$	56.97 [†]	$r > 0$	-1.752*
Qinghai	14.12*	$r > 2$	18.81*	$r > 2$	-1.053
Shaanxi	26.79*	$r > 0$	52.34*	$r > 0$	-2.632 [†]
Shandong	17.30 [†]	$r > 2$	22.31 [†]	$r > 2$	-0.466
Shanghai	13.78*	$r > 2$	19.33*	$r > 2$	-2.833 [‡]
Shanxi	26.18*	$r > 0$	32.21*	$r > 1$	-1.294
Sichuan	7.74*	$r > 3$	7.74*	$r > 3$	-2.579 [†]
Tianjin	35.94 [‡]	$r > 0$	18.45*	$r > 2$	-0.923
Xinjiang	14.25*	$r > 2$	19.97 [†]	$r > 2$	-2.162 [†]
Yunnan	46.66 [‡]	$r > 0$	32.84*	$r > 1$	-2.213 [†]
Zhejiang	28.14 [‡]	$r > 1$	43.52 [‡]	$r > 1$	-1.995*
National	22.15 [†]	$r > 1$	39.72 [†]	$r > 1$	-2.245 [†]

Note: J_{MaxEig} and J_{Trace} denote the Johansen maximum eigenvalue statistics and the Johansen trace statistics, respectively. H_A denotes the **last** alternative hypothesis considered when its associated null hypothesis is rejected in the sequential testing procedure. For example, statistically significant test results with $H_A : r > 0$ indicate the presence of one cointegrating relationship, whereas statistically insignificant results with $H_A : r > 0$ suggest no cointegrating relationship. EG denotes the Engle-Granger Test statistics, which tests the null of no cointegration against the alternative hypothesis of a single cointegration vector. *, [†], and [‡] indicates a rejection of the null hypothesis at the 10%, 5%, and 1% significance level, respectively.

4.3 Dynamic Ordinary Least Squares Estimation

Given the strong evidence for cointegration, we employ the dynamic ordinary least squares (DOLS) regression proposed by [Stock and Watson \(1993\)](#) to estimate the cointegration relationship between $hp_{i,t}$ and $\mathbf{z}_{i,t}$. Abstracting from deterministic terms, consider the following regression equation:

$$hp_{i,t} = \beta' \mathbf{z}_{i,t} + \sum_{j=-p}^q \gamma_j \Delta \mathbf{z}_{i,t+j} + \varepsilon_{i,t}, \quad (2)$$

where β denotes the cointegration vector. Note that both past ($-p$) and future (q) values of $\Delta \mathbf{z}_{i,t}$ appear in this regression equation to ensure the strict exogeneity of $\mathbf{z}_t$, as shown by [Stock and Watson \(1993\)](#).⁴

Table 3 presents the DOLS estimation results with $\mathbf{y}_{i,t} = [ry_{i,t} \ rr_t \ bc_t \ hp_{i,t}]'$ including an intercept and a time trend. Despite the strong statistical evidence of cointegration shown in the previous section, a surprising number of DOLS estimates, particularly those for rr_t and bc_t , are inconsistent with the prediction of the conventional economic model.

According to standard theory, stronger demand driven by higher real income should raise housing prices, while an increase in the real interest rate should shift the demand curve leftward, leading to lower housing prices. Similarly, higher building cost should shift the supply curve leftward, pushing the equilibrium price upward. Thus, the expected signs of the coefficients are positive for $ry_{i,t}$ and bc_t , and negative for rr_t .

Notably, the coefficient of $ry_{i,t}$ is statistically significantly positive at the 1% level for 28 out of 29 regions. The exception is Heilongjiang, where the coefficient is significant at the 5% level but has the wrong sign. Recall that Heilongjiang was the only case in which the Johansen maximum eigenvalue test failed to confirm cointegration. These findings, therefore, provide solid evidence of an income effect, supporting the existence of a long-run relationship between $hp_{i,t}$ and $ry_{i,t}$ in most regional housing markets.

Regarding the housing market effect of the real interest rate, the other demand shifter, its coefficient estimates are significantly negative at the 5% level for 16 out of 29 regions. In contrast, 10 regions show coefficients with the wrong (positive) sign, while 3 regions have correctly signed but statistically insignificant estimates. Thus, we find only limited evidence supporting the effect of rr_t .

As for the real building cost bc_t , its coefficient estimates are largely inconsistent with standard theory across many regions as well as at the national level. It is significantly positive at the 10% level in only 13 out of 29 regions, with 2 additional regions showing

⁴The Bartlett kernel was used to estimate the long-run variance, with automatic bandwidth selection following [Andrews \(1991\)](#). The number of leads (q) and lags (p) was selected via the Akaike Information Criteria ([Akaike \(1974\)](#)).

the correct sign but statistically insignificant estimates. The remaining 14 regions and the national level data show significantly negative coefficients, with 11 of them including the national estimate being significant at the 1% level.

Taken all together, the DOLS estimation results provide solid evidence of an income effect but suggest a much weaker and inconsistent relationship between $hp_{i,t}$ and the other two variables, $rr_{i,t}$ and bc_t . In the next section, we examine a range of alternative models to identify the reasonable ones for each region, guided by both statistical and economic inferences.

5 Exploring Alternative Models for Regional Markets

5.1 Alternative Model Specifications

In addition to the benchmark (BM) model in the previous section with $\mathbf{y}_t = [ry_{i,t} \ rr_t \ bc_t \ hp_{i,t}]'$, we consider the following 5 alternative models.

- Model M1: $\mathbf{y}_{i,t} = [ry_{i,t} \ rr_t \ hp_{i,t}]'$
- Model M2: $\mathbf{y}_{i,t} = [ry_{i,t} \ bc_t \ hp_{i,t}]'$
- Model M3: $\mathbf{y}_{i,t} = [ry_{i,t} \ hp_{i,t}]'$
- Model M4: $\mathbf{y}_{i,t} = [rr_t \ hp_{i,t}]'$
- Model M5: $\mathbf{y}_{i,t} = [bc_t \ hp_{i,t}]'$

Table 4 presents a summary of the Johansen cointegration test results and the DOLS estimation outcomes. For detailed results, see Tables A1 through A8 in the Appendix.

The cointegration tests, based on J_{MaxEig} and J_{Trace} statistics, indicate strong evidence of cointegration for most models at the 10% significance level. Notably, the inclusion of the real interest rate, rr_t , seems to strengthen the cointegration relationship, showing over 98% of the tests exhibit cointegration even in the bivariate VECM specification $\mathbf{y}_{i,t} = [rr_t \ hp_{i,t}]'$ (Model M4).

However, interpreting the cointegration test results requires caution, particularly when evaluating the conformity of DOLS coefficients with economic theory. In Model M4, for instance, although DOLS estimates for rr_t were correctly signed across all regions, none were statistically significant, even at the 10% level. In contrast, the role of regional income, $ry_{i,t}$, appears robust. Whenever included in the model (Models BM, M1, M2, and M3), its DOLS coefficient estimates were consistently correctly signed and statistically significant across

Table 3: DOLS Cointegrating Regression Results

$$\mathbf{y}_{i,t} = [ry_{i,t} \ rr_t \ bc_t \ hp_{i,t}]'$$

Region	$ry_{i,t}$	$s.e.$	rr_t	$s.e.$	bc_t	$s.e.$
Anhui	0.747 [‡]	0.003	0.045 [‡]	0.005	-2.419 [‡]	0.137
Beijing	0.748 [‡]	0.007	0.000	0.002	-3.465 [‡]	0.231
Fujian	0.873 [‡]	0.016	0.011	0.015	-1.149	1.116
Gansu	0.403 [‡]	0.013	-0.029 [‡]	0.009	-3.345 [‡]	0.746
Guangdong	0.463 [‡]	0.070	-0.011	0.023	-2.791 [‡]	0.777
Guangxi	0.485 [‡]	0.021	-0.052 [‡]	0.016	0.324	0.529
Guizhou	0.578 [‡]	0.004	0.054 [‡]	0.005	4.366 [‡]	0.485
Hainan	0.402 [†]	0.151	-0.528 [‡]	0.108	13.016 [‡]	2.399
Hebei	0.335 [‡]	0.024	-0.053 [‡]	0.007	-0.168	0.314
Heilongjiang	-0.568 [†]	0.231	-0.492 [‡]	0.093	66.685 [‡]	9.497
Henan	0.292 [‡]	0.044	-0.079 [‡]	0.014	-4.406 [‡]	0.799
Hubei	0.659 [‡]	0.020	-0.011	0.008	-1.743 [‡]	0.455
Hunan	0.516 [‡]	0.011	-0.092 [‡]	0.008	-0.244	0.292
Inner Mongolia	0.417 [‡]	0.004	-0.020 [‡]	0.002	0.711 [‡]	0.063
Jiangsu	0.681 [‡]	0.015	-0.022 [‡]	0.006	0.159	0.227
Jiangxi	0.769 [‡]	0.022	-0.102 [‡]	0.017	0.942 [*]	0.502
Jilin	0.642 [‡]	0.063	-0.017	0.023	4.570 [‡]	0.942
Liaoning	0.287 [‡]	0.034	-0.040 [‡]	0.007	-0.690 [‡]	0.177
Ningxia	0.331 [‡]	0.010	-0.089 [‡]	0.005	0.681 [‡]	0.169
Qinghai	0.627 [‡]	0.000	0.081 [‡]	0.000	-1.231 [‡]	0.004
Shaanxi	0.154 [†]	0.065	-0.166 [‡]	0.023	-9.429 [‡]	2.422
Shandong	0.540 [‡]	0.009	-0.057 [‡]	0.003	9.659 [‡]	0.346
Shanghai	1.824 [‡]	0.017	0.103 [‡]	0.003	2.349 [‡]	0.412
Shanxi	0.749 [‡]	0.015	0.042 [‡]	0.007	-1.672 [‡]	0.270
Sichuan	0.689 [‡]	0.004	-0.073 [‡]	0.004	2.716 [‡]	0.087
Tianjin	0.686 [‡]	0.038	0.002	0.014	2.208 [‡]	0.634
Xinjiang	0.632 [‡]	0.005	-0.107 [‡]	0.010	14.900 [‡]	0.838
Yunnan	0.459 [‡]	0.004	0.053 [‡]	0.004	-2.017 [‡]	0.233
Zhejiang	1.157 [‡]	0.027	0.011	0.008	3.112 [‡]	0.326
National	0.508 [‡]	0.023	-0.013	0.008	-2.020 [‡]	0.283

Note: We report the dynamic ordinary least squares (DOLS) coefficients along with the associated standard errors (s.e.). The long-run variance was estimated employing the Newey-West estimator (Newey and West (1987)). *, †, and ‡ indicate a rejection of the null hypothesis at the 10%, 5%, and 1% significance level, respectively.

Table 4: Statistical and Economic Assessment of Competing Models

$\mathbf{y}_{i,t}$	J_{test} 5%	J_{test} 10%	Variables	Correct (%)	C&Sig (%)
BM: $[ry_{i,t} \ rr_t \ bc_t \ hp_{i,t}]'$	48.3	98.3	$ry_{i,t}$	96.7	96.7
			rr_t	66.7	53.3
			bc_t	50.0	43.3
M1: $[ry_{i,t} \ rr_t \ hp_{i,t}]'$	55.0	98.3	$ry_{i,t}$	100.0	100.0
			rr_t	60.0	30.0
M2: $[ry_{i,t} \ bc_t \ hp_{i,t}]'$	33.3	70.0	$ry_{i,t}$	100.0	100.0
			bc_t	70.0	50.0
M3: $[ry_{i,t} \ hp_{i,t}]'$	40.0	56.6	$ry_{i,t}$	100.0	100.0
M4: $[rr_t \ hp_{i,t}]'$	90.0	98.3	rr_t	100.0	0.0
M5: $[bc_t \ hp_{i,t}]'$	31.6	81.6	bc_t	0.0	0.0

Note: J_{test} p% denotes the rejection rate (in percent) of the null hypothesis of no cointegration at the p% significance level, based on J_{MaxEig} and J_{Trace} statistics. ‘Correct (%)’ refers to the percentage of cases in which the sign of the coefficient matches theoretical expectations, while ‘C&Sig (%)’ denotes the percentage of cases with a correct sign that is also statistically significant at the 10% level.

nearly all regions. The supply-side variable, real building cost, bc_t , contributes meaningful information only in a limited number of regions, and primarily when included in conjunction with other variables.

Table 5 provides the identified models based on these DOLS estimation results. In the selection procedure, we put the highest priority to models that yield theoretically correct and statistically significant coefficients. Models with correct signs but statistically insignificant estimates were given secondary priority. The greatest penalty was applied to cases in which coefficients were statistically significant but exhibited incorrect signs.

As emphasized earlier, real per capita income $ry_{i,t}$ consistently appears in all selected models, not only for all 29 regions but also at the national level. The income elasticity of housing prices, $\eta_{hp,ry}$, ranges from 0.331 for Ningxia to 1.414 for Shanghai. Notably, $\eta_{hp,ry}$ tends to be larger in urban regions such as Beijing (0.896), Fujian (0.834 or 0.914), Jiangxi (0.769), Shanghai (1.412), and Zhejiang (1.081).

In contrast, the real interest rate rr_t is included in fewer than 50% of the estimated models, and only 37% of the cases yield statistically significant coefficients at the 10% level. This suggests that real interest rates are not a key demand shifter in many regional housing

markets in China. It is somewhat surprising that rr_t does not play an important role in large and rich urban areas such as Beijing, Guangdong, and Shanghai, indicating that liquidity constraints may not be binding in these regions.

The real building cost bc_t appears in 57% of the models, but only 43% cases show statistically significant coefficients. Once again, we find little evidence of a significant elasticity with respect to real building cost in major urban centers such as Beijing, Guangdong, and Shanghai.

Model BM, the most comprehensive specification, was selected for 10 regions: Guangxi, Hainan, Inner Mongolia, Jiangsu, Jiangxi, Jilin, Ningxia, Shandong, Sichuan, and Xinjiang. Notably, with the exceptions of Jiangsu and Shandong, these regions tend to have lower housing prices, lower levels of industrialization, and economies more reliant on agriculture or natural resources. In other words, their housing markets appear to be more closely aligned with fundamental supply and demand conditions, thereby exhibiting a lower likelihood of speculative bubbles.

Meanwhile, Model M3, the simplest specification incorporating only real income, was selected for 9 regions, including highly urbanized and affluent areas such as Beijing, Guangdong, and Shanghai. The remaining 6 regions in this group are mostly less urbanized, suggesting that rapid real estate booms have occurred not only in major metropolitan centers but also across a broader spectrum of regions in China. This pattern implies that rising housing prices in these areas may have emerged independently of changes in borrowing costs. The remaining 10 regions are best described by models that include real income along with either the real interest rate or real building cost, indicating more nuanced housing market dynamics influenced by both demand- and cost-side factors.

These findings underscore the importance of designing housing policies that account for the idiosyncratic determinants specific to each region. They also highlight the need for further research into the potentially asymmetric dynamics of housing prices in more prosperous areas. In the next section, we present additional evidence of heterogeneous dynamics across regional housing markets.

5.2 Regional Comparison of Impulse–Response Functions

This section presents the regional housing price responses to housing market shocks based on unrestricted structural VAR (SVAR) models. While the impulse–response functions could be estimated directly from the vector error correction (VEC) models discussed in the previous sections, we instead employ an SVAR model without imposing cointegration restrictions. This approach allows us to better capture and understand the regional housing price dy-

Table 5: Identified Models via Statistical and Economic Assessment

Region	Model #	$ry_{i,t}$	s.e.	rr_t	s.e.	bc_t	s.e.
Anhui	M3	0.758 [‡]	0.012				
Beijing	M3	0.896 [‡]	0.079				
Fujian	M1	0.834 [‡]	0.033	-0.032*	0.016		
	M2	0.914 [‡]	0.033			1.686 [†]	0.645
Gansu	M3	0.580 [‡]	0.034				
Guangdong	M3	0.543 [‡]	0.019				
Guangxi	BM	0.485 [‡]	0.021	-0.052 [‡]	0.016	0.324	0.529
Guizhou	M2	0.525 [‡]	0.021			2.120 [‡]	0.437
Hainan	BM	0.402 [†]	0.151	-0.528 [‡]	0.108	13.016 [‡]	2.399
Hebei	M2	0.601 [‡]	0.022			1.959 [‡]	0.394
Heilongjiang	M3	0.564 [‡]	0.086				
Henan	M3	0.632 [‡]	0.022				
Hubei	M1	0.682 [‡]	0.024	-0.013	0.010		
	M2	0.706 [‡]	0.025			0.635	0.523
Hunan	M1	0.593 [‡]	0.017	-0.016*	0.009		
	M2	0.656 [‡]	0.013			1.621 [‡]	0.249
Inner Mongolia	BM	0.417 [‡]	0.004	-0.020 [‡]	0.002	0.711 [‡]	0.063
Jiangsu	BM	0.681 [‡]	0.015	-0.022 [‡]	0.006	0.159	0.227
Jiangxi	BM	0.769 [‡]	0.022	-0.102 [‡]	0.017	0.942*	0.502
Jilin	BM	0.642 [‡]	0.063	-0.017	0.023	4.570 [‡]	0.942
Liaoning	M1	0.584 [‡]	0.024	-0.001	0.007		
Ningxia	BM	0.331 [‡]	0.010	-0.089 [‡]	0.005	0.681 [‡]	0.169
Qinghai	M2	0.439 [‡]	0.025			0.434	0.422
Shaanxi	M1	0.527 [‡]	0.021	-0.020 [†]	0.009		
	M2	0.559 [‡]	0.022			1.368 [‡]	0.475
Shandong	BM	0.540 [‡]	0.009	-0.057 [‡]	0.003	9.659 [‡]	0.346
Shanghai	M3	1.412 [‡]	0.047				
Shanxi	M3	0.655 [‡]	0.027				
Sichuan	BM	0.689 [‡]	0.004	-0.073 [‡]	0.004	2.716 [‡]	0.087
Tianjin	M1	0.589 [‡]	0.048	-0.032*	0.017		
	M2	0.685 [‡]	0.022			2.058 [‡]	0.409
Xinjiang	BM	0.632 [‡]	0.005	-0.107 [‡]	0.010	14.900 [‡]	0.838
Yunnan	M3	0.529 [‡]	0.035				
Zhejiang	M2	1.081 [‡]	0.015			2.506 [‡]	0.248
National	M2	0.585 [‡]	0.015			0.063	0.178

Note: We report the identified models based on dynamic ordinary least squares (DOLS) estimations for 5 alternative models in addition to the benchmark model. The highest priority was assigned to models that yield statistically significant coefficients with theoretically correct signs. On the other hand, the heaviest penalty was given to models that produce coefficients that were statistically significant but theoretically incorrect. Two models were chosen for 5 regions, Fujian, Hubei, Hunan, Shaanxi, and Tianjin. The long-run variance was estimated employing the Newey-West estimator. *, †, and ‡ indicate a rejection of the null hypothesis at the 10%, 5%, and 1% significance level, respectively.

namics in response to market shocks. The model is specified as follows.

$$\mathbf{y}_{i,t} = \mathbf{a}_i + \sum_{j=1}^k \mathbf{B}_j \mathbf{y}_{i,t-j} + \mathbf{u}_{i,t}, \quad (3)$$

where

$$\mathbf{y}_{i,t} = [\Delta ry_{i,t} \ rr_t \ \Delta bc_t \ \Delta hp_{i,t}]'$$

Note that $\mathbf{y}_{i,t}$ includes the log-differenced quantity variables, $\Delta ry_{i,t}$, Δbc_t , and $\Delta hp_{i,t}$, while rr_t is included in levels without differencing. This specification is adopted because differencing rr_t would result in model misspecification in the presence of cointegration. We report selected regional housing price responses to real interest rate shocks and real building cost shocks.⁵ It should also be noted that we present the cumulative responses of regional housing prices, as the model is specified with log-differenced housing prices in the VAR.⁶

Figure 3 presents two groups of regions. The first group (Model M3) includes three regions, Beijing, Guangdong, and Shanghai, where only $ry_{i,t}$ was identified as a determining factor in the previous cointegration analysis. The second group (Model BM) includes three regions, Hainan, Inner Mongolia, and Shandong, where all three candidate factors were identified as influential.

As shown in Panel (a), the housing price responses of the first group to real interest rate shocks are either statistically insignificant or exhibit an unexpected sign, contrary to the prior that a higher real interest rate should shift the demand curve leftward by contracting housing demand. In contrast, the three regions in the second group exhibit statistically significant negative housing price responses to real interest rate shocks.

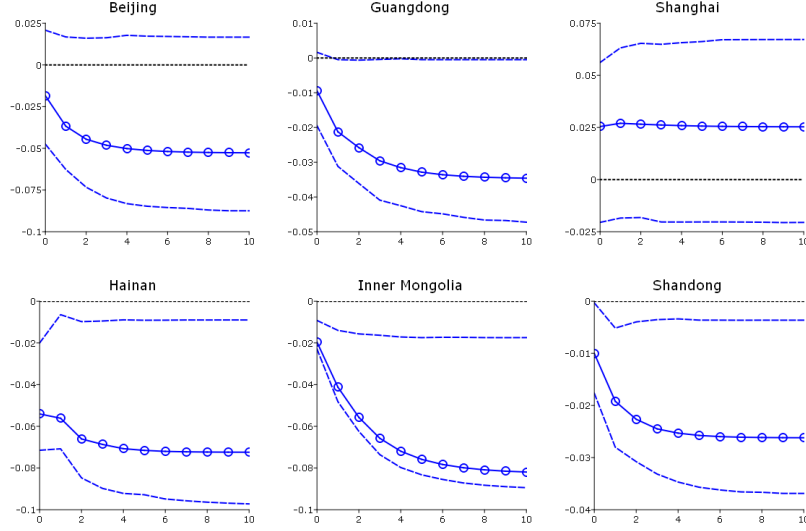
Panel (b) presents the housing price responses to real building cost shocks for the same two groups. Again, the responses of Beijing, Guangdong, and Shanghai are generally insignificant and/or exhibit an incorrect sign in the case of Beijing. In contrast, the three regions in the second group show statistically significant positive responses when the supply curve shifts leftward due to unexpected increases in real building costs. Overall, these results underscore the heterogeneity of regional housing markets and suggest that nationally uniform real estate policies may not effectively achieve their intended objectives across regions.

⁵Regional housing price responses to regional GDP shocks are mostly statistically significantly positive, as expected, reflecting the strong influence of real income shocks across regions. Complete results are available upon request.

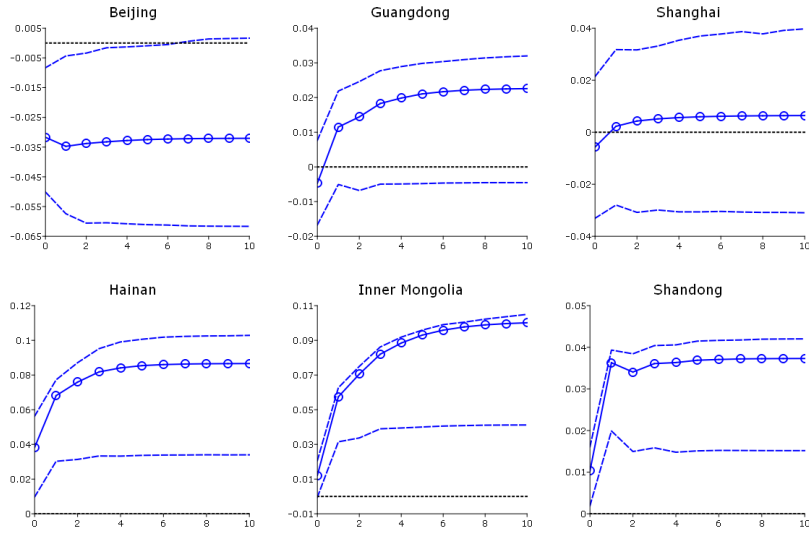
⁶We employed two lags based on the Akaike Information Criterion. The one-standard-deviation confidence bands are obtained from nonparametric bootstrap simulations.

Figure 3: Regional Housing Price Responses from Unrestricted VAR Models

$$\mathbf{y}_{i,t} = [\Delta r y_{i,t} \ rr_t \ \Delta bc_t \ \Delta hp_{i,t}]'$$



(a) Responses to the Real Interest Rate Shock



(b) Responses to the Building Cost Shock

Note: We constructed an unconstrained VAR model without imposing cointegration restrictions. Specifically, the model includes the log-differenced real GDP per capita, real building cost, and real housing price, along with the real interest rate in levels, since differencing the real interest rate would be inconsistent with the concept of cointegration. The optimal lag length of two was selected based on the Akaike Information Criterion (AIC). We report the cumulative impulse responses of housing prices to orthogonalized shocks, with one-standard-deviation confidence bands obtained from nonparametric bootstrap simulations.

Table 6: Pesaran’s Cross-Section Dependence Test

Test	Statistic	P-value
Pesaran CD	25.8394	0.0000

5.3 Panel Evidence

This section examines further evidence regarding the heterogeneity in regional housing markets in China via panel cointegration tests developed by [Westerlund \(2007\)](#), applied to the benchmark model and 5 alternative specifications. These tests are optimized for the presence of cross-section dependence in the panel, therefore we use the test developed by [Pesaran \(2021\)](#) to formally test for it. Table 6 shows that we have strong evidence for cross-section dependence in our panel.

Westerlund’s approach is based on error correction models. Let α_i denote the coefficient on the error correction term for region i , $i = 1, 2, \dots, N$. The null hypothesis of no cointegration is specified as $H_0 : \alpha_i = 0$ for all i . Two group mean tests, G_τ and G_α , do not assume homogeneity in α_i and test the null against the alternative hypothesis $H_A : \alpha_i < 0$ for at least one i . In contrast, two panel test, P_τ and P_α , impose the homogeneity restriction, testing the null against $H_A : \alpha_i = \alpha < 0$ for all i . These tests account for cross-section dependence via bootstraps to avoid size distortion. The results for all models are presented in Table 7.

As shown in Table 2, Johansen’s cointegration test for the benchmark model provides strong evidence of cointegration when applied to individual regions. Surprisingly, however, all panel cointegration tests fail to reject the null hypothesis of no cointegration for Model BM, which may reflect substantial heterogeneity in the cointegration relationships across regions. In contrast, all panel cointegration tests, G_τ , G_α , P_τ , and P_α , uniformly reject the null hypothesis at the 5% significance level for Model M3, which includes a scalar $\mathbf{z}_{i,t}$ with $ry_{i,t}$. This result suggests that the inclusion of additional variables, such as the real interest rate or real building cost, could introduce noise by imposing uniform model specifications that overlook heterogeneous housing market structures, potentially leading to misspecification problems.

6 Conclusion

This paper presents a comprehensive analysis of the long-run determinants of housing prices across 29 regional markets in China, using annual data from 1994 to 2021. By examining cointegration relationships between real housing prices and key macroeconomic fundamentals, including regional real income, real interest rates, and real building cost, we uncover

Table 7: Panel Cointegration Test Results with CSD

<i>Group Mean Cointegration Tests</i>				
	G_τ	pv	G_α	pv
Model BM	-1.568	0.792	-3.773	0.780
Model M1	-1.816	0.466	-5.710	0.368
Model M2	-1.825	0.480	-7.821*	0.066
Model M3	-2.276 [†]	0.022	-9.457 [‡]	0.002
Model M4	-0.290	0.994	-0.263	1.000
Model M5	-0.173	1.000	-0.175	1.000

<i>Panel Cointegration Tests</i>				
	P_τ	pv	P_α	pv
Model BM	-5.834	0.862	-2.859	0.748
Model M1	-7.819	0.528	-4.585	0.332
Model M2	-8.442	0.420	-6.245	0.124
Model M3	-10.729 [†]	0.042	-8.485 [‡]	0.000
Model M4	-2.007	0.978	-0.424	0.984
Model M5	-1.127	0.998	-0.226	1.000

Note: We report two panel cointegration test results that account for cross-sectional dependence. G_τ and G_α denote the group mean cointegration τ -test and α -test statistics, respectively. P_τ and P_α refer the panel cointegration τ -test and α -test statistics, respectively. pv denotes the robust p -value, computed under the null hypothesis of no cointegration while accounting for cross-section dependence (CSD). See [Westerglund \(2007\)](#) for detailed information about these panel tests. *, [†], and [‡] indicates a rejection of the null hypothesis at the 10%, 5%, and 1% significance level, respectively.

substantial heterogeneity in housing market structures across regions. To ensure theoretical consistency, we exclude model specifications in which the estimated coefficients contradict standard economic predictions, thereby identifying region-specific models that more accurately reflect the distinct dynamics of each regional housing market.

Our findings indicate that real income is the most robust and consistent long-run determinant of housing prices across all regions. However, the estimated income elasticities vary widely, with wealthier urban regions such as Shanghai, Beijing, and Zhejiang exhibiting notably higher responsiveness. In contrast, the effects of real interest rates and construction costs are far less consistent and often yield estimates that are inconsistent with theoretical expectations. These discrepancies underscore the potential pitfalls of imposing uniform models on heterogeneous regional markets. We further demonstrate this through the failure of panel cointegration tests, which likely stem from model misspecification arising from the neglect of regional heterogeneity.

We identify region-specific models that align with both statistical rigor and economic theory. Notably, we find that relatively simple income-based models often outperform more complex specifications, particularly in urban regions where liquidity constraints are likely to be less binding and supply rigidities more pronounced. The heterogeneity in long-run associations that we find suggests that a uniform national policy may not be equally effective across regions, and points to the value of differentiated policies tailored to the structural characteristics and macroeconomic conditions of each region.

This study contributes to the literature by offering a methodologically rigorous, disaggregated framework for analyzing housing market dynamics. Future research could build on this approach by explicitly incorporating housing price expectations, demographic changes, or credit market frictions. In addition, China’s ongoing policy experimentation in the property sector offers a promising avenue for causal identification, particularly through difference-in-differences or regression discontinuity designs.

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References

- Akaike, Hirotugu**, “A new look at the statistical model identification,” *IEEE transactions on automatic control*, 1974, *19* (6), 716–723.
- Andrews, Donald W K**, “Heteroskedasticity and autocorrelation consistent covariance matrix estimation,” *Econometrica*, 1991, *59* (3), 817–858.
- Chen, Kaiji and Yi Wen**, “The great housing boom of China,” *American Economic Journal: Macroeconomics*, 2017, *9* (2), 73–114.
- Chivakul, Mali, Raphael Lam, Xiaoguang Liu, Wojciech Maliszewski, and Alfred Schipke**, “Understanding Residential Real Estate in China,” *IMF Working Papers*, 2015, *15* (84), 1.
- Chow, Gregory C. and Linlin Niu**, “Housing prices in urban China as determined by demand and supply,” *Pacific Economic Review*, 2015, *20* (1), 1–16.
- Das, Ramesh Chandra**, “Roles of Fiscal, Monetary and Governance Factors upon Inflation: Outcomes from Panel Data Analysis,” *European Review*, 2026, pp. 1–19.
- **and Jagabandhu Mandal**, “Long-Run Associations and Short-Run Dynamics Between Corruption and Inflation: Examining Social Unsustainability for the Panel of Countries,” *International Journal of Social Ecology and Sustainable Development (IJSESD)*, 2022, *13* (1), 1–16.
- **, Tonmoy Chatterjee, and Enrico Ivaldi**, “Nexus between housing price and magnitude of pollution: Evidence from the panel of some high-and-low polluting cities of the world,” *Sustainability*, 2022, *14* (15), 9283.
- Deng, Lan and Jie Chen**, “Market development, state intervention, and the dynamics of new housing investment in China,” *Journal of Urban Affairs*, 2019, *41* (2), 223–247.
- **and —**, “Market development, state intervention, and the dynamics of new housing investment in China,” *Journal of Urban Affairs*, 2019, *41* (2), 223–247.
- Deng, Yongheng, Joseph Gyourko, and Jing Wu**, “Land and house price measurement in China,” NBER Working Paper 18403, National Bureau of Economic Research, Inc 2012.
- Elliott, Graham, Thomas J Rothenberg, and James Stock**, “Efficient tests for an autoregressive unit root,” *Econometrica*, 1996, *64* (4), 813–36.

- Engle, Robert F and Clive WJ Granger**, “Co-integration and error correction: representation, estimation, and testing,” *Econometrica: journal of the Econometric Society*, 1987, pp. 251–276.
- Fang, Hanming, Quanlin Gu, Wei Xiong, and Li-An Zhou**, “Demystifying the Chinese housing boom,” *NBER macroeconomics annual*, 2016, *30* (1), 105–166.
- Gong, Yifan and Yuxi Yao**, “Demographic changes and the housing market,” *Regional Science and Urban Economics*, 2022, *95*, 103734.
- Jiang, Shenzhe, Jianjun Miao, and Yuzhe Zhang**, “China’s housing bubble, infrastructure investment, and economic growth,” *International Economic Review*, 2022, *63* (3), 1189–1237.
- Johansen, Søren**, “Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models,” *Econometrica: journal of the Econometric Society*, 1991, pp. 1551–1580.
- Newey, Whitney K and Kenneth D West**, “Hypothesis testing with efficient method of moments estimation,” *International Economic Review*, 1987, pp. 777–787.
- Pesaran, M Hashem**, “General diagnostic tests for cross-sectional dependence in panels,” *Empirical economics*, 2021, *60* (1), 13–50.
- Piazzesi, Monika and Martin Schneider**, “Housing and Macroeconomics,” Working Paper 22354, National Bureau of Economic Research June 2016.
- Poterba, James M**, “Tax subsidies to owner-occupied housing: an asset-market approach,” *The quarterly journal of economics*, 1984, *99* (4), 729–752.
- Rogoff, Kenneth and Yuanchen Yang**, “Has China’s housing production peaked?,” *China & World Economy*, 2021, *29* (1), 1–31.
- Stock, James H and Mark W Watson**, “A simple estimator of cointegrating vectors in higher order integrated systems,” *Econometrica*, 1993, *61* (4), 783–820.
- Wang, Songtao, Su Han Chan, and Bohua Xu**, “The estimation and determinants of the price elasticity of housing supply: Evidence from China,” *Journal of Real Estate Research*, 2012, *34* (3), 311–344.
- Westerlund, Joakim**, “Testing for error correction in panel data,” *Oxford Bulletin of Economics and Statistics*, 2007, *69* (6), 709–748.

Wu, Dejin and Guozhu Li, *Real estate bubble: Theory, early warning, and governance*, Social Sciences Academic Press, 2007. (in Chinese).

Wu, Jing, Joseph Gyourko, and Yongheng Deng, “Evaluating the risk of Chinese housing markets: What we know and what we need to know,” *China Economic Review*, 2016, *39*, 91–114.

Xu, Xiaoyue, Anran Mi, Xiuting Li, Xuerong Li, and Jichang Dong, “Bad news travels fast: Network analysis of the Chinese housing market connectivity,” *China Economic Review*, 2024, *84* (C).

Appendix

A Cointegration Tables

Table A1. Cointegration Test Results for Model M1

$$\mathbf{y}_{i,t} = [ry_{i,t} \ rr_t \ hp_{i,t}]'$$

Region	J_{MaxEig}	H_A	J_{Trace}	H_A	EG
Anhui	14.90*	$r > 1$	20.28 [†]	$r > 1$	-2.833 [‡]
Beijing	7.64*	$r > 2$	7.64*	$r > 2$	-1.658
Fujian	23.38 [†]	$r > 0$	39.91 [†]	$r > 0$	-1.731*
Gansu	8.63*	$r > 2$	8.63*	$r > 2$	-1.793*
Guangdong	11.06 [†]	$r > 2$	11.06 [†]	$r > 2$	-1.348
Guangxi	27.37 [‡]	$r > 0$	44.27 [‡]	$r > 0$	-2.133 [†]
Guizhou	33.09 [‡]	$r > 0$	47.55 [‡]	$r > 0$	-2.967 [‡]
Hainan	7.56*	$r > 2$	7.56*	$r > 2$	-2.347 [†]
Hebei	10.21 [†]	$r > 2$	10.21 [†]	$r > 2$	-1.481
Heilongjiang	15.61*	$r > 1$	18.74*	$r > 1$	-2.490 [†]
Henan	8.54*	$r > 2$	8.54*	$r > 2$	-3.315 [‡]
Hubei	30.88 [‡]	$r > 0$	44.61 [‡]	$r > 0$	-2.599 [†]
Hunan	7.76*	$r > 2$	7.76*	$r > 2$	-2.053*
Inner Mongolia	19.88 [†]	$r > 1$	26.68 [‡]	$r > 1$	-0.676
Jiangsu	21.02 [‡]	$r > 1$	27.76 [‡]	$r > 1$	-3.030 [‡]
Jiangxi	18.19 [†]	$r > 1$	22.83 [†]	$r > 1$	-3.144 [‡]
Jilin	7.99*	$r > 2$	7.99*	$r > 2$	-0.423
Liaoning	20.49*	$r > 0$	33.33*	$r > 0$	-0.296
Ningxia	21.77*	$r > 0$	31.70	$r > 0$	-1.699
Qinghai	25.72 [†]	$r > 0$	42.04 [‡]	$r > 0$	-0.996
Shaanxi	22.65 [†]	$r > 0$	36.20 [†]	$r > 0$	-2.627 [†]
Shandong	7.68*	$r > 2$	7.68*	$r > 2$	-0.776
Shanghai	21.63 [‡]	$r > 1$	27.05 [‡]	$r > 1$	-2.591 [†]
Shanxi	25.39 [†]	$r > 0$	40.09 [†]	$r > 0$	-1.301
Sichuan	9.13*	$r > 2$	9.13*	$r > 2$	-2.430 [†]
Tianjin	14.09*	$r > 1$	19.31*	$r > 1$	-0.597
Xinjiang	8.44*	$r > 2$	8.44*	$r > 2$	-1.619
Yunnan	36.68 [‡]	$r > 0$	47.86 [‡]	$r > 0$	-2.547 [†]
Zhejiang	32.49 [‡]	$r > 0$	48.85 [‡]	$r > 0$	-2.231 [†]
National	28.44 [‡]	$r > 0$	42.60 [‡]	$r > 0$	-2.261 [†]

Note: J_{MaxEig} and J_{Trace} denote the Johansen maximum eigenvalue statistics and the Johansen trace statistics, respectively. H_A denotes the **last** alternative hypothesis considered when its associated null hypothesis is rejected in the sequential testing procedure. For example, statistically significant test results with $H_A : r > 0$ indicate the presence of one cointegrating relationship, whereas statistically insignificant results with $H_A : r > 0$ suggest no cointegrating relationship. EG denotes the Engle-Granger Test statistics, which tests the null of no cointegration against the alternative hypothesis of a single cointegration vector. *, [†], and [‡] indicates a rejection of the null hypothesis at the 10%, 5%, and 1% significance level, respectively.

Table A2. Cointegration Test Results for Model M2

$$\mathbf{y}_{i,t} = [ry_{i,t} \ bc_t \ hp_{i,t}]'$$

Region	J_{MaxEig}	H_A	J_{Trace}	H_A	EG
Anhui	29.67 [‡]	$r > 0$	46.98 [‡]	$r > 0$	-2.025*
Beijing	14.95	$r > 0$	31.53	$r > 0$	-1.683
Fujian	22.19 [†]	$r > 0$	29.94	$r > 0$	-1.740*
Gansu	18.44	$r > 0$	20.15 [†]	$r > 1$	-1.979*
Guangdong	23.68 [†]	$r > 0$	19.56*	$r > 1$	-1.327
Guangxi	15.80	$r > 0$	29.93	$r > 0$	-2.241 [†]
Guizhou	7.57*	$r > 2$	7.57*	$r > 2$	-2.455 [†]
Hainan	14.88	$r > 0$	30.62	$r > 0$	-2.638 [†]
Hebei	30.73 [‡]	$r > 0$	19.79*	$r > 1$	-1.093
Heilongjiang	15.89	$r > 0$	26.65	$r > 0$	-2.382 [†]
Henan	8.44*	$r > 2$	8.44*	$r > 2$	-3.550 [‡]
Hubei	15.78 [†]	$r > 1$	22.83 [†]	$r > 1$	-2.577 [†]
Hunan	21.71*	$r > 0$	33.88*	$r > 0$	-2.824 [‡]
Inner Mongolia	8.16*	$r > 2$	8.16*	$r > 2$	0.051
Jiangsu	16.15 [†]	$r > 1$	19.61*	$r > 1$	-3.020 [‡]
Jiangxi	18.4	$r > 0$	33.79*	$r > 0$	-3.515 [‡]
Jilin	8.33*	$r > 2$	8.33*	$r > 2$	-0.385
Liaoning	15.32*	$r > 1$	19.76*	$r > 1$	-0.883
Ningxia	14.83	$r > 0$	19.98 [†]	$r > 1$	-2.194 [†]
Qinghai	18.45	$r > 0$	18.38*	$r > 1$	-0.596
Shaanxi	11.46	$r > 0$	23.67	$r > 0$	-2.340 [†]
Shandong	15.35*	$r > 1$	21.85 [†]	$r > 1$	-0.177
Shanghai	24.22 [†]	$r > 0$	20.81 [†]	$r > 1$	-2.730 [†]
Shanxi	15.18	$r > 0$	29.09	$r > 0$	-1.256
Sichuan	13.77*	$r > 1$	20.29 [†]	$r > 1$	-2.296 [†]
Tianjin	14.88*	$r > 1$	20.53 [†]	$r > 1$	-0.979
Xinjiang	23.89 [†]	$r > 0$	41.00 [†]	$r > 0$	-1.560
Yunnan	16.35 [†]	$r > 1$	20.71 [†]	$r > 1$	-2.143 [†]
Zhejiang	18.43	$r > 0$	32.51*	$r > 0$	-2.134 [†]
National	21.17*	$r > 0$	37.17 [†]	$r > 0$	-2.193 [†]

Note: J_{MaxEig} and J_{Trace} denote the Johansen maximum eigenvalue statistics and the Johansen trace statistics, respectively. H_A denotes the **last** alternative hypothesis considered when its associated null hypothesis is rejected in the sequential testing procedure. For example, statistically significant test results with $H_A : r > 0$ indicate the presence of one cointegrating relationship, whereas statistically insignificant results with $H_A : r > 0$ suggest no cointegrating relationship. EG denotes the Engle-Granger Test statistics, which tests the null of no cointegration against the alternative hypothesis of a single cointegration vector. *, †, and ‡ indicates a rejection of the null hypothesis at the 10%, 5%, and 1% significance level, respectively.

Table A3. Cointegration Test Results for Model M3

$$\mathbf{y}_{i,t} = [ry_{i,t} \ hp_{i,t}]'$$

Region	J_{MaxEig}	H_A	J_{Trace}	H_A	EG
Anhui	16.42 [†]	$r > 0$	21.66 [†]	$r > 0$	-2.523 [†]
Beijing	12.54	$r > 0$	16.96	$r > 0$	-1.618
Fujian	10.89	$r > 0$	14.26	$r > 0$	-1.719*
Gansu	12.87 [†]	$r > 1$	12.87 [†]	$r > 1$	-2.070*
Guangdong	11.24 [†]	$r > 1$	11.24 [†]	$r > 1$	-1.468
Guangxi	11.94	$r > 0$	16.05	$r > 0$	-2.107 [†]
Guizhou	11.95	$r > 0$	18.80*	$r > 0$	-2.957 [‡]
Hainan	18.34 [†]	$r > 0$	22.98 [†]	$r > 0$	-2.555 [†]
Hebei	10.84	$r > 0$	18.08*	$r > 0$	-1.086
Heilongjiang	15.13*	$r > 0$	19.18*	$r > 0$	-2.494 [†]
Henan	8.95*	$r > 1$	8.95*	$r > 1$	-3.925 [‡]
Hubei	17.06 [†]	$r > 0$	22.21 [†]	$r > 0$	-2.906 [‡]
Hunan	10.52	$r > 0$	16.54	$r > 0$	-2.581 [†]
Inner Mongolia	9.41 [†]	$r > 1$	9.41 [†]	$r > 1$	-1.264
Jiangsu	18.93 [†]	$r > 0$	26.31 [‡]	$r > 0$	-2.822 [‡]
Jiangxi	17.79 [†]	$r > 0$	24.63 [‡]	$r > 0$	-3.899 [‡]
Jilin	7.95*	$r > 1$	7.95*	$r > 1$	-0.939
Liaoning	9.08	$r > 0$	12.02	$r > 0$	-1.017
Ningxia	5.92	$r > 0$	11.30	$r > 0$	-2.077 [†]
Qinghai	8.65	$r > 0$	16.12	$r > 0$	-0.510
Shaanxi	9.47	$r > 0$	16.20	$r > 0$	-2.467 [†]
Shandong	9.41 [†]	$r > 1$	9.41 [†]	$r > 1$	-1.188
Shanghai	8.65*	$r > 1$	8.65*	$r > 1$	-2.658 [†]
Shanxi	11.01	$r > 0$	15.12	$r > 0$	-1.255
Sichuan	12.13 [†]	$r > 1$	12.13 [†]	$r > 1$	-2.759 [†]
Tianjin	18.42 [†]	$r > 0$	23.47 [†]	$r > 0$	-0.881
Xinjiang	9.36 [†]	$r > 1$	9.36 [†]	$r > 1$	-1.731*
Yunnan	12.13	$r > 0$	15.70	$r > 0$	-2.780 [†]
Zhejiang	9.95	$r > 0$	13.77	$r > 0$	-2.258 [†]
National	8.42	$r > 0$	14.27	$r > 0$	-2.210 [†]

Note: J_{MaxEig} and J_{Trace} denote the Johansen maximum eigenvalue statistics and the Johansen trace statistics, respectively. H_A denotes the **last** alternative hypothesis considered when its associated null hypothesis is rejected in the sequential testing procedure. For example, statistically significant test results with $H_A : r > 0$ indicate the presence of one cointegrating relationship, whereas statistically insignificant results with $H_A : r > 0$ suggest no cointegrating relationship. EG denotes the Engle-Granger Test statistics, which tests the null of no cointegration against the alternative hypothesis of a single cointegration vector. *, †, and ‡ indicates a rejection of the null hypothesis at the 10%, 5%, and 1% significance level, respectively.

Table A4. Cointegration Test Results for Model M4

$$\mathbf{y}_{i,t} = [rr_t \ hp_{i,t}]'$$

Region	J_{MaxEig}	H_A	J_{Trace}	H_A	EG
Anhui	19.69 [†]	$r > 0$	26.25 [‡]	$r > 0$	-0.190
Beijing	20.60 [‡]	$r > 0$	23.11 [†]	$r > 0$	-0.225
Fujian	24.26 [‡]	$r > 0$	27.29 [‡]	$r > 0$	-0.620
Gansu	19.55 [†]	$r > 0$	25.69 [‡]	$r > 0$	0.302
Guangdong	21.24 [‡]	$r > 0$	28.67 [‡]	$r > 0$	0.367
Guangxi	12.38 [†]	$r > 1$	12.38 [†]	$r > 1$	-0.542
Guizhou	17.67 [†]	$r > 0$	20.67 [†]	$r > 0$	-0.144
Hainan	18.81 [†]	$r > 0$	22.46 [†]	$r > 0$	-0.077
Hebei	19.09 [†]	$r > 0$	23.48 [†]	$r > 0$	-0.257
Heilongjiang	13.86 [*]	$r > 0$	15.93	$r > 0$	-0.719
Henan	10.89 [†]	$r > 1$	10.89 [†]	$r > 1$	-1.585
Hubei	10.85 [†]	$r > 1$	10.85 [†]	$r > 1$	0.310
Hunan	24.44 [‡]	$r > 0$	28.21 [‡]	$r > 0$	-0.117
Inner Mongolia	19.46 [†]	$r > 0$	24.16 [†]	$r > 0$	0.423
Jiangsu	24.36 [‡]	$r > 0$	31.51 [‡]	$r > 0$	-0.116
Jiangxi	25.75 [‡]	$r > 0$	32.29 [‡]	$r > 0$	0.029
Jilin	8.36 [*]	$r > 1$	8.36 [*]	$r > 1$	0.224
Liaoning	9.88 [†]	$r > 1$	9.88 [†]	$r > 1$	-0.049
Ningxia	12.13 [†]	$r > 1$	12.13 [†]	$r > 1$	0.037
Qinghai	9.68 [†]	$r > 1$	9.68 [†]	$r > 1$	1.122
Shaanxi	7.55 [*]	$r > 1$	7.55 [*]	$r > 1$	0.520
Shandong	12.39 [†]	$r > 1$	12.39 [†]	$r > 1$	0.331
Shanghai	22.42 [‡]	$r > 0$	28.92 [‡]	$r > 0$	-0.150
Shanxi	9.39 [†]	$r > 1$	9.39 [†]	$r > 1$	0.055
Sichuan	22.49 [‡]	$r > 0$	26.29 [‡]	$r > 0$	0.187
Tianjin	19.54 [†]	$r > 0$	22.79 [†]	$r > 0$	-0.448
Xinjiang	18.17 [†]	$r > 0$	20.86 [†]	$r > 0$	0.378
Yunnan	16.41 [†]	$r > 0$	22.08 [†]	$r > 0$	0.181
Zhejiang	25.67 [‡]	$r > 0$	30.36 [‡]	$r > 0$	-0.601
National	10.04 [†]	$r > 1$	10.04 [†]	$r > 1$	0.019

Note: J_{MaxEig} and J_{Trace} denote the Johansen maximum eigenvalue statistics and the Johansen trace statistics, respectively. H_A denotes the **last** alternative hypothesis considered when its associated null hypothesis is rejected in the sequential testing procedure. For example, statistically significant test results with $H_A : r > 0$ indicate the presence of one cointegrating relationship, whereas statistically insignificant results with $H_A : r > 0$ suggest no cointegrating relationship. EG denotes the Engle-Granger Test statistics, which tests the null of no cointegration against the alternative hypothesis of a single cointegration vector. *, †, and ‡ indicates a rejection of the null hypothesis at the 10%, 5%, and 1% significance level, respectively.

Table A5. Cointegration Test Results for Model M5

$$\mathbf{y}_{i,t} = [bc_t \ hp_{i,t}]'$$

Region	J_{MaxEig}	H_A	J_{Trace}	H_A	EG
Anhui	8.31*	$r > 1$	8.31*	$r > 1$	-1.110
Beijing	8.62	$r > 0$	13.81	$r > 0$	-0.766
Fujian	7.82*	$r > 1$	7.82*	$r > 1$	-1.065
Gansu	10.28	$r > 0$	16.12	$r > 0$	-0.207
Guangdong	16.33 [†]	$r > 0$	23.17 [†]	$r > 0$	-0.638
Guangxi	8.44*	$r > 1$	8.44*	$r > 1$	-1.010
Guizhou	10.32 [†]	$r > 1$	10.32 [†]	$r > 1$	-1.152
Hainan	11.46	$r > 0$	18.10*	$r > 0$	-0.599
Hebei	11.02	$r > 0$	17.21	$r > 0$	-0.814
Heilongjiang	8.89	$r > 0$	11.39	$r > 0$	-0.700
Henan	8.99*	$r > 1$	8.99*	$r > 1$	-0.572
Hubei	23.96 [‡]	$r > 0$	29.95 [‡]	$r > 0$	-0.660
Hunan	8.46*	$r > 1$	8.46*	$r > 1$	-0.903
Inner Mongolia	7.58*	$r > 1$	7.58*	$r > 1$	-0.835
Jiangsu	7.69*	$r > 1$	7.69*	$r > 1$	-1.146
Jiangxi	8.88*	$r > 1$	8.88*	$r > 1$	-0.912
Jilin	7.65*	$r > 1$	7.65*	$r > 1$	-0.588
Liaoning	35.18 [‡]	$r > 0$	41.75 [‡]	$r > 0$	-1.331
Ningxia	9.17*	$r > 1$	9.17*	$r > 1$	-0.741
Qinghai	11.33 [†]	$r > 1$	11.33 [†]	$r > 1$	-0.257
Shaanxi	8.00*	$r > 1$	8.00*	$r > 1$	-0.544
Shandong	7.88*	$r > 1$	7.88 *	$r > 1$	-0.879
Shanghai	15.04*	$r > 0$	21.3 [†]	$r > 0$	-0.669
Shanxi	9.41 [†]	$r > 1$	9.41 [†]	$r > 1$	-0.816
Sichuan	19.01 [†]	$r > 0$	25.84 [‡]	$r > 0$	-1.281
Tianjin	9.98	$r > 0$	13.98	$r > 0$	-1.074
Xinjiang	8.01*	$r > 1$	8.01*	$r > 1$	-0.435
Yunnan	17.61 [†]	$r > 0$	22.98 [†]	$r > 0$	-0.920
Zhejiang	10.39 [†]	$r > 1$	10.39 [†]	$r > 1$	-1.450
National	7.91*	$r > 1$	7.91*	$r > 1$	-0.825

Note: J_{MaxEig} and J_{Trace} denote the Johansen maximum eigenvalue statistics and the Johansen trace statistics, respectively. H_A denotes the **last** alternative hypothesis considered when its associated null hypothesis is rejected in the sequential testing procedure. For example, statistically significant test results with $H_A : r > 0$ indicate the presence of one cointegrating relationship, whereas statistically insignificant results with $H_A : r > 0$ suggest no cointegrating relationship. EG denotes the Engle-Granger Test statistics, which tests the null of no cointegration against the alternative hypothesis of a single cointegration vector. *, †, and ‡ indicates a rejection of the null hypothesis at the 10%, 5%, and 1% significance level, respectively.

Table A6. DOLS Regression Results for Model M1
 $\mathbf{y}_{i,t} = [ry_{i,t} \ rr_t \ hp_{i,t}]'$

Region	$ry_{i,t}$	$s.e.$	rr_t	$s.e.$
Anhui	0.757 [‡]	0.012	-0.009	0.006
Beijing	0.947 [‡]	0.076	0.021	0.024
Fujian	0.834 [‡]	0.033	-0.032*	0.016
Gansu	0.590 [‡]	0.043	0.002	0.015
Guangdong	0.536 [‡]	0.037	-0.001	0.013
Guangxi	0.521 [‡]	0.022	-0.017	0.012
Guizhou	0.487 [‡]	0.029	0.000	0.008
Hainan	0.859 [‡]	0.058	-0.019	0.011
Hebei	0.395 [‡]	0.101	-0.064 [†]	0.026
Heilongjiang	0.501 [‡]	0.113	-0.012	0.024
Henan	0.643 [‡]	0.026	0.015	0.010
Hubei	0.682 [‡]	0.024	-0.013	0.010
Hunan	0.593 [‡]	0.017	-0.016*	0.009
Inner Mongolia	0.408 [‡]	0.010	-0.019 [‡]	0.005
Jiangsu	0.680 [‡]	0.012	-0.020 [‡]	0.005
Jiangxi	0.897 [‡]	0.025	-0.017	0.012
Jilin	0.513 [‡]	0.021	-0.020 [‡]	0.007
Liaoning	0.584 [‡]	0.024	-0.001	0.007
Ningxia	0.475 [‡]	0.026	0.015 [†]	0.006
Qinghai	0.446 [‡]	0.040	0.000	0.013
Shaanxi	0.527 [‡]	0.021	-0.020 [†]	0.009
Shandong	0.592 [‡]	0.014	-0.022 [‡]	0.004
Shanghai	1.510 [‡]	0.046	0.015	0.011
Shanxi	0.838 [‡]	0.017	0.093 [‡]	0.008
Sichuan	0.713 [‡]	0.029	0.007	0.015
Tianjin	0.589 [‡]	0.048	-0.032*	0.017
Xinjiang	0.670 [‡]	0.037	0.034 [†]	0.012
Yunnan	0.515 [‡]	0.015	0.046 [‡]	0.013
Zhejiang	1.062 [‡]	0.042	-0.005	0.009
National	0.583 [‡]	0.014	0.002	0.003

Note: We report the dynamic ordinary least squares (DOLS) coefficients along with the associated standard errors (s.e.). The long-run variance was estimated employing the Newey-West estimator. *, †, and ‡ indicate a rejection of the null hypothesis at the 10%, 5%, and 1% significance level, respectively.

Table A7. DOLS Regression Results for Model M2
 $\mathbf{y}_{i,t} = [ry_{i,t} \ bc_t \ hp_{i,t}]'$

Region	$ry_{i,t}$	$s.e.$	bc_t	$s.e.$
Anhui	0.763 [‡]	0.014	0.032	0.319
Beijing	0.841 [‡]	0.020	-0.769	0.630
Fujian	0.914 [‡]	0.033	1.686 [†]	0.645
Gansu	0.559 [‡]	0.011	-1.044 [‡]	0.283
Guangdong	0.552 [‡]	0.017	0.390	0.312
Guangxi	0.492 [‡]	0.021	-1.154 [†]	0.466
Guizhou	0.525 [‡]	0.021	2.120 [‡]	0.437
Hainan	0.928 [‡]	0.040	1.832 [‡]	0.436
Hebei	0.601 [‡]	0.022	1.959 [‡]	0.394
Heilongjiang	0.556 [‡]	0.094	0.647	1.217
Henan	0.590 [‡]	0.016	-1.138 [‡]	0.311
Hubei	0.706 [‡]	0.025	0.635	0.523
Hunan	0.656 [‡]	0.013	1.621 [‡]	0.249
Inner Mongolia	0.463 [‡]	0.003	1.092 [‡]	0.073
Jiangsu	0.759 [‡]	0.016	0.727 [‡]	0.211
Jiangxi	0.946 [‡]	0.018	1.255 [‡]	0.337
Jilin	0.579 [‡]	0.018	0.873 [†]	0.330
Liaoning	0.530 [‡]	0.010	-0.005	0.244
Ningxia	0.419 [‡]	0.022	-0.144	0.435
Qinghai	0.439 [‡]	0.025	0.434	0.422
Shaanxi	0.559 [‡]	0.022	1.368 [‡]	0.475
Shandong	0.639 [‡]	0.012	0.493 [†]	0.211
Shanghai	1.382 [‡]	0.042	-1.505 [†]	0.548
Shanxi	0.650 [‡]	0.011	-2.234 [‡]	0.291
Sichuan	0.748 [‡]	0.019	2.255 [‡]	0.369
Tianjin	0.685 [‡]	0.022	2.058 [‡]	0.409
Xinjiang	0.600 [‡]	0.027	1.073 [†]	0.468
Yunnan	0.459 [‡]	0.019	-1.824 [‡]	0.398
Zhejiang	1.081 [‡]	0.015	2.506 [‡]	0.248
National	0.585 [‡]	0.015	0.063	0.178

Note: We report the dynamic ordinary least squares (DOLS) coefficients along with the associated standard errors (s.e.). The long-run variance was estimated employing the Newey-West estimator. *, †, and ‡ indicate a rejection of the null hypothesis at the 10%, 5%, and 1% significance level, respectively.

Table A8. DOLS Regression Results for Model M3, M4, and M5

Region	Model 4		Model 5		Model 6	
	$ry_{i,t}$	$s.e.$	rr_t	$s.e.$	bc_t	$s.e.$
Anhui	0.758 [‡]	0.012	-0.152	0.121	-4.864	5.752
Beijing	0.896 [‡]	0.079	-0.078	0.114	-3.805	5.569
Fujian	0.856 [‡]	0.036	-0.151	0.125	-2.961	3.776
Gansu	0.580 [‡]	0.034	-0.060	0.073	-2.505	2.556
Guangdong	0.543 [‡]	0.019	-0.062	0.073	-2.431	2.605
Guangxi	0.569 [‡]	0.038	-0.076	0.088	-4.244	4.176
Guizhou	0.487 [‡]	0.029	-0.064	0.082	-2.603	4.462
Hainan	0.863 [‡]	0.067	-0.176	0.117	-3.440	6.062
Hebei	0.539 [‡]	0.045	-0.057	0.094	-4.473	4.352
Heilongjiang	0.564 [‡]	0.086	-0.011	0.052	-3.692	3.151
Henan	0.632 [‡]	0.022	-0.092	0.099	-6.216	4.832
Hubei	0.685 [‡]	0.023	-0.101	0.095	-4.982	4.804
Hunan	0.638 [‡]	0.020	-0.073	0.088	-2.262	3.112
Inner Mongolia	0.445 [‡]	0.011	-0.078	0.085	-1.630	3.143
Jiangsu	0.710 [‡]	0.010	-0.147	0.117	-5.018	5.786
Jiangxi	0.930 [‡]	0.019	-0.160	0.144	-5.570	7.230
Jilin	0.573 [‡]	0.022	-0.068	0.083	-3.720	4.610
Liaoning	0.564 [‡]	0.027	-0.091	0.073	-3.744	3.827
Ningxia	0.447 [‡]	0.020	-0.081	0.074	-3.071	3.782
Qinghai	0.447 [‡]	0.025	-0.049	0.066	-2.720	3.665
Shaanxi	0.536 [‡]	0.023	-0.136	0.094	-3.394	5.346
Shandong	0.641 [‡]	0.011	-0.088	0.098	-4.368	4.944
Shanghai	1.412 [‡]	0.047	-0.163	0.120	-6.544	6.712
Shanxi	0.655 [‡]	0.027	-0.094	0.094	-4.829	4.994
Sichuan	0.684 [‡]	0.034	-0.138	0.114	-2.672	3.486
Tianjin	0.644 [‡]	0.039	-0.147	0.120	-4.889	5.688
Xinjiang	0.568 [‡]	0.041	-0.007	0.043	-1.145	2.186
Yunnan	0.529 [‡]	0.035	-0.057	0.061	-5.145	3.668
Zhejiang	1.062 [‡]	0.044	-0.201	0.141	-5.427	7.281
National	0.583 [‡]	0.014	-0.067	0.083	-3.933	3.864

Note: We report the dynamic ordinary least squares (DOLS) coefficients along with the associated standard errors (s.e.). The long-run variance was estimated employing the Newey-West estimator. *, †, and ‡ indicate a rejection of the null hypothesis at the 10%, 5%, and 1% significance level, respectively.

B A Demand-Supply Model of Regional Housing Prices in China

We develop a stylized partial equilibrium model for regional housing markets. In this model, we derive a long-run reduced form equation illustrating the relationship between housing prices and the macroeconomic fundamentals in our system. This framework provides economic grounds for predicting the signs of the coefficients in the cointegrating vector.

B.1 Inverse Demand Function for Housing

Housing is both a consumption good and an asset. Based on the seminal work of [Poterba \(1984\)](#), demand for housing is positively driven by real income, and negatively affected by user costs. Given that a higher real interest rate raises the opportunity cost of funds invested in housing (similarly it raises the cost of mortgage financing), it follows that user costs increase with interest rates. Therefore, we have the following inverse demand function for housing:

$$hp_{i,t} = \alpha_0 + \alpha_1 ry_{i,t} - \alpha_2 rr_t - \alpha_3 h_{i,t}^{(D)}, \quad \alpha_1, \alpha_2, \alpha_3 > 0,$$

where i indexes each region and t indexes each time period. $hp_{i,t}$ represents housing prices, $ry_{i,t}$ is real income, and $h_{i,t}^{(D)}$ is the stock of housing demanded. $\alpha_3 < 0$ reflects the traditional law of demand, which stipulates a negative relationship between price and quantity demanded.

B.2 Inverse Supply Function for Housing

With respect to supply, the supply of housing is determined by the stock of housing supplied (the developers' construction decisions), $h_{i,t}^{(S)}$ and the cost of construction, bc_t . These assumptions yield the following inverse supply curve:

$$hp_{i,t} = \omega_0 + \omega_1 h_{i,t}^{(S)} - \omega_2 bc_t, \quad \omega_1, \omega_2 > 0,$$

B.3 Long-Run Equilibrium

In the long-run, the market clears when $h_{i,t}^{(D)} = h_{i,t}^{(S)} = h_{i,t}$. The following procedure enables us to obtain a reduced-form equation showing the long-run relationship between housing prices and the other variables in our system:

1. Solve for $h_{i,t}$ from the inverse supply function equation:

$$h_{i,t} = \frac{-\omega_0 + hp_{i,t} - \omega_2 bc_t}{\omega_1}$$

2. Substitute into the inverse demand function:

$$hp_{i,t} = \alpha_0 + \alpha_1 ry_{i,t} - \alpha_2 rr_t - \alpha_3 \left(\frac{-\omega_0 + hp_{i,t} - \omega_2 bc_t}{\omega_1} \right),$$

which can be expanded to:

$$hp_{i,t} = \frac{\alpha_0 \omega_1 + \omega_0 \alpha_3}{\omega_1 + \alpha_3} + \frac{\alpha_1 \omega_1}{\omega_1 + \alpha_3} ry_{i,t} - \frac{\alpha_2 \omega_1}{\omega_1 + \alpha_3} rr_t + \frac{\omega_2 \alpha_3}{\omega_1} bc_t,$$

Finally, we rewrite this reduced-form equation as:

$$hp_{i,t} = \beta_0 + \beta_1 ry_{i,t} + \beta_2 rr_t + \beta_3 bc_t$$

Given that: $\alpha_1, \alpha_2, \alpha_3, \omega_1, \omega_2 > 0$, we can conclude that:

1. $\beta_1 = \frac{\alpha_1 \omega_1}{\omega_1 + \alpha_3} > 0$: housing prices have a positive long-run relationship with real income
2. $\beta_2 = -\frac{\alpha_2 \omega_1}{\omega_1 + \alpha_3} < 0$: housing prices have a negative long-run relationship with real interest rates
3. $\beta_3 = \frac{\omega_2 \alpha_3}{\omega_1} > 0$: housing prices have a positive long-run relationship with building costs

C Data Appendix

C.1 Details on our Variables

Housing prices are represented by the average selling price of commercial residential buildings (yuan per square meter), as reported in the China Statistical Yearbook. In most years, the official yearbook directly provides this average selling price data. However, in some earlier years, when this information was not reported separately, the average selling price was calculated manually by dividing the officially reported sales value of commercial residential buildings by their corresponding sales area.

We obtained construction cost data at both the national and regional levels from various editions of the *China Statistical Yearbook*, supplemented with observations from regional statistical yearbooks. Our main analysis is based on the national building cost data because the regional data are more likely to suffer from data quality and completeness issues in some provinces. Nevertheless, the empirical results based on the regional data are qualitatively similar to our baseline findings using the national data. This similarity is not surprising, as construction costs are largely driven by building materials, which are generally standardized

and highly tradable. According to the law of one price, standardized tradable goods should exhibit similar prices across regions because arbitrage tends to eliminate persistent price differentials. Any remaining differences are likely to reflect transportation and other transaction costs, resulting primarily in differences in price levels rather than in the dynamics of price movements⁷.

The CPI series was originally reported with the previous year as the base (1994 = 100). Using a standard rebasing procedure, all CPI series were converted to a common 1994-based index for the empirical analysis. Regional CPI data are available for all regions spanning the period from 1994 to 2021. These CPI series were not sourced from a single edition of the statistical yearbook; rather, they were compiled from multiple editions of the China Statistical Yearbook. For instance, the 2022 edition provides regional CPI data only for the years 2006 to 2021, while earlier data were gathered from previous editions and combined to create a continuous series. Because the reported CPI values are based on the previous year (i.e., 100), all regional CPI series were further converted to a common CPI index with 1994 as the base year to ensure consistency throughout the entire sample period.

The real interest rate variable used in this study is not manually deflated from the nominal lending rate using the CPI. Instead, we utilize the real interest rate series directly from the World Bank database. According to the World Bank’s definition, the real interest rate is calculated as the lending interest rate adjusted for inflation, measured by the GDP deflator.

The majority of variables in this study are obtained directly from the China Statistical Yearbook, with most data points being fully available. For instances of missing, unreported, or inconsistent entries in the national data, provincial and local statistical yearbooks were consulted to verify and supplement the information. Consequently, the final dataset integrates data from both national and regional statistical sources to ensure completeness and accuracy. A limited number of missing data points for Chongqing and Tibet were supplemented using provincial statistical yearbooks. Since 1997, Chongqing has been designated as a centrally administered municipality and is reported separately within the national statistical system; therefore, data prior to 1997 were obtained from its regional statistical yearbooks. To maintain consistency in data coverage, Chongqing was excluded from the baseline analysis. Similarly, Tibet was excluded from the baseline analysis due to its relatively underdeveloped housing market and potential issues concerning data comparability.

⁷Our results based on the regional building cost data are available upon request.

C.2 Data Limitations

It is essential to recognise that the official Chinese housing price data employed in this study, which are derived from the average selling prices of commercial residential properties, have several inherent limitations. Specifically, these data may be influenced by composition effects, variations in property quality, urban bias, and other measurement issues, suggesting that they may not accurately represent a constant-quality house price index. Some observed fluctuations in housing prices may result from changes in the composition and characteristics of housing transactions rather than genuine price movements. Although these limitations should be considered when interpreting the empirical findings, the official statistics remain among the most comprehensive and widely used sources of housing market information in China, providing valuable insights into long-term regional housing market trends.

C.3 Data Sources

The data used in this paper was compiled from several sources. The references are below:

Tibet Autonomous Region Bureau of Statistics. (1996). Tibet statistical yearbook 1996. China Statistics Press.

Tibet Autonomous Region Bureau of Statistics. (2020). Tibet statistical yearbook 2020. China Statistics Press.

Chongqing Municipal Bureau of Statistics. (1994). Chongqing statistical yearbook 1994. China Statistics Press.

Chongqing Municipal Bureau of Statistics. (1995). Chongqing statistical yearbook 1995. China Statistics Press.

Chongqing Municipal Bureau of Statistics. (1996). Chongqing statistical yearbook 1996. China Statistics Press.

Chongqing Municipal Bureau of Statistics. (1998). Chongqing statistical yearbook 1998. China Statistics Press.

Chongqing Municipal Bureau of Statistics. (2020). Chongqing statistical yearbook 2020. China Statistics Press.

Inner Mongolia Autonomous Region Bureau of Statistics. (2001). Inner Mongolia statistical yearbook 2001. China Statistics Press.

National Bureau of Statistics of China. (1994–2022). China Statistical Yearbook. China Statistics Press. Available at: <https://www.stats.gov.cn/sj/ndsj/>

World Bank. World Development Indicators (WDI). Lending interest rate (%), FR.INR.LEND. Washington, DC: World Bank. Available at: <https://data.worldbank.org/indicator/FR.INR.LEND>

National People's Congress of the People's Republic of China. (1991). The Eighth Five-Year Plan for National Economic and Social Development of the People's Republic of China (1991–1995).

National People's Congress of the People's Republic of China. (1996). The Ninth Five-Year Plan for National Economic and Social Development of the People's Republic of China (1996–2000).

National People's Congress of the People's Republic of China. (2001). The Tenth Five-Year Plan for National Economic and Social Development of the People's Republic of China (2001–2005).

National People's Congress of the People's Republic of China. (2006). The Eleventh Five-Year Plan for National Economic and Social Development of the People's Republic of China (2006–2010).

National People's Congress of the People's Republic of China. (2011). The Twelfth Five-Year Plan for National Economic and Social Development of the People's Republic of China (2011–2015).

National People's Congress of the People's Republic of China. (2016). The Thirteenth Five-Year Plan for National Economic and Social Development of the People's Republic of China (2016–2020).

National People's Congress of the People's Republic of China. (2021). The Fourteenth Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Long-Range Objectives Through 2035. http://www.gov.cn/xinwen/2021-03/13/content_5592681.htm