A study of the space divergence of factors influencing house prices in Chinese cities based on the additivity model

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Abstract: The study analyses the direction of association and variability between housing prices and their influencing factors in eastern and central-western cities in China. A panel of housing prices and selected factors for eastern and mid-western cities in China during 2010-2020, an additivity model is developed and the model is fitted using the R software mgcv package. The study finds positive effects of urban disposable income per household, the share of tertiary industry in GDP, and permanent population on housing prices in eastern and midwestern cities, and negative effects of loan interest rates of financial institutions. The effects of GDP per capita, residential investment amount, and domestic site area on house prices in eastern and central-western cities show differences.

1. Introduction

After China began to carry out housing system reforms in 1998, the country's real estate industry rose rapidly and housing prices climbed year after year. Since 2010, China has enacted policies such as purchase restriction orders, tax policies for second-home transactions, and lower down payment ratios to effectively regulate housing prices. Behind this success has also emerged the problem that regional disparities in house prices are becoming more pronounced, for example, at the end of 2016, the average house price in Shenzhen was 15 times higher than the house price in Xianning. The regional imbalance in house prices has become a hot issue that has attracted a great deal of attention from scholars at home and abroad, with one strand of literature reflecting the imbalance in house prices between the east and west from a provincial perspective, with house prices in the east being much higher than in the west [1].

There are many factors that influence house prices, and most of the literature focuses on the supply and demand dimensions. From a supply perspective, land prices and real estate investment are the more important factors. Michael (1996), in his analysis of the reasons for the differences between house prices, rents and land prices in the US, identified one of the most important factors contributing to the differences, namely architectural costs [2]. Similar results were found by Guest and Rohde (2017) [3]. From a demand perspective, population and income are the most important factors. Firstly, demographic factors, Lin, Ma, Zhao, Hu and Wei (2018) analyzed the effect of population on house prices using data in 32 cities between 2007 and 2016 and found that an increase in population inflow rate significantly increases house prices [4]. Secondly, the income factor, Fortura and Kushner (1986), in their analysis of the causes of house price differentials in Canada, found that a rise in household income resulted in a concomitant increase in house prices that slightly exceeds the increase in household income [5]. Similar results were found by Davidoff (2006) [6] and Gallin (2006) [7]. In addition, macroeconomic dimensions, such as money, credit, GDP, unemployment and other indicators have also been found to affect house prices (Goodhart & Hofmann (2008) [8], Hossain & Latif (2009) [9], Maynou, Monfort, Morley & Ordóñez (2021) [10]).

Therefore, the study was conducted from three perspectives: supply, macroeconomic aspects and administrative, and identified various factors affecting urban house prices.

The remaining content of the paper has the following main segments. Part 2 presents a focus on statistics and methods, Part 3 presents a discussion of the findings, identifying the factors influencing housing prices and the orientation of these factors, and Part 4 contains conclusions and

recommendations.

2. Statistics and Method

2.1 Data Sources and Data Descriptions

The data used in the study are panel data for 30 provinces and cities in China, containing 200 cities from 2010 to 2020, and house prices are defined as the average price of commodity housing, and the data are mainly collected from the statistical almanacs from the provinces and municipalities and the official websites of the statistical bureaus of each province and city in the Knowledge Network Statistics.

In this paper, the provinces and cities of China are classified into three segments: Eastern, Central and Western. In order to show the division more visually, this paper displays a map of China after the division, as shown in Figure 1.

Figure 1 Division of Eastern and Midwestern provinces and cities.

In this paper, housing price is taken as the causal variable, and the independent variables are based mainly on three aspects: supply and demand, macroeconomics and administration, and Table 1 describes the basic situation of the reliable variables in detail. To eliminate the problem of disparity in values caused by different magnitudes of independent variables, all independent variables are normalized.

Table 1 Basic information of model variables.

Explanatory Variables		Min.	Max.	Average
GDP per capita	GDP	9788	165851	71774
real estate development residential investment	RI	67	3246.8	619.9
per capita disposable income of urban families	PCDI	14062	66694	32837
ratio of tertiary industry to GDP	Ratio	23.5	80.5	53.8
resident population	Population	68.5	3205	738.8
residential land area	RLA	10	418	98.2
actual utilization of foreign capital	AUFC	0.44	908.3	150.5
loan-to-deposit ratio of financial institutions	LTD	0.37	1.43	0.83
loan interest rate of financial institutions	LIR	0.52	6.49	3.03

2.2 Research Method

Assuming that (Y_i, X_i), $i = 1, \cdots, n$ are independent identically distributed samples from (Y, X), where Y is the explanatory variable, namely the dependent variable, and $X = (X_1, \cdots, X_p)^T$ is the p-dimensional explanatory variable, the additivity model can be expressed in the following form:

$$Y_i = \mu + \sum_{j=1}^{p} f_j(x_{ij}) + \varepsilon_i, \tag{1}$$

Where μ is the intercept term, X_{ij} is the jth component of X_i, $f_j, j = 1, \dots, p$ is the unknown smooth function, ε_i is the zero-mean random error, and the variance is σ^2. To ensure the unique identification of f_j, it is usually assumed that for all $1 \leq j \leq p$, there is $E\left[f_j(X_j)\right] = 0$. In this paper, a B spline function is used to approximate $f_j(X_j)$, transforming the nonparametric part into the parametric part, and applying penalized least squares to solve for.

In R software, the additivity model can be implemented with the mgcv package, whose gam function is used to perform the basic fit of the model. The concurvity function is used to check the co-curvature, and vis. gam can visualize the results. The modeling results are stored in the model variable, which can also be further processed with generic functions such as summary, predict, anova, and plot. The main form of the gam function is as follows:

$$gam(formula, family = gaussian(), data = list, weights = null, offset = NULL, \cdots) \quad (2)$$

Only some common parameters are listed here, formula is the model expression, different smoothing functions can be chosen and the connection between them. Commonly used smoothing functions are: spline s(smoothing spline), tensor product smoothing te (tensor product smooths), tensor product interactions ti (tensor product interactions).

3. Results and Analysis

3.1 Overview of the Study Area

During 2010-2020, the average housing price in China is 57,220.3 yuan/square meter, with a maximum value of 5,742.7 yuan/square meter and a minimum value of 1,603.1 yuan/square meter.

As can be seen from Figure 2, between 2010 and 2020, the evolution of house prices in the East and overall remained largely consistent, with house prices in the Midwest also rising slowly, but not as much as overall house prices. before 2015, house prices were in a slow-rising phase, suggesting that the state's housing policies were playing a role in curbing excessive house price growth, but after 2015, house price rises became larger, suggesting that the state was stimulating a rapid rise in house prices. In addition, a comparison of house prices in the east and the mid-west indicates that the former is not only much higher but also have risen more steeply.
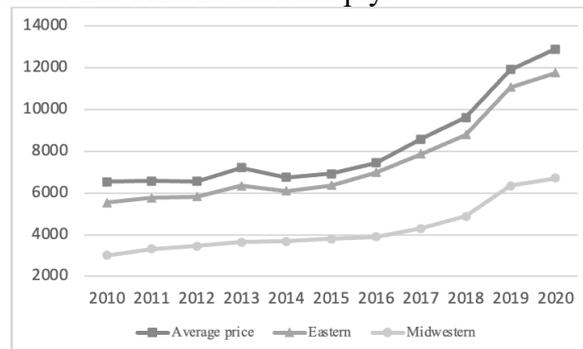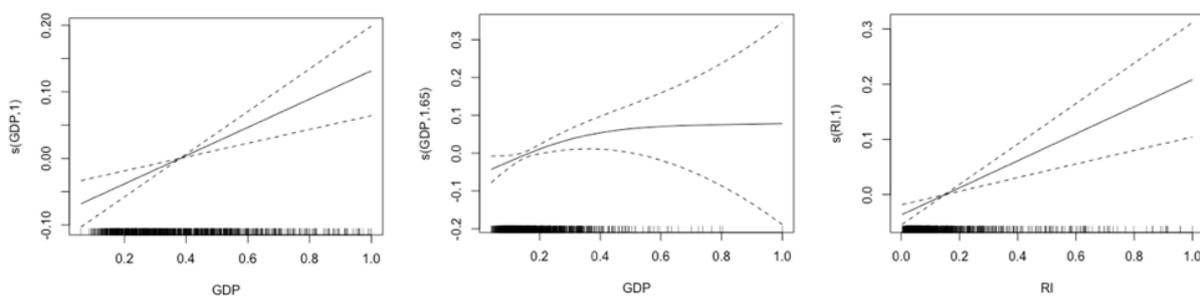

Figure 2 Trends in average housing value 2010-2020.

3.2 Results

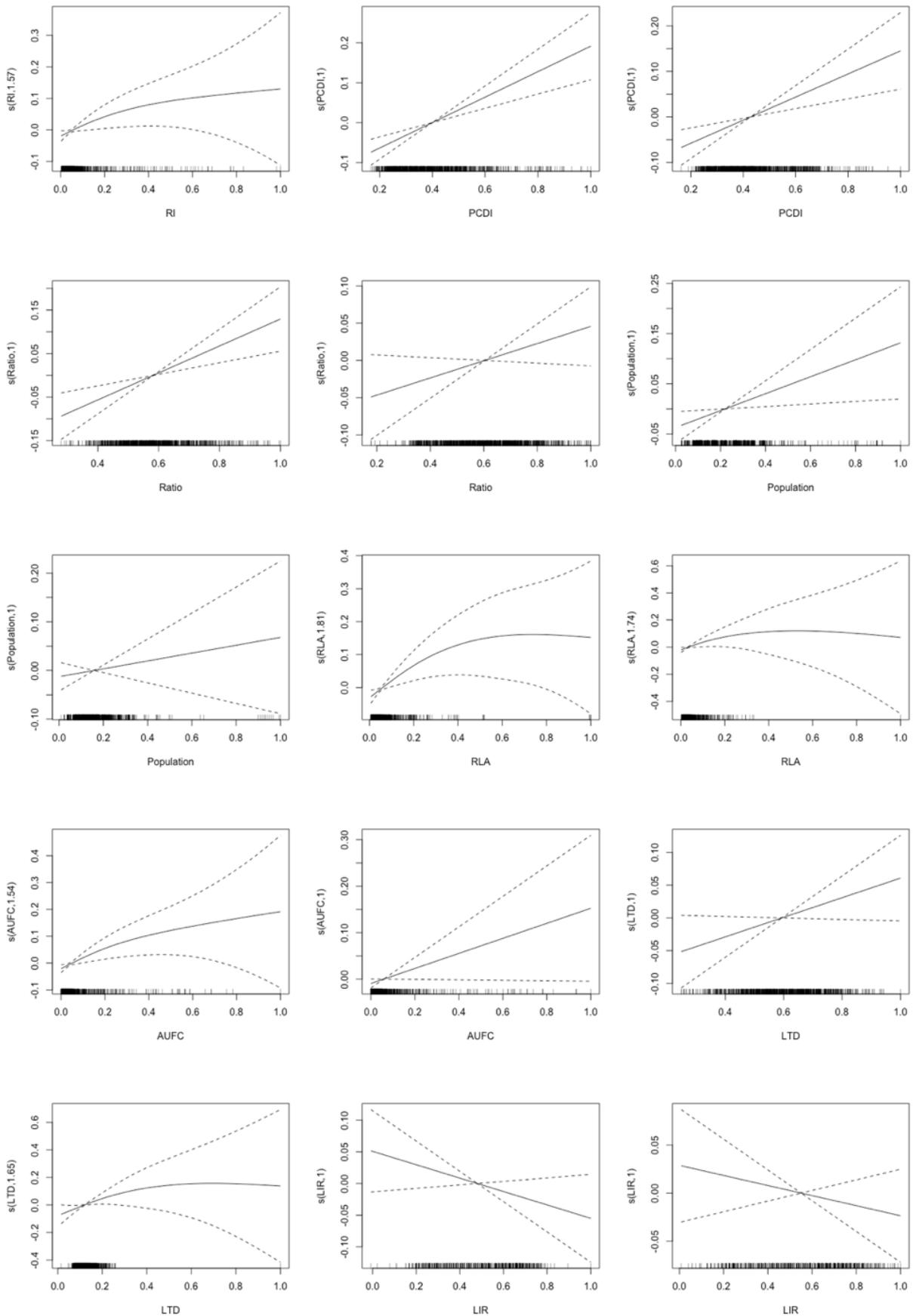The model graphics were performed by R software and the results are shown in Figure 3:

Figure 3 Schematic diagram of the East (left) and Midwest (right) additivity models.

First, the effects of GDP per capita, residential investment and loan-to-deposit ratio of financial

institutions on household prices in eastern and central and western cities show differences, with all three having pronounced positive effects on household prices in eastern cities and some stimulating effects on household prices in central and western cities, but all are nonlinear.

Second, urban household disposable income per capita, the share of tertiary industry in GDP and resident population all have positive effects on house prices in all regions, with the resident population having a more pronounced force on house prices in eastern cities in relative terms.

Third, the impact of home site area on household prices in all regions is nonlinear, with an effect on household prices in eastern cities but a weak effect on household prices in midwestern cities.

Fourth, the implication of the actual volume of overseas capital employed in the current year on household prices in eastern and mid-western cities differs, with a positive influence on house prices in mid-western cities and a non-linear, but tending to linear, effect on house prices in eastern cities.

Fifth, the interest rates on loans from financial institutions has an adverse impact on house prices in all regions, with little difference in the degree of impact.

4. Conclusions and Recommendations

The following conclusions are drawn from the study results: the positive impacts of urban household disposable income per capita, the share of tertiary industry in GDP and resident population on house prices in eastern and central-western cities, and the negative effects of loan interest rates of financial institutions. GDP per capita, residential investment amount, residential land area, actual foreign capital utilization and loan-to-deposit ratio of financial institutions show differences in their effects on house prices in eastern and central-western cities.

In response to the fact that the impact factors will have different effects on housing prices in eastern and central and western cities, the government should do what is appropriate for the local context, and this paper provides the following proposals.

The price of housing in the eastern region is higher and is in the stage of rapid increase, and it is exposed to policy changes, so the government should respond in a timely manner. The government can exert an effective regulation on the price of housing by adjusting the amount of residential investment, the amount of lending by financial institutions and the interest rate of loans by financial institutions.

The government should first support mid-western region's progress, especially to support the development of tertiary industry, and continuously improve the economic level to enhance t the GDP per head and discretionary earnings per head, so that residents have the strength to purchase houses and thus boost the improvement of household prices. Secondly, the government can increase the efforts to introduce talents to the central and western cities, so that people with high education level can become the main force to increase the population, and the government can also appropriately reduce the loan interest rate of financial institutions, so that more talents can settle in the region. Finally, the government can promote the development of foreign cooperation, so that more foreign capital can flow into the country and strengthen the realized volume of overseas capital utilized in the real estate industry.

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