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Predictivity of House Prices between Cities: The Case of Chengdu and Xian

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Abstract: **Located in West China, Chengdu and Xian are two spatially close cities. Hence, their housing markets may move together due to similar macro-regulative policies, short geographical distance, and close trade ties. This paper aims to study the new home markets between Chengdu and Xian. Data were monthly house price indices over the period from January 2011 to August 2020. We tested for unit root using the ADF, PP tests, and the Perron test (Model C). Cointegration tests used the Engle-Granger and Johansen methods. We found no long-run relationships, which may be attributed to geographical barriers for a long period and typical climate difference. We estimated VARs. A uni-directional causal effect was suggested running from Xian to Chengdu. The short-run dynamics may help the development of a long-run connection. In the long run, home investors may gain from a home portfolio across these two cities.**

Keywords: **Long-run equilibrium, house price, market, dynamic, Granger causality, VAR model.**

I. INTRODUCTION

Located in West China, Chengdu and Xian are the capitals of Sichuan Province and Shanxi Province, respectively. They are geographically neighboring cities. The distance between these two cities is 605 km. By high-speed train, one can take about three hours to go between these two cities. Urban and regional housing markets may affect each other [1-10]. This paper aims at studying the connections between the new housing markets in Chengdu and Xian.

II. METHODS

We conducted cointegration tests to examine long-run relations between housing markets [11-15]. The Johansen test used the following vector autoregressive model (VAR):

$$\Delta y_t = \Gamma_1 \Delta y_{t-1} + \ldots + \Gamma_{k-1} \Delta y_{t-k+1} + \Pi y_{t-k} + \mu + \Phi D_t + \varepsilon_t$$

We estimated $\mathbf{\Pi} = \boldsymbol{\alpha\beta}'$. Given that variables were not cointegrated, we estimated a valid linear Vector autoregressive model (VAR) between I(1) variables. We conducted the Granger causality test in estimated VARs; Wald-χ^2 tests were applied [16-19].

We tested for unit roots using the augmented Dickey-Fuller (ADF) [20-22], Phillips-Perron (PP) [23]. We tested for a structural shift using the following Perron IO Model C [24-26]:

$$y_t = \mu + \theta DU_t + \beta t + \gamma DT_t + \delta D(TB)_t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \varepsilon_t$$

III. DATA

Data was the monthly newly-completed house price index (2015=100) for the period from January 2011 to August 2020. Two time series are new house prices in Chengdu (HP_CHENGDU) and new house prices in Xian (HP_XIAN). Data were from NBSC [27]. We seasonally adjusted monthly series using the X-12 technique. Data were in logarithms. Data have non-zero means (TABLE I) and have moved upwards over time (FIGURE I). We rejected the normality for HP_CHENGDU and HP_XIAN at the 1% level.

TABLE I: STATISTICS FOR HOUSE PRICES

Definition	New house prices in Chengdu	New house prices in Xian
Variable	HP_CHENGDU	HP_XIAN
Mean	4.74	4.79
Median	4.68	4.72
Maximum	5.08	5.18
Minimum	4.62	4.62
Std. Dev.	0.14	0.17
Skewness	1.31	1.15
Kurtosis	3.18	2.96
Jarque-Bera	33.51	25.47
Probability	0.00	0.00

Notes: The log of a price index (2015=100). Seasonally adjusted (X-12, multiplicative).

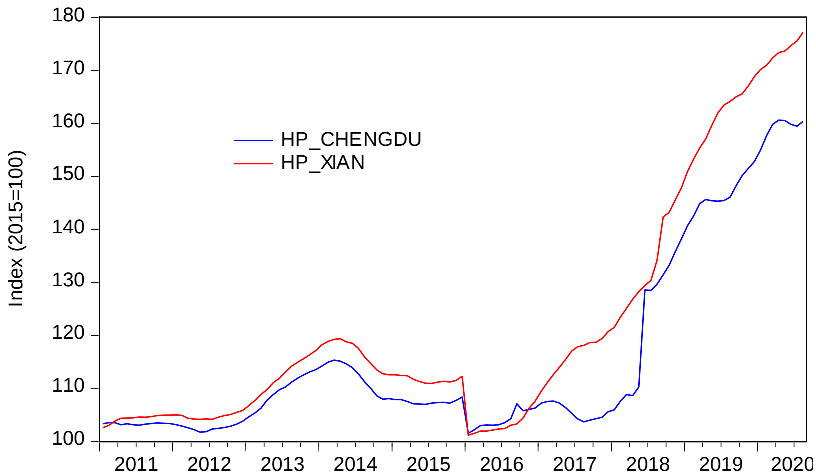

FIGURE I: NEW HOUSE PRICES IN CHENGDU AND XIAN, CHINA (2011.01-2020.08)

IV. EMPIRICAL RESULTS

The ADF, PP tests consistently indicated that HP_CHENGDU and HP_XIAN were I(1) (TABLE II). Although they were trend-stationary, for HP_CHENGDU $\alpha \approx 1(0.93)$ and for HP_XIAN $\alpha \approx 1(0.96)$ (TABLE III). Thus, both HP_CHENGDU and HP_XIAN ~ I(1).

Engle-Granger tests suggested no cointegration (TABLE IV). Also, the Johansen test suggested no (TABLE V). Hence, HP_CHENGDU and HP_XIAN were not cointegrated.

We selected the lag order of 3 for VARs (TABLE VI) and accordingly estimated VAR(3)s (TABLE VII). In the short run, house prices in Xian Granger caused Chengdu but not vice versa (TABLE VIII).

TABLE II: THE UNIT ROOT TESTS

Log variable			k	Level	k	First dif.
HP_CHENGDU		ADF	1	-0.57	1	-6.78***
HP_XIAN						
HP_CHENGDU		PP	6	-0.75	5	-9.72***
HP_XIAN						

Notes: k is the lag length. Tests selected k using the t-statistic for ADF tests, the Newey-West method for PP tests. k was set between 1 and 12 [28]. Test equations contained both the trend and intercept [29]. ***Significance at the 1% level.

TABLE III: THE BREAK-DATE TESTS (THE PERRON MODEL C)

Log variable	k	α	t^*_α	T_b
HP_CHENGDU	3	0.93	17.1	Aug 2018
HP_XIAN	3	0.96	24.1	Mar 2016

Note: We report α only for space reduction. T_b was the break date. The lag order k was chosen between 2 and 12 according to [28]. $\lambda = 0.20$. The critical values for the sample size of 100 were −6.21, −5.55, and −5.25 at the 1%, 5%, and 10% level, respectively [24].

TABLE IV: ENGLE-GRANGER TESTS

Dependent variable	Z_α-statistic	p-value
HP_CHENGDU	-13.6	0.23
HP_XIAN	-13.4	0.22

Notes: Data are transformed into logarithms and in first differences. We selected the lag order k using the t-statistic [30]. The selection was made from a maximum value of 10 downwards. Tests were at the 5% level. p-values in [31].

TABLE V: JOHANSEN COINTEGRATION TESTS

r	Trace	O-L*	Cheung-Lai**	Reinsel-Ahn***
0	11.46	20.3	21.6	10.3
≤1	1.87	9.16	9.77	1.67

Notes: r is the null hypothesis of the cointegration rank of at most r. Assumption: II. *5% Osterwald-Lenum asymptotical critical values [32]. **Cheung-Lai finite-sample critical value corrections [33]. ***Reinsel-Ahn finite-sample trace corrections [34]. The lag order was selected by AIC = -11.5, and SIC = -10.9. LM statistic up to the lag order 1 for no serial correlation = 5.96, with a p-value of 0.20. Multivariate normality (Jarque-Bera) = 111, with a p-value of 0.00 [35].

TABLE VI: LAG SELECTION FOR THE VAR MODEL

Lag	LR	AIC	SC	HQ
0	NA	-4.67	-4.62	-4.65
1	696.75	-11.23	-11.08*	-11.17*
2	7.30	-11.23	-10.98	-11.13
3	4.76	-11.20	-10.85	-11.06
4	19.31*	-11.32*	-10.87	-11.14
5	4.10	-11.29	-10.74	-11.07
6	2.17	-11.24	-10.59	-10.98
7	1.68	-11.18	-10.44	-10.88
8	1.87	-11.13	-10.28	-10.79

Notes: *indicates the selected lag. LR: sequential modified LR test statistic (each test at 5% level). HQ: Hannan-Quinn information criterion. Final lag=3.

TABLE VII: ESTIMATES OF VECTOR AUTOREGRESSIVE MODELS (VARS)

	Dependent	Dependent
Independent lagged term	HP_CHENGDU	HP_XIAN
HP_CHENGDU(-1)	-1.002(-9.32)	-0.008(-0.10)
HP_CHENGDU(-2)	-0.07(-0.44)	0.15(1.26)
HP_CHENGDU(-3)	-0.06(-0.58)	-0.13(-1.61)
HP_XIAN(-1)	0.13(0.93)	1.21(11.5)
HP_XIAN(-2)	0.15(0.22)	-0.12(-0.78)
HP_XIAN(-3)	-0.06(-0.41)	-0.08(-0.74)
Adj. R^2	0.99	0.99
F-statistic	1339	3192
AIC	-5.27	-5.82

Notes: t-statistics in parentheses.

TABLE VIII: GRANGER CAUSALITY TESTS

H_0	Wald-χ^2	p-value
HP_XIAN to HP_CHENGDU	8.87	0.03
HP_CHENGDU to HP_XIAN	2.92	0.40

Notes: Tests were conducted in estimated VARs.

V. CONCLUDING REMARKS

We found no long-run relationships between Chengdu and Xian's new home markets. Although Sichuan and Shanxi provinces are geographically adjacent, with Chengdu and Xian being their respective capitals, two cities had long been blocked by mountains and have typical climate differences. Along with the Chengdu-Xian high-speed train in operation in mid-2017, buyers may have more choices across cities. Thus, we found a uni-directional causal effect running from Xian to Chengdu.

In the long run, home investors may gain from a home portfolio across these two cities.

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