Locally Weighted Quantile House Price Indices and Distribution in Japanese Cities, 1986–2015

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Introduction

In many economically advanced nations, the formation and collapse of property bubbles has had a profound impact on economic administration. In Japan, the property bubble that began around the mid-1980s has been called the greatest bubble of the 20th century.

It is important to understand how house prices develop during a boom and a burst. House prices may not change at a uniform rate within a suburban area or across metropolitan areas. For example, the timing of the boom in the Greater Tokyo area may have varied from that of the Kansai area. Moreover, as each metropolitan area is large, the appreciation rates of high and low-priced houses might differ within a region; even the change in distribution can vary within a metropolitan area. In such cases, a single price index cannot adequately describe changes in house price distribution across metropolitan areas.

The objective of this study is to use locally weighted and the quantile approach to construct house price indices, to show how distribution changed in both the Greater Tokyo area and the Kansai area in the 1986–2015 period. We then compare the difference in the change in distribution of these two metropolitan areas affected by the asset bubbles.

Data

The dataset used in this study contains condominium data listings for two large Japanese metropolitan areas (i.e., the Greater Tokyo and Kansai areas) over 30 years (i.e., 120 quarters), starting from the first quarter of 1986 (i.e., 1986Q1) and ending with the fourth quarter of 2015 (i.e., 2015Q4). This dataset is provided by Suumo (Residential Information Website), which is owned by Recruit Co., Ltd., one of the largest vendors of residential lettings information in Japan.

This dataset contains the final week's listing price, just before removal due to sale. The structural characteristics include floor space and building age. The amenity characteristics include walking time to the nearest station, time by train in the day time to the nearest terminal station, and to the city center. The location characteristics include city code, address, latitude, and longitude. There are 438,020 observations for the Greater Tokyo area, and 119,779 observations for the Kansai area.

In this dataset, house transactions in the Greater Tokyo area involve three large cities (Tokyo, Yokohama, and Kawasaki) and several small cities (Saitama, Chiba, Hachioji, Mitaka, and Sagmihara). House transactions in the Kansai area involve three large cities (Osaka, Kyoto, and Kobe) and three small cities (Otsu, Sakai, and Nara). The transactions in Tokyo's 23 special wards account for 44% of all transactions, while those in Osaka account for 10% of all transactions.

Table.1 Summary Statistics

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	Nylh{ly#[vr¢v		Rhuzhp	
	M|ss	Th{jolk	M|ss	Th{jolk
Spz{#Wypjl	3668.6	3662.9	2783.8	2499.5
/873777 `lu0	(2021.0)	(2151.4)	(1549.8)	(1448.3)
Wypjl#wly#zx|hyl#tl{ly	61.69	58.96	41.96	36.12
/873777#`lu/$m^2$0	(31.27)	(29.99)	(22.77)	(18.05)
Hnl	61.49	63.17	67.86	69.15
/tvu{o0	(18.51)	(18.16)	(15.96)	(15.01)
Hnl	163.2	165.9	157.0	167.0
/tvu{o0	(93.95)	(94.62)	(92.42)	(90.54)
[ptl#{v#{ol#Ulhylz{	8.500	8.359	7.553	7.728
Z{h{pvu#/tpu|{lz0	(4.776)	(4.720)	(4.479)	(4.534)
[ptl#{v#[lytpuhsZ{h{pvu	17.06	16.97	14.97	15.81
/tpu|{lz0	(10.46)	(10.11)	(8.708)	(8.921)
[ptl#{v#JIK	34.64	34.69	32.73	33.80
/tpu|{lz0	(13.26)	(13.13)	(17.36)	(17.22)
U	438020	235048	119779	57883

Method

We present a locally weighted quantile method to show the change of distribution for the Greater Tokyo area and Kansai area. Locally weighted regression (loess) is a non-parametric approach that allows coefficients to vary smoothly for a neighborhood. Indices based on the locally weighted approach could describe more appropriately how property markets develop within small geographic areas. We apply following procedures for both the Greater Tokyo area and Kansai area.

Step 1. We first use propensity score matching to prepare a matched sample. Using 2000Q1 as the base each time, we estimate a series of logit models for each subsequent quarter. First, for each quarter q from 1986Q1 to 2015Q4 (excluding 2000Q1), we estimate a logit regression of all sales in 2000Q1 and q.

Step 2. Estimate locally weighted models for a set of target locations, with more weighted being assigned to observations that are closer to the target locations. Letting d_i represent the distance from the target site to the location associated with observation i, the weight assigned to observation i when estimating the model for the target location is $K(d_i)$, where K is any standard kernel weight function. For the quantile approach, the weighted version can be expressed as finding the $\hat{\beta}(q,d)$ that minimizes the locally weighted objective function $\sum_i K(d_i)\rho_q(y_i - x_i'\beta)$

Step 3. The quantile range of $q = 0.02 - 0.98$, in increments of 0.02, implies a number of quantiles $B = 48$. For each quantile, we estimate the Step 2. at a set of target locations and then interpolate to all other locations in the dataset for each metropolitan area. We use a tri-cube kernel with a 25% window, based on the straight-line distance between each observation and the target point. The result of the estimation procedure is a set of $n \times B \times k$ estimated coefficients for each metropolitan area. (n is number of observations for each region and k is number of explanatory variables.)

Step 4. Multiple set of $n \times B \times k$ estimated coefficients with explanatory variables for each observations. We get a set of $n \times B$ counterfactual prices for each metropolitan area. In this way, the estimated density in each year for each of the Greater Tokyo and Kansai areas can be easily derived.

Results

We first show a standard hedonic regression results for the log of price for matched samples of he Greater Tokyo and Kansai areas in Figure 1. The hedonic formation is as follows:

$$\ln(Price) = \beta_0 + \beta_1 area + \beta_2 age + \beta_3 t_{station} + \beta_4 t_{center} + \beta_5 t_{CBD} + \beta_6 latitude + \beta_7 logtitude + D_t\beta + \epsilon$$

The coefficient of time dummies D_t are shown as hedonic indices in Figure 1. For both areas, the peak of the boom is in 1990; however, the beginning of the boom in the Greater Tokyo area occurred in 1986, which is somewhat earlier than that in the Kansai area (i.e., after 1987). The appreciation rate for the Kansai area was incredibly large during the 1987–1990 period. For the Kansai area, the postpeak decline occurred a little earlier than did that of the Greater Tokyo area; additionally, the burst in the Greater Tokyo area stopped in 2000—even as house prices in the Kansai area continued to decline, until 2003. In both areas, house prices recovered after 2006 and declined again in the 2008–2010 period, principally because of the subprime crisis in the United States. House prices again recovered after 2012, to reach their highest postbubble level.

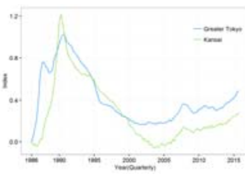

Figure. 1 Hedonic Price Indices

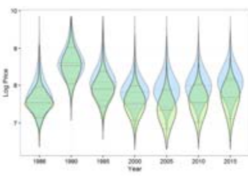

Figure. 2 Violin Plot

Figure 2 presents violin plots of locally weighted quantile regressions, to show the estimated distributions. It is possible to compare the change of distribution of two metropolitan areas. The blue violins are estimated densities for the Greater Tokyo area, and the green violins are estimated densities for the Kansai area. We select seven years to show the change in densities. The density of the Kansai area in 1986 shows small variance and many middle-priced houses, while the variance of density of the Kansai area in 1900 is smaller than that of Greater Tokyo. The difference in price increased after 2000, as did the difference in variance. After 2000, the variance in house prices in Kansai increased, and the depreciation rate of low-priced houses was larger than those of middle and high-priced houses.

Figure 3 and 4 shows the counterfactual distributions of two metropolitan areas. Left panels of both Figure 3 and 4 are the results of locally weighted quantile regression estimates for the set of matched samples. We select three years—namely, 1986, 1990, and 2000—to show the change in distribution in the bubble period, and the change in three recent years (i.e., 2005, 2010, and 2015). These densities indicate that not only the price changed over time, but also that variance changed considerably. Middle panels are the counterfactual distributions of simulating the floor space as $65\ m^2$. Right panels are the counterfactual distributions of simulating the building age as 13 years. The results shows that the change of covariates impact the change of distributions a lot. It is comparable of counterfactual distributions using locally weighted quantile approach.

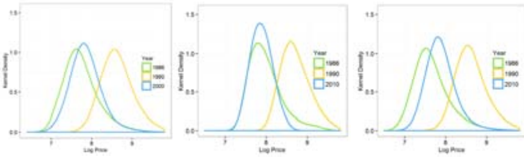

Figure. 3 Counterfactual Distributions of the Greater Tokyo Area

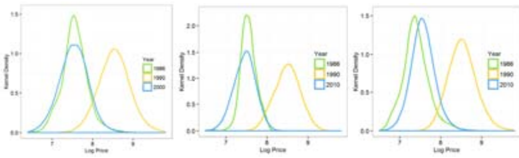

Figure. 4 Counterfactual Distributions of the Kansai Area

Figure 5 presents the appreciation rates for 1986–1990 (top panels) and 1990–2000 (bottom panels), for small, local districts. In that figure, wherever there is more red of top panels and dark blue of bottom panels, it means the absolute values of the appreciation rate are large. During the bubble and the burst, the absolute values of the appreciation rates were large in Osaka, Kyoto, and Nara. However, the northern part of Kobe had the largest appreciation rate in the 1986–1990 period, while the southern part saw a greater decline in the 1990–2000 period. The 23 special wards of the Greater Tokyo area saw the biggest decline of the 1990–2000 period. The regions that saw the largest appreciation rates are not limited to those in special wards.

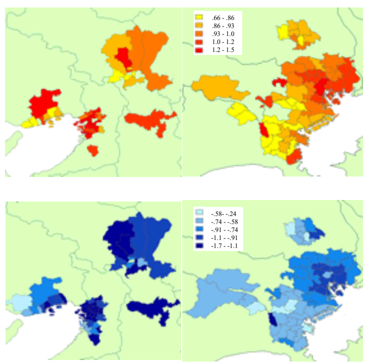

Figure. 5 Appreciation Rate 1986-1990, 1990-2000