Weekly Hedonic House Price Indices and the Rolling Time Dummy Method: An Application to Sydney and Tokyo

Presenter: Robert Hill
University of Graz

Joint work with
Michael Scholz (University of Graz) and Chihiro Shimizu
(Nihon University)

Hitotsubashi-RIETI International Workshop on Real Estate Market, Productivity, and Prices in Tokyo 13-14 Oct 2016

Introduction

• The Rolling-Time-Dummy (RTD) method for computing hedonic house price indexes was first proposed by Shimizu, Takatsuji, Ono and Nishimura (2010).

• RTD is a flexible method that is particularly well suited to smaller data sets. For example, the smaller the window length, the longer the window can be made to ensure there are enough data to estimate the hedonic model.

• RTD has now been adopted by the national statistical institutes (NSIs) of Ireland, Malta, and Cyprus to compute the official House Price Indexes (HPIs) of these countries.

• Given RTD is well suited to smaller data sets it is a natural candidate for constructing weekly indexes.

- An important question with the RTD method is how can one determine the optimal window length for a particular data set?

- There are also different versions of the RTD method depending on which time dummy variable in the window is selected to link with the current period time dummy. This further increases the flexibility of the RTD method.

- We assess the sensitivity of quarterly, monthly, and weekly RTD price indexes to the choice of window length and linking method using detailed micro data for Sydney and Tokyo.

- We then consider some criteria for deciding on the optimal window length and linking method in a data set.

The RTD Method of Shimizu et al. (2010)

Supposing that the first period in the window is period t, the first step is to estimate a semilog hedonic model as follows:

$$\ln p_h = \sum_{c=1}^{C} \beta_c Z_{hc} + \sum_{s=t+1}^{t+k} \delta_s D_{hs} + \varepsilon_{hs},$$

where c indexes the set of characteristics and the D_{hs} are time dummy variables.

The change in the price index from period $t + k - 1$ to period $t + k$ is then calculated as follows:

$$\frac{P_{t+k}}{P_{t+k-1}} = \frac{\exp(\hat{\delta}^t_{t+k})}{\exp(\hat{\delta}^t_{t+k-1})}.$$

An Alternative Linking Method

Instead of always focusing on the last two estimated δ coefficients in each hedonic model, an alternative would be to take the last and third last coefficients. Now we have that:

$$\frac{P_{t+k}}{P_{t+k-1}} = \left(\frac{P_{t+k-2}}{P_{t+k-1}}\right) \frac{\exp(\hat{\delta}^t_{t+k})}{\exp(\hat{\delta}^t_{t+k-2})}.$$

More generally,

$$\frac{P_{t+k}}{P_{t+k-1}} = \left(\frac{P_{t+k-j}}{P_{t+k-1}}\right) \frac{\exp(\hat{\delta}^t_{t+k})}{\exp(\hat{\delta}^t_{t+k-j})},$$

where $j \leq k$. In other words, there are k distinct ways of linking period $t+k$ with the earlier periods when the window length is $k+1$ periods.

Another possibility is to take an average of these k sets of results as follows:

$$\frac{P_{t+k}}{P_{t+k-1}} = \prod_{j=1}^{k} \left[\left(\frac{P_{t-j}}{P_{t-1}} \right) \left(\frac{\exp(\hat{d}_t)}{\exp(\hat{d}_{t-j})} \right) \right]^{1/k} .$$

In the empirical comparisons that follows we assess the impact on the RTD price indexes of both varying the window length and changing the way period $t + k$ is linked to the earlier periods.

The Estimated Hedonic Models

The data set for Sydney focuses on houses only (i.e., apartments are excluded) covering the years 2001-2014 and containing 433 202 observations.

The explanatory variables are:
number of bedrooms
number of bathrooms
land area
house type (detached, or semi)
longitude and latitude

The estimated hedonic model is semiparametric with the geospatial data (i.e., longitudes and latitudes) included as a nonparametric spline surface.

The data set for Tokyo focuses on condominiums only (i.e., houses are excluded) covering the years 1986-2016 and containing 242 233 observations.

The explanatory variables used here are:
floor area (included as quadratic)
age (included linearly)
city code

More data are available for Tokyo. So the results are preliminary. The hedonic model will be re-estimated in due course using more characteristics and a more flexible functional form.

How Much Difference Does It Make?

We consider quarterly window lengths of 2-9 quarters,
monthly window lengths of 2-13 months,
weekly window lengths of 2-53 weeks.

Similar results are observed for both Sydney and Tokyo.

The quarterly and monthly indexes are not very sensitive to the choice of window length, while the weekly indexes are highly sensitive to it.

Holding the window length fixed at 53 weeks, the sensitivity of a weekly RTD method to the choice of linking method is smaller (although still significant) for Sydney than the sensitivity to the choice of window length.

Figure 1 : The Spread of Quarterly RTD Indexes for Sydney as the Window Length Is Varied Between 2 and 9 Quarters

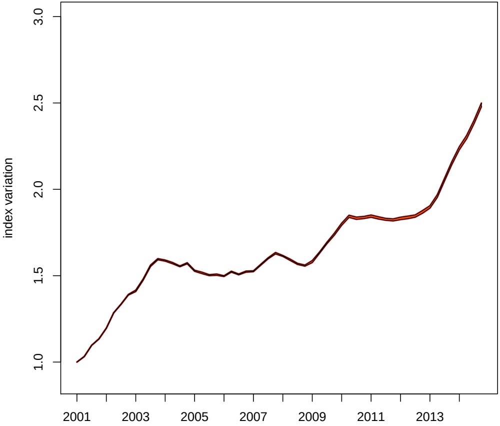


Figure 2 : The Spread of Monthly RTD Indexes for Sydney as the Window Length Is Varied Between 2 and 13 Months

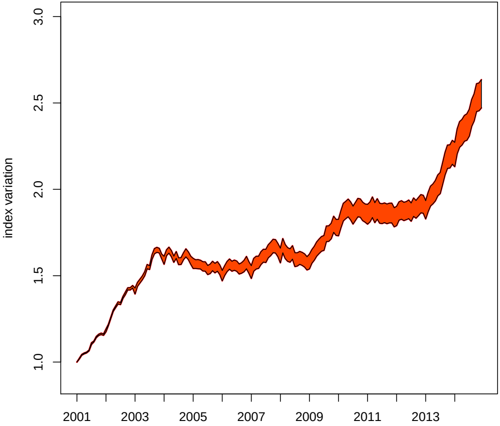


Figure 3 : The Spread of Weekly RTD Indexes for Sydney as the Window Length Is Varied Between 2 and 53 Weeks

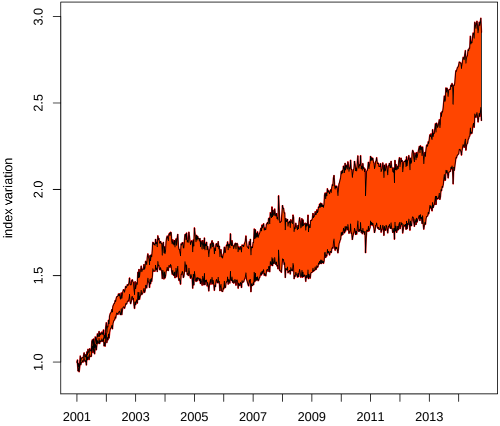


Figure 4 : The Spread of Quarterly RTD Indexes for Tokyo as the Window Length Is Varied Between 2 and 9 Quarters

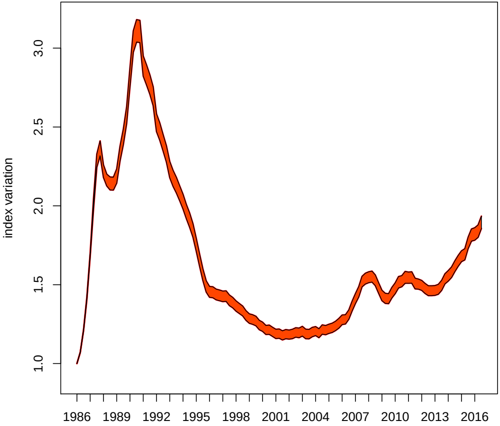


Figure 5 : The Spread of Monthly RTD Indexes for Tokyo as the Window Length Is Varied Between 2 and 13 Months

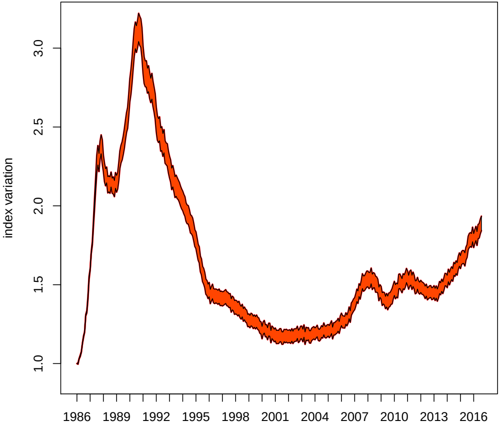


Figure 6 : The Spread of Weekly RTD Indexes for Tokyo as the Window Length Is Varied Between 2 and 53 Weeks

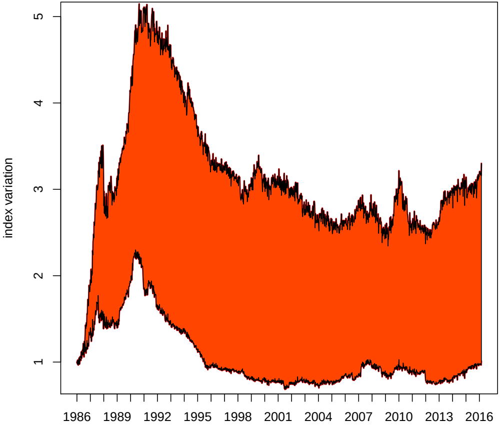
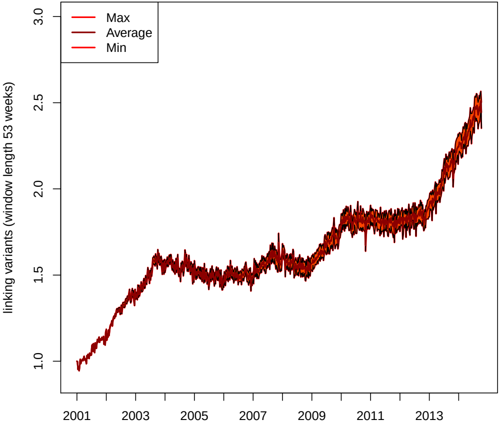


Figure 7 : The Spread of Weekly RTD Indexes with a 53 Week Window for Sydney as the Linking Method Is Varied



Criteria for Determining the Right Window Length

(i) Quarterly indexes as a benchmark

Given the relative stability of quarterly indexes, they can be used as a benchmark to assess the performance of weekly indexes.

$$E = \sum_{t=1}^{T-25} \left[\ln \left(\frac{P^w_{t+19}}{P^w_{t+6}} \right) - \ln \left(\frac{P^q_{(t+13,t+25)}}{P^q_{(t,t+12)}} \right) \right]^2$$

where t indexes the weeks in the data set and T denotes the total number of weeks (e.g., 712 in the Sydney data set). P^w denotes a weekly index while P^q denotes a quarterly index.

To ensure the time intervals being compared match, we define each period in the quarterly index as consisting of 13 weeks.

Here we use a quarterly time-dummy hedonic index as the benchmark. We will check the robustness of the results to the choice of benchmark formula.

The optimal window length for Sydney according to the E-statistic is about 26 weeks.

For Tokyo, no clear pattern seems to emerge for the E-statistic. Possibly we could conclude that about 20 weeks is best.

Figure 8 : The E Statistics for Sydney as the Window Length Is Varied Between 2 and 53 Weeks

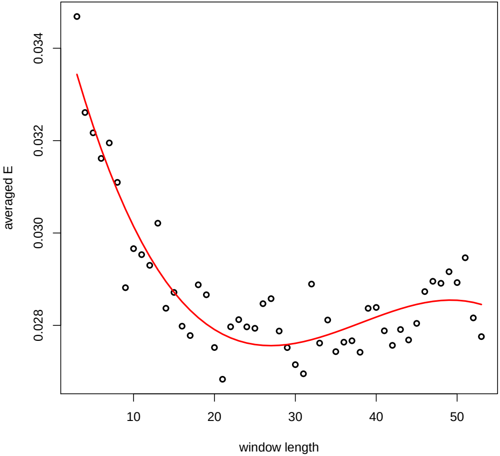
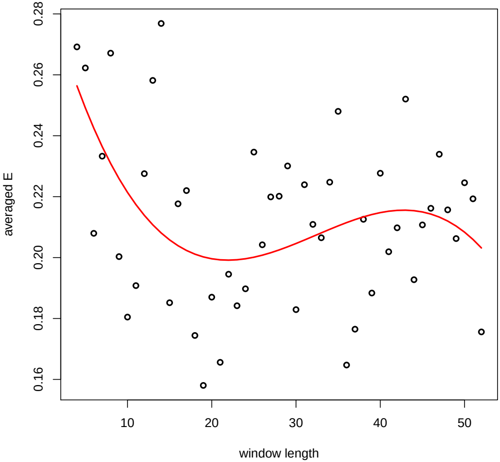


Figure 9 : The E Statistics for Tokyo as the Window Length Is Varied Between 2 and 53 Weeks

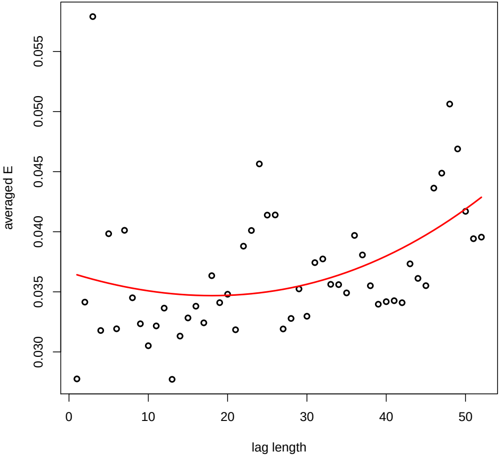


Applying the E-statistic to the linking question holding the window length fixed at 53 weeks, we find that the optimal link is about 18 weeks before the current period.

The average linking method generates a E-statistic that is lower than 51 of the 52 shown in the Figure.

This suggests that the average linking method applied to a rolling window of about 26 weeks may be a good candidate for constructing a weekly house price index for the Sydney data set.

Figure 10 : The E Statistics for Sydney for a 53 Week Window as the Linking Method Is Varied



(ii) A weekly repeat-sales index as a benchmark

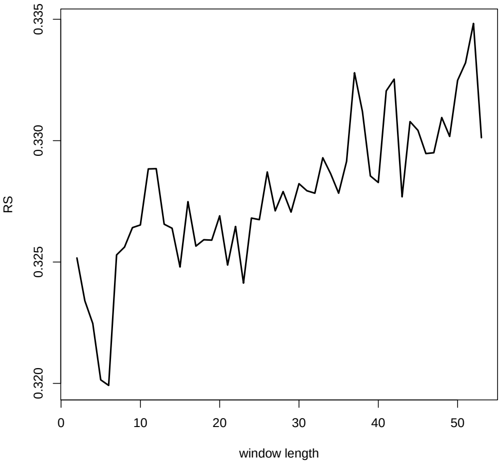
The same principle can be applied except now using a weekly repeat-sales index as the benchmark. The RS statistic is calculated as follows:

$$RS = \sum_{t=1}^{T-1} \left[\ln \left(\frac{P_{t+1}^{RTD}}{P_t^{RTD}} \right) - \ln \left(\frac{P_{t+1}^{RS}}{P_t^{RS}} \right) \right]^2 .$$

This is not to say that a repeat-sales index is better than a hedonic index, but it does provide a neutral benchmark that is not linked to any particular hedonic method.

When a weekly repeat-sales index is used as the benchmark, the results are quite different. Now the optimal window length for Sydney is about 6 weeks.

Figure 11 : The *RS* Statistics for Sydney as the Window Length Is Varied Between 2 and 53 Weeks



(iii) Volatility

Our third criterion V has been previously advocated by Guo et al. (2016). It measures the volatility of the price indexes from one week to the next as follows:

$$V = \sum_{t=1}^{T-1} \left[\ln \left(\frac{P_{t+1}}{P_t} \right) \right]^2 .$$

A high value of V suggest that the house price index is failing to adjust for quality change. For example, a median index should have a high V.

A variant on V also considered by Guo et al. (2016) is compare the week-on.week changes in a price index with its smoothed Hodrik-Prescott filter (or some other filter):

$$HP = \sum_{t=1}^{T-1} \left[\ln \left(\frac{P_{t+1}^{RTD}}{P_t^{RTD}} \right) - \ln \left(\frac{P_{t+1}^{HP}}{P_t^{HP}} \right) \right]^2 .$$

Again the presumption is that a smaller value of HP is better.

The RS, V and HP criteria all give similar results for Sydney. In all cases the optimal window length is about 6 weeks.

For Tokyo the V and HP statistics likewise give similar results, with the optimal value being about 12 weeks. We have not yet computed RS for Tokyo.

Figure 12 : The V Statistics for Sydney as the Window Length Is Varied Between 2 and 53 Weeks

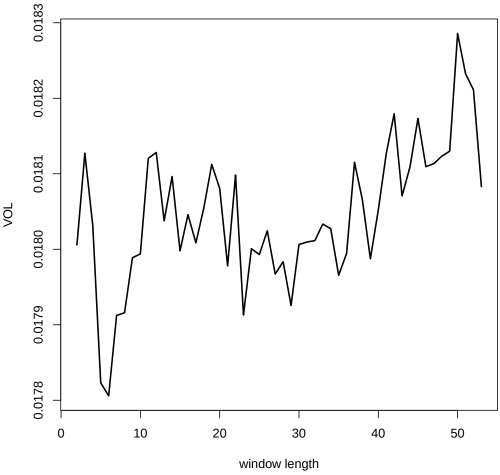


Figure 13 : The V Statistics for Tokyo as the Window Length Is Varied Between 2 and 53 Weeks

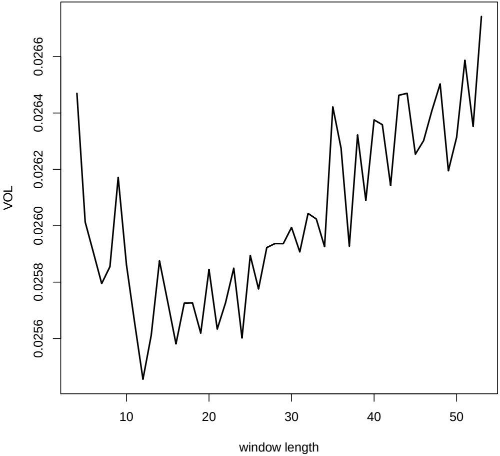


Figure 14 : The *HP* Statistics for Sydney as the Window Length Is Varied Between 2 and 53 Weeks

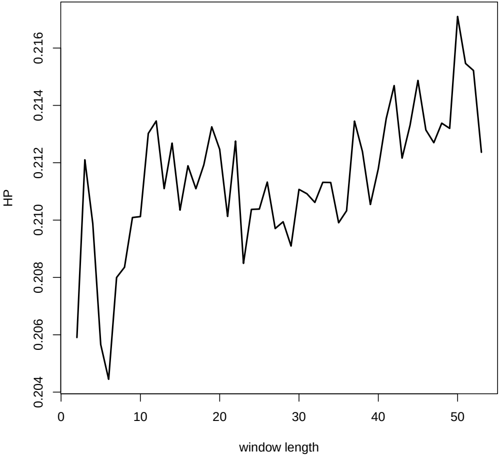
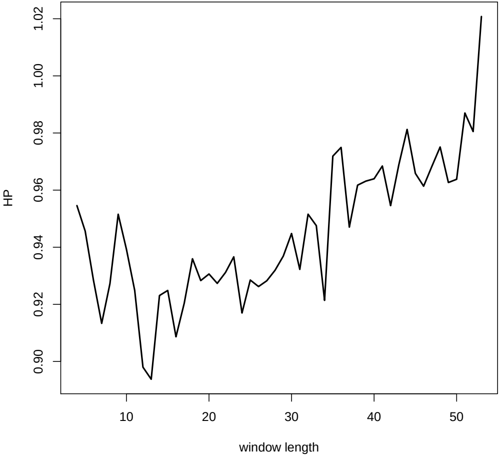


Figure 15 : The *HP* Statistics for Tokyo as the Window Length Is Varied Between 2 and 53 Weeks



Conclusions

• Weekly RTD house price indexes are highly sensitive to the choice of window length. Monthly and quarterly indexes are much less sensitive to this choice.

• A weekly RTD index is a bit sensitive to the choice of linking method, although definitely not as much as to the choice of window length.

• We have proposed some criteria for comparing the performance of weekly house price indexes. Our preferred criterion is to use quarterly indexes as a benchmark.

• According to our preferred criterion (which uses quarterly indexes as a benchmark), the optimal window length for the Sydney data set seems to be about 26 weeks, and the best linking method is to take an average of all possibilities.

• The *RS*, *V* and *HP* criteria all generate similar results in each city. We are still trying to interpret the meaning of these results.