Risk Modelling - Unsmoothing project

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Unsmoothing

Appraisal-based indices are a major source of empirical time-series data on unsecuritised commercial property. These indices are characterised by lag or, in other words, they are smoothed. This smoothing is a consequence of two factors. Factor from appraisers' partial adjustment plays a role on the level of individual properties. On the index level, however, temporal aggregation plays a role.
Our aim is to correct this smoothing without assuming an efficient market. This is achieved by modelling the structure of publicly reported index returns and taking into account the effects of appraisal smoothing, temporal aggregation, and seasonality of appraisals.

On the individual level the appraised value of a property is the appraisers' estimate of its market value or its most likely transaction price at a certain point in time. However, these values are only partially adjusted over time - each new appraisal is, to some degree, based on the last one. One of the reasons for it to happen is having the same appraiser perform a valuation of a property year after year. This means that the appraiser is aware of the previous appraised value and will therefore be reluctant to make large changes to it. This type of error resists diversification in an index.

We can model this behaviour using adaptive expectations approach. Here, V_t^* will represent the appraisal value at time t, V_t^E empirical indication of true market value V_t and α the smoothing factor.

$$V_t^* = \alpha V_t^E + (1 - \alpha)V_{t-1}^* \tag{1}$$

Furthermore, we shall assume that the difference between V_t^E and V_t is a purely random error e_t:

$$V_t^E = V_t + e_t. \tag{2}$$

Combining two previous equations gives us:

$$V_t^* = \alpha V_t + (1 - \alpha)V_{t-1}^* + \alpha e_t \tag{3}$$

Unsmoothing factor α lies between 0 and 1 and is determined by the market return series and the random error series through:

$$\alpha = \frac{\sigma^2(r_t)}{\sigma^2(r_t) + \sigma^2(e_t)} \tag{4}$$

We can see that if the factor α is set too high we get large errors in our appraisal value and if it is set too low not enough weight is given to the current market value.

This effect that plays a role on the individual level is compounded by temporal aggregation on an index level. Valuation of properties is done on an annual level with most of them reported in the fourth quarter. Indices we will be working on, however, are reported quarterly, and this introduces a fourth order autocorellation in our data and increases quarterly volatility.

Taking these effects into account we can model the index returns as:

$$r_t^{**} = \frac{\alpha}{2}(2-3f)r_t^U + \frac{\alpha}{2}(2-2\alpha+3f)r_{t-1}^U + \\ + \frac{\alpha}{2}(2-2\alpha+3f)(1-\alpha)r_{t-2}^U + \frac{\alpha}{2}(2-2\alpha+3f)(1-\alpha)^2 r_{t-3}^U + \cdots \tag{5}$$

Where r_t^{**} represents the publicly reported index return for year t, r_t^U the underlying market return and f fraction of properties reappraised in each of the first three quarters of the year.

The problem arises due to impossibility of recovering underlying return series from the series of index returns. However, due to exponential decline of all coefficients beyond lag 1 we can approximate the relation with the first-order autoregressive model:

$$r_t^{**} = ar_t^U + (1-a)r_{t-1}^{**} = ar_t^U + a(1-a)r_{t-1}^U + a(1-a)^2 r_{t-2}^U + \cdots \tag{6}$$

The key in this approximation is choosing a good value for the coefficient a. To do this we need to approximate α and f first. As roughly 55% of reappraisals are done in the fourth quarter we can approximate f as $f \approx \frac{1-55\%}{3} \approx 0.15$. Optimal level for α should be around 0.5. This can be justified by looking at empirical evidence that suggests that for the error series $sigma^2(e_t) \approx 0.01$ and that the volatility of commercial property returns are about one-half of those of the stock market. Given that the standard deviation of the later is around 20%, volatility of the property return series is roughly $\sigma^2(r_t) = 0.01$. This gives us an alpha of $\alpha \approx \frac{0.01}{0.01+0.01} = 0.5$. These values of the coefficients α and f gives transfer function lag weight similar to those coefficient a would give for the value of $a = 0.4$. When unsmoothing the returns we will, in addition to the already mentioned baseline scenario, consider upper and lower bound of $a = 0.5$ and $a = 0,33$ respectively.

Nowcasting

Nowcasting is the science of determining a trend or a trend reversal objectively in real-time for very short intervals. It focuses on the known and knowable, and is the basis of a robust decision-making process. To nowcast the model we shall use expectation maximisation algorithm. It optimises the likelihood of seeing observed data while estimating the parameters of a statistical model with unobserved variables. First step in doing so is upsampling the quarterly data to monthly. This will be done using linear interpolation. After this step is done data needs to be fed to the machine learning algorithm. This will be done twice - once with the entire data set and once with the reduced data set containing only complete index data. In the first case missing data was replaced with the mean index values. Output will provide not only the predicted values but also the influence of different indices in creating those predictions.