Repeat Sales and Urban Price Indices: a New Approach

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Abstract

In the framework of the standard repeat-sales model we present a new methodology for estimating house price indices, which is based on the application of a final compound return. This technique, while being straightforward, has a strong advantage as it avoids the revision of previous price trends after new data become available in later years. The first application we attempt to achieve by constructing such an index is to discover profitability variations resulting from environmental changes. The results obtained both from a simulation procedure and a database sample for Bordeaux region in France, demonstrate the validity of our method and are consistent with the estimators calculated by means of existing well-known techniques within the repeat sales approach.

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Introduction

Indices are indicators which aim at describing the evolution of a set of variables through time. As they seek to capture the general performance of the whole market, they should perfectly mimic the evolution of its underlying components in order to reflect as closely as possible price variations. A benchmark index is, in some sense, a reference point that can be used as a standard to quantify the relative performance of an investment manager on behalf of an investor (Geltner and Ling, 2001). There is also a theoretical interest that is revealed in building numerous real estate price indices whose aim is to describe more precisely the changes in the market and its tendencies.

Most existing indices are based on a sequence of successive price changes, recorded at regular time intervals, for a given sample. The index value for the corresponding sample is computed through aggregating the sample individual values. However, different methodologies arise regarding the way the individual values should be aggregated (eg. Laspeyres, Paasche, Fisher).

The repeat sale indices diverge from this general principle in three ways. First, the time period between the observations is not constant as it depends on the duration between two successive transactions for a given property. Second, the weighing scheme in aggregation is no longer a concern: repeat sales avoid the heterogeneity issue as they always involve the same property. But the "genius" of the repeat sales method is that it directly aggregate growth rates rather than prices to obtain a growth rate. Index variation explains rather the evolution of the enrichment than that of the price, therefore the result and its interpretation can not be identical in both cases.

In the seminal work by Bailey Muth and Nourse, the computation of indices is based on a regression technique. This technique proves particularly useful from a research perspective whether it be to study the interaction between index values and a set of explanatory variables or to build a predictive model. Crucial to this approach however, is the fact that the studying period remains stable. Actually, as soon as new observations are added to the initial sample, the entire index is going to be revised all the way back to the beginning

Our study is born within the research that focuses on the consequences of political decisions effecting the environment on the evolution of the urban housing market prices. Within the initial hypothesis that, in the absence of environmental changes in infrastructure or legislation applied to the existing market, the growth rates do not reveal radical changes[i] for the different sectors of the city centre, the BMN method appeared to be more pertinent than other models. However, we find strong evidence that indices constructed using the traditional repeat sales approach can lead to significant modifications in the study conclusions as the time period of interest is progressively extended.

Our paper will proceed as follows. In the first section, we set out the model developed by Bailey, Muth and Nourse in 1963 and its most recent improvements, within the framework of the repeat–sales approach. We then turn to the critique of this approach. In section 2, we detail the essentials of our new methodology – which is based on the computation of a final compound return – as well as its major characteristics. Section 3 is devoted to the application of the FCR method. After studying the advantage of FCR over BMN through a simulation study, we turn to its application on field data. Section 4 concludes.

1. Traditional repeat sales methods

1.1. Presentation of the methodology

The repeat sales techniques (hereafter RSM) consist in calculating the price variation for assets that experienced at least two consequent transactions during a given period. Within these techniques, the set of compound returns is used to compute a global index of price evolution.

One drawback is that computations waste a great deal of information as the assets that experienced only one transaction during the sample period are excluded from the computations. However this critique becomes less pertinent when the period is sufficiently long as the sample becomes more representative of the entire population of properties that sold (Mark and Goldberg (1984), find 40% repeat-sales over a twenty-two-year period. Moreover, the longer the sample period, the larger the volatility (Case and Shiller,1989).

Bailey, Muth and Nourse (BMN) suggested to compute the growth rates G_k based on the ratio of $P_{k,t}$ (the price of house k on period t) to $P_{k,t+1}$ (the price of the same house at the next time period t+1). Growth rates for all houses can then be calculated as $G_{k,t} = P_{k,t+1} / P_{k,t}$ (see column 6 in Table 1). In the BMN method, an extrapolation of transaction prices is made for all intermediate periods based on matrix calculations with an aggregation of prices per period. In other words, the BMN method determines the return for each sub-period using Repeat Sale Regression (hereafter RSR) estimators obtained for some “virtual house”. This “virtual” house presents the whole set of assets on the market at this particular time period, and its price depends on all real estate transactions taking place. The “virtual” house is characterized by a ratio of an aggregated price of the first sales’ houses to an aggregated price of the second sales’ houses.

Technically speaking, the BMN method defines the unbiased estimator b which allows to compute the best possible approximation of the extrapolated price P_{extr} with respect to the price of resale P_2. Direct application of ordinary least squares regression yields :

$$\hat{b} = (x' x)^{-1} (x' r) \qquad (1)$$

where:

- x - is the N by T matrix of *dummy* variables taking a value of -1 in the period of the first sale, +1 in the period of the second sale, and 0 otherwise;
- $r_k = \ln(P_{k,tF} / P_{k,t0})$ - is the N by 1 column matrix of the logarithms of the ratio of second prices to the first sale prices of the k^{th} asset, $k=1,\ldots N$. (See the intermediate matrix in Table 1).

From this method, the optimal extrapolated price is found to be:

$$P_{k,t} = P_{k,t-1} * \exp(\hat{b}_t - \hat{b}_{t-1}) \qquad (2)$$

1.2. Illustration

To illustrate the RSM technique we posit an artificial 5 years market with transactions taking place at the market price on years 2000 to 2004. On year 2005, we artificially add two repeat sales: a long one and a short one. The pairs of repeat sales are reported in the left part of Table 1. They are constructed is a way such that the sample pairs cover all possible distributions over time, except in the last year.

The application of the BMN methodology to our artificial market gives the following results. Restricting the analysis to the 2000-2004 period, the BMN estimation of the price index evolution yields: Index ={1; 1,05; 1,1; 1,0; 1,05}. However, as soon as we add the data corresponding to year 2005, the previous index values changes to the one presented in the second row of Table 1 and are found to be: Index ={1; 1,0661; 1,1168; 1,0309; 1,0661; 1,1122}. This modification of all the intermediate indices shows the variations due to the revising done all the way back to the starting period of the year 2000. We will discuss these issues below in part 1.3.

[Table 1]

Note that at the same time the right hand side matrix in Table 1 shows the impact of the additional one year data added; the data contains two repeat sales of the optimized prices of the past transactions; new intermediate prices are obtained by a simple application of the regression coefficients.

Now suppose that the two value of units in 2005 "e=120" and "n=100" are reversed.

The vector of growth rates becomes: Index= {1; 1,034; 1,083; 0,970; 1,034; 1,079} (curve “3” Fig.1) instead of Index={1; 1,066; 1,117; 1,031; 1,066; 1,112} (curve “2” Fig.1)

In this graph we observe readily that a high return (line "e") applied to a long period results in an upward distortion of previous indices (curve "2"). When applied to a short period (curve "3”), on the contrary, it results in a downward distortion. From this illustration, we observe that long-interval sales with higher average rates of price increase lead to upward revisions, while lower average rates of price increase appeal to the downward revisions

[Fig.1]

1.3. Recent improvements of the classic methodology

The example, though basic and simple, brings to light the two major technical problems in the application of the BMN method:

1. The addition of a new date in regression method requires the modification of the equation resulting in the necessity to revise the final index. The methodology does not allow

to introduce new data without a revision of the whole set of price indices. The result is that past values of the price index are revised at the same time that the current value is estimated, and all past indices are modified.

2. The relative importance of the pairs held for longer periods from those held for shorter periods in a data sample infers different final indices over the given period. Moreover, this can be altered by a move from a period of one year to a period of one semester for example. The system way housing units are evaluated affects the price index calculation: the growth rate curves undergo crucial changes, depending on the duration of the period between new transactions added into the set.

Many studies have been generated partly or in whole to resolve these problems. As a result the repeat sales method has strongly benefited from several refinements. Case and Shiller (1989) have contributed in introducing a weighted least squares (WLS) repeat sales method as an improvement to the BMN approach. WLS give less weight to highly influential sale pairs with a long time interval between transactions. Their method uses random walk drift to add weights that are inversely related to the time between sales. The WLS scheme has carried through to such recent works as Deng, Quigley and Van Order (2000).

Goetzmann and Spiegel (1995) introduced an intercept term to the WLS repeat sales methodology, removing the bias associated with the non-temporal component of repeat sales indices, which they attribute to incremental improvements which are not fully screened from the data. RSR estimators are essentially geometric averages of individual asset returns because of the logarithmic transformation of price relatives. In a more recent work, Goetzmann and Peng (2001) proposed unbiased repeat sales estimators analogous to the RSR estimators, relying on arithmetic averages of individual returns instead of geometric averages. They revise arithmetic repeat-sales weights to allow for convexity in the averaging of random returns. Their modification of the BMN algorithm amounts to an optimization problem with a search for an extremum (minimum) for a square metric by β, using the initial conditions on β from formula (1) in order to obtain a minimum variance linear unbiased estimator[ii].

Also let us note that at the base of the matrix construction within the BMN method and its variations, there is the definition of the number of pairs per period and their distribution in time. As soon as this number changes in the past, the data obtained become biased. Many studies have been undertaken in order to eliminate the bias resulting from an anachronistic distribution in number as well as in time (see, for example, Goetzmann and Peng, 2001, or Dombrow et al., 1997).

This brings us to another methodological drawback as stated in Clapp and Giaccotto, (1999), who revealed the fragility of the system of housing units evaluation on the market: the revisions performed within the repeat-sales approach tend systematically to be downward biased. The effect of the duration between transactions is an empirical artifact: the longer or the shorter the period between transactions representing differences in units evaluation are presented, the more the growth rate curve behaviour may change. In terms of indices, the curve may go above or below than the initial growth rate curve.

1.4. Applications

We have performed the comparison of the discussed methodologies within the RS model, namely BMN, WLS and RSR. An application of these techniques to our data sample has proved their consistency, with results comparable to the BMN method. The final results, vectors of growth rate indices b_{WLS}, b_{RSR} are close to the original b_{BMN} indices of market prices, in particular for calculating intermediate prices. This is in line with the conclusions for WRS made by Baroni, Barthelemy and Mokrane (2004) in their study of the Paris repeat sales residential index. There are no considerable changes in the behavior of any of the calculated indices: the differences we observe for the various methodologies are sometimes sensible though they do not allow to improve significantly the results.

We have applied the developed methodology of the RS model to the database of realized real estate transactions in Bordeaux during the period 1985–2000. Prices of individual houses (of a total surface between $50m^2$ and $150m^2$) situated within Bordeaux city form the database. This database has been studied in part in earlier works (see Thion and Bouzdine-Chameeva, 2001 and Thion, Favarger and Hoesli, 2001) and is here completed with data for 3 additional years compared with the initial sample. The new sample contains 1904 cases of repeat sales. In other words, the database includes 3808 transactions corresponding to repeat sales of properties, which represents 29% of total transactions performed (13072 transactions see Table 2). The resale prices $P_{k,t}$ for the transactions that took place during the three years being added to the previous base of transactions have an effect on the whole set of indices constructed before. This is illustrated in Fig. 2, which reports indices calculated by the BMN method for three sub-periods 1985-1995, 1985-1997, and 1985-2000 from the whole database of real estate transactions.

[Fig. 2]

On this graph we observe that in 1995 the value of the index decreases systematically as we add to the sample the new data originated in previous years. The index drops successively from 2.04 for a period 1985-95 to 1.98, as we add the years 1996 and 1997, and to 1.76 with the years 1998-2000 added to the initial set.

The use of the proposed method FCR shall allow us to avoid these problems of revision of index values.

2. New methodology of Final Compound Return (the FCR method)

2.1 General considerations and major concerns

The BMN model implicitly hypothesizes that the evolution of prices between two transactions on the same asset is a function of all pairs of transactions which have taken place before, during and after the related period. Alternatively, this means that for any period considered, e.g. 15 years, the market evolution is affected not only by the set of known transaction pairs but also by all transactions that happened within this period.

Following these considerations, for a given pair of transactions on the same asset, we observe the theoretical evolution of intermediate prices during all the sub-periods preceding a second sale (or a resale) being a function of the evolution of the market. Thus the model suggests that, if a resale happened just one year earlier, it would be possible to identify the price by assigning a theoretical market price, the price that is an adjustment based on the whole set of transactions.

This attractive hypothesis takes into account the whole real estate market whose evolution is affected not only by the day-to-day transactions but also by the valorization of the whole set of assets on the market. There exist similar discussions on the construction of a stock exchange index: is the market price at a given moment a result of the only one observed transaction (that is often marginal compared to the set) or is it determined by the set of shares which are likely to give rise to transactions? The practice, starting with the most well known and used Dow Jones index, favors the first assumption.

However these remarks arises because of the inherent nature of the information embodied in the arrival of an additional paired sale: while one observation reveals information about current market conditions, the accompanying paired-sale reveals information about past prices (Clapham, Englund, Quigley and Redfearn, 2004)

There are two other consequences resulting of the RSR application. The first one concerns the quality of the asset that should reside constant over time, which is a rare case; the second one relates to the methods feature of smoothing the obtained results due to the construction process.

Note that our objective is to construct an index based on the repeat sales that will not be adjusted each time period and that, contrary to the BMN, will reveal differences in prices created by the environmental change. Thereupon we review the problem to construct an index basing on a database comprising the variation rates of prices in between the two dates.

From the technical point of view, there exist two issues that need to be addressed:

1) Which distribution should be adopted for the corresponding return on multiple periods for each sub-period?

2) What aggregation method should be used for the indices' construction for each sub-period?

Multiple solutions can be given for different situations, the consequences of which we analyze in turn.

2.1.1 Intermediate compound return model

This implies that the value of an asset *k* evolves during these two real transactions following a growth rate *g* that reflects the fluctuations of a theoretical market:

$$P_2 / P_1 = (1+G) = (1+g_1)\,(1+g_2)\ldots\,(1+g_t)\ldots.(1+g_n), \qquad (5)$$

where P_1 represents any first sale price and P_2 any resale (repeat, or second sale) price, G corresponds to the global growth rate and g_t describes intermediate growth rates for the N observed years, as *t* changes from *1* to *n*.

Now let us discuss the two other feasible hypotheses regarding this intermediate growth rate. The first one states that an intermediate growth remains the same during all the sub-periods:

$$P_2 /P_1 = (1+G) = (1+g_k)\ (1+g_k)\ldots(1+g_k) = (1+g_k)^n \qquad (6)$$

This actually means that the asset increases or decreases in value in a constant way during all the years when the housing unit has been kept by the same property owner before a resale. This hypothesis, the one that accountants favor due to its simplicity, is far from being feasible when confronting our empirical experience of market evolution.

The second hypothesis assumes that the growth rate is concentrated at the time of the resale, thus considering that the intermediate periodic growth rates are zero for all years prior to the last one. In this case equation (5) can be rewritten as:

$$P_2 /P_1 = (1+G) = (1+0)\ (1+0)\ldots.(1+G), \qquad (7)$$

This hypothesis implicitly assumes that markets evolve only at the time a resale occurs, and that those assets prices at a given moment are independent of transactions held before or after that date.

However, two valuable consequences result from this approach of constructing an index that distinguishes it from the BMN method: the first relates to the aggregation of growth rates G_i; the second one is a procedure to define the base for applying the rates resulting from that aggregation.

2.1.2 Aggregation of returns per sub-periods

Prices from different time periods have to be matched to develop mean indices of the price changes over fixed time periods. This is critical to measure the price changes for a given property over a defined time period. We can integrate variations of annual returns in two different ways.

Through the construction of an index for the whole set of prices with an initial starting value (e.g. 100). This leads us to the calculation of prices at the end of each period (with a value of 100 for the starting year), with a subsequent aggregation of these prices and a recalculation of growth rates. Several statistical tools can be used to synthesize the whole set of compound returns calculated for each pair of transactions. Those most widely used are those cited by Wang and Zorn (1996): arithmetic mean, allowing for the dispersion of data; geometric mean, to reduce the influence of extreme data; and median value that divides a given set into two equivalent groups.

Another way consists in a direct aggregation based on regression analysis of compound returns obtained thanks to the BMN method. Matrix calculations allow to adjust the intermediate compound returns to an aggregated method. The discussion on the preference of methods to use is also linked with biases resulting from these adjustments.

2.2 Methodology based on evaluation of the final compound return.

2.2.1. The FCR model.

Instead of considering a compound return for each pair of transactions per sub-period decomposing in time the corresponding approximate market values (which leads normally to bias explained by an approximation technique applied), we make the hypothesis that one repeat transaction has an effect on the whole market only at the moment it occurs.

This allows us to compute G_t , the average growth rate of the period *t*. In order to determine the index value, we need to know the market value at the starting date t_0. This value is equal to the growth rate which corresponds to the available pairs maturing at the corresponding date. Thus, if we start at the origin date, the average growth rate can be computed as the average of those pairs whose maturity is one year. The computed index serves as a basis to compute the growth rate for those pairs whose original date corresponds to the year t_1, and so on. This method (see Wenzlick, 1952) is important for the future dates, as it allows us to lock the index for all transactions which mature by the corresponding date, irrespective of future transactions[iii] in those properties.

How should we compute the average for a given time unit or sub-period? We suggest the arithmetic mean, which gives indications on the proportion of long maturity pairs with respect to short maturity pairs. The standard deviation gives a good indication for a distribution of long /short maturity pairs.

The number of observations clearly increases as we move further from the original date. In order to cope with possible biases given the heterogeneous distribution of pairs across time, we perform the analysis both forward (from past to future) and backward[iv]. As a consequence we need to split the whole sample period into two sub-periods. The cut-off point is located twelve years from the beginning of a sample period. Motivation for this choice arises from the fact that the average real estate turnover observed in France for current assets is 10 to 11 years (Filippi, 2002).

2.2.2 Comparison with the BMN model.

We suggest to construct an which reflects the evolution of rates and not prices, next assembling the rates obtained for each sub-period. We adjust the variation of growth rates using the repeat sales approach to reveal market changes. Note, that the motivation for the weighting in the work of Case and Schiller (1989) is different from ours, here. The major characteristics of the methodology proposed for constructing the FCR indices are:

1. For each year of the studied period, the corresponding growth rate indices G_t correspond only to the repeated sales pairs known until this year and are not affected by future transactions.

2. The application of a growth rate g=0 for all sub-periods preceding the year of a repeat sale induces the concentration of all growth rates on the last year.
3. Aggregating all growth rates for the last year of the period between two transactions, we obtain an average growth of prices for all the repeat sales that have been carried out by that date. The duration of these repeat sales may cover a relatively long period, but this results in building average values from year to year that can be considered as a continuous representation adjusted to the evolution of a market.

Compared to the BMN, the growth rate as calculated by the FCR method is entirely concentrated on the repeat sale date. As a consequence, years which are characterized by a high proportion of either long or short maturities will lead to biases in computations of the index. Nevertheless, this corresponds to genuine market situations: in some years the ratio of recent versus old houses on real estate market can be more important than in other periods, and vice versa. To summarize, we favor the housing units that have been held on the market for a long time.

The FCR method, applied to our artificial 5 years market, yields the following indices: {100; 105; 110; 100; 105; 110} irrespective of the direction of the transaction in year 2005. This is logical as the duration of the pairs is unknown from market, and also as the FCR index is calculated using the means.

3. Validation of the FCR method

3.1. Simulation results.

In order to analyze the efficiency of the FCR index with respect to the traditional BMN methodology, we use a simulation procedure in which the results from both approaches are compared with an artificial index. We first describe the simulation procedure before turning to the results.

We consider a population of 1000 individual houses with a common initial starting value of 100 on date 0. The simulation is run over a T = 15 year period which is divided in t = 1...15 one year sub-periods. The evolution of individual prices $P_{i,t}$ from date t to date (t+1) is assumed to follow a discretized geometric brownian motion process of the form:

$$P_{i,t+1} = P_{i,t} \exp\left\{\left(\mu - \frac{\sigma^2}{2}\right) + \sigma\varepsilon\right\} \qquad (8)$$

where μ denotes the annual expected return, σ the annual volatility and ε is an i.i.d random number drawn from a standard normal distribution. Notice that μ and σ are assumed to be constant across houses and sub-periods.

For a given simulation, we randomly determine for each house how many transactions take place over the 15 year period. Depending on our parameterisation, between one to two or one to three transactions are allowed to take place, so that some of the houses from our initial sample will not exhibit a sufficient number of transactions (two at least are necessary) to be included in the repeat-sales sample, while they are included in the artificial index computations. The artificial index on date t is computed as the average of house prices that are traded that year while the FCR and the BMN indices are computed based on the available repeat-sales pairs.

The simulation is conducted over 1000 trials which gives rise to a j=1...15000 lines × 3 columns matrix (one column per computed index). Based on this matrix, we performed the following two regressions:

$$\begin{cases} FCR_j = \alpha_{FCR} + \beta_{FCR} Index_j + \eta_{FCR} \\ BMN_j = \alpha_{BMN} + \beta_{BMN} Index_j + \eta_{BMN} \end{cases} \quad (9)$$

where $Index_j$ denotes the artificial index value for observation j and η_{FCR} and η_{BMN} are error terms. Parameter estimates along with T-Stats are reported in Table 3.

There are two results important to mention: the beta parameter for the FCR method is closer (1.00006) to the real market index than for the BMN method (0.8852); the regression square term R^2 is less important for the FCR method compared to the BMN one, that could be explained by the effect of data smoothing in the last case. The results of this simulation provide a critical evidence of the efficiency of the FCR technique and validate the utilisation of the method.

3.2 Comparison of results for a real case study: the FCR method versus the classic BMN method

We have applied the FCR method to the database of realized real estate transactions in Bordeaux during the period 1985–2000. It is important to note that 13702 studied transactions are an exhaustive base of relatively comparable assets. Indeed, it contains houses of the 50 to 150 m2 surface, similar construction plans situated in the city center of Bordeaux. This homogeneity permits to compare our results with those obtained by the calculation of mean prices.

We present below the results obtained using the FCR method for the 1904 pairs of a complete repeat sales set. As confirmed by a local house agent, the FCR indices reflect much better the real situation on the houses' market compared to the BMN indices. Moreover the cyclic character of price evolution of the real estate individual house market in the province becomes more evident during the periods of crisis: a light fall of prices in 1990 followed by a quasi stable period till 1995 and a market expansion starting in 1995 and continuing further.

This corresponds to the actual situation of the real estate market in Bordeaux during the years 1985-2000, which is characterized by the market rise starting in 1997 after long period of slow price evolution even in the beginning of 90s. In Fig. 3, we report the comparison of the FCR indices with the indices calculated by the BMN method, as well as by a growth rate of a mean house price for each year calculated from transaction prices (sale or resale).

Our technique allows us to observe an evolution of market from 100 in 1985 to 211 in 1999 and 242 in 2000. This corresponds approximately to the evolution of average house prices during this period as described earlier in the work of Thion, Favarger and Hoesli (2001). According to local real estate agencies, the estimation of 259 for 1999 and 292 for 2000 found by the BMN method appears rather distant from the actual situation on the real estate market of Bordeaux

In Fig. 3, the mean value allows us to track year after year the evolution of the compound return of prices for all the transactions in our database. We observe intersections of the two curves "Mean" and "FCR" in the graph, which shows that the compound return calculated for "heterogeneous" assets is sometimes exactly the same as the one calculated for the same assets "homogenized" within the repeat sales approach.

[Fig. 3]

We also observe that the curves "BMN" and "FCR" behave alike and show a very similar evolution. This confirms the closeness of the two applied models that differ only in a temporary date overvaluing within the BMN framework.

The next assessment that we have been interested to perform is the comparison of the FCR and BMN indices calculated by real estate sectors. In the studies developed earlier, the initial hypothesis was that the price growth rate of real estate assets persisted until any major environmental changes, either infrastructure or legislation, occur. To check this hypothesis, it is necessary to elaborate special indicators in order to exhibit deviations in the rates for representative samples of geographic sectors with the known specific evolution of their environment.

The city of Bordeaux was divided into two similar real estate sectors with a comparable number of assets taken into consideration. The first residential sector (A-IL) - the one where the important environmental changes took place starting 1995 - is inhabited mostly by "blue-collar" workers while the second one (IM-Z) is the sector of middle-class people. We consider the differences of indices calculated for these two geographical sectors for the same period with the same assets. It is important to mention that the evolution of deviations between the indices for sectors is really sensible for an application of the FCR method. The results of our comparison are presented in the Fig. 4 below.

The results show that deviations of prices growth rates depend upon environmental changes in these two sectors A-IL and IM-Z. The application of the FCR method captures the significant differences in the sectors and allows a deeper analysis of the same sample compared with the BMN method. This result is logical however, as the BMN method has a natural tendency to smooth the evolution of indices, spreading any price variation over the years since prior sale, while the FCR exploits the whole price variation in the last year, the one of resale.

[Fig. 4].

Another important issue of the methodology relates to the possibility to build up a price index gradually year after year – there is no need to keep the data of the transaction pairs of all previous and revise years. It suffices to keep only the arithmetic means calculated previously.

Conclusions.

The construction of an index must meet at least two objectives: to accomplish what the index intends, and to point out the implicit hypothesis confirmed by this construction. We have focused on a search for a reliable estimator that could be constructed gradually, describing price variations year by year. The first application we attempt to achieve by constructing such an index is to discover profitability variations resulting from environmental changes.

The BMN model relies on the necessity to seize the set of information used by the market starting from the date and the value of a sold asset and then the date and the price of its resale. An underlying hypothesis of the method is the direct effect of a resale price on the market starting from the moment of the first asset sale. Our hypothesis is different: we suppose and show that in the case of repeated sales, this is the growth rate and not the price of a transaction that matters. Furthermore this rate can and even must be applied in total at the moment of the resale.

We propose a modified algorithm, which we call the FCR method, and which is easier to implement compared to the BMN method. A price estimator is built up consecutively year after year, without affecting the results of previous calculations. This means that new transaction pairs do not modify the indices established for previous years. Simulations as well as actual database calculations prove the reliability of our new estimator and confirm its ability to track market changes.

Another practical consequence is the implied possibility to downsize the data sample. In fact, proving that the essence of price variations between two districts or two towns primarily originates from environmental changes, it is straightforward to deduce that, in the absence of such changes, these price variations should be similar, or should be perfectly correlated.

Therefore, it is useless to have an exhaustive sample to understand these changes, implying that research can use parsimonious data set.

The application of a repeat sales method appears to be well adapted for price index construction as it aims to measure variation in return by the evolution of prices from real estate assets. Coming back to the point on hypothesis validation, we observe that, in the case of the BMN method, the calculation procedure itself affects intermediate returns between transactions for the previously obtained results. Every new "repeat sale" actually modifies prior measures of market evolution. Following this reasoning, the final index value in the market should be the result not only from past transactions, but also from future transaction of resale pairs. With the FCR method, we actually put forward an inverse hypothesis: the future transactions do not have an effect on the evolution of the existing market, and this one is actually the result of the transactions known by the given date.

To enhance our results, it could be interesting to test our model on a more exhaustive sample. Furthermore, another objective would be to figure out the proportion of data we need to hold back from the initial entire base in order to obtain reliable results. In addition, the developed FCR methodology opens avenues for performing comparative studies of the new and straightforward repeat sales technique with strata and hedonic methods.

References

1. BAILEY M. J., MUTH R. F., NOURSE H. O. (1963) A Regression Method for Real Estate Price Index Construction, *Journal of the American Statistical Association*, 58, 933-42.

2. BARONI M., BARTHELEMY F., MOKRANE M. (2004) Physical Real Estate: A Paris Repeat Sales Residential Index, *ERES paper* 2004..

3. CASE K. E., SHILLER R. J. (1989) The Efficiency of the Market for Single Family Homes, *American Economic Review*, 79(1), 125-137.

4. CLAPHAM E., ENGLUND P., QUIGLEY J.M., REDFEARN C. L. (2004) Revisiting the Past: Revision in Repeat Sales and Hedonic Indexes of House Prices. *Working Paper*

5. CLAPP J.M., GIACCOTTO C. (1999) Revisions in Repeat-Sales Price indexes: here today, gone tomorrow? *Real Estate Economics*, 27 (1), 79-104.

6. CLAPP J.M., GIACCOTTO C. (1991) New evidence on Home prices from Freddie Mac Repeat Sales", *AREUEA Journal,* 19 (3), 333-352.

7. DENG Y., QUIGLEY J., VAN ORDER R. (2000) Mortgage Terminations, Heterogeneity and the Exercise of Mortgage Option, *Econometrica*, 68(2), 275-307.

8. DOMBROW J., KNIGHT J.R., SIRMAN C. (1997) Aggregation Bias in Repeat-Sales Indices, *Journal of Real Estate Finance and Economics*, vol.14, pp.75-88.

9. FILIPPI B. (2002) Marchés de la location et de la vente: nouvelles inflexions du cycle immobilier, in *La Conjoncture Immobilière*, Chambre Interdépartementale des Notaires de Paris.

10. FRIGGIT J. (2001) *Prix des logements, produits financiers immobiliers et gestion des risques,* Economica,

11. HOESLI M., GIACCOTTO C., FAVARGER P. (1997) Three New Real Estate Price Indices for Geneva, Switzerland, *Journal of Real Estate Finance and Economics*, vol. 15, No.1, pp. 93-109

12. HOESLI M., MACGREGOR B. (2000) *Property Investment : principles and Practice of Portfolio Management*, Longman Pearson Education, pp. 66-68

13. GOETZMANN W., SPIEGEL M. (1995) Non-temporal components of residential real estate appreciation, *Review of Economics and Statistics* , vol. 71, no 1, pp. 199-206.

14. GOETZMANN W.,PENG L. (2001) The Bias of the RSR estimator and the accuracy of some alternatives, *Yale School of Management working paper*, No ICF- 00-27.

15. KNIGHT J., DOMBROW J., SIRMANS C. (1995) A Varying Parameters approach to Constructing Housing Price Indexes, *Real Estate Economics*, vol. 23, pp. 187-205.

16. MARK J., GOLDBERG M. (1984) Alternative Housing Price Indices : an Evaluation, *AREUEA Journal*, vol.12 n°1, pp. 30-49.

17. MCMILLEN D. P. (2003) The return of centralisation to Chicago: using repeat sales to identify changes in house price distance gradients, *Regional Science and Urban Economics*, vol. 33, pp. 287-304.

18. SHILLER R.J. (1993) The problem of Index Number Revisions. *Macro-Markets*, Chapter 8. " Indices derived by conditioning on lagged index values".

19. THION B., BOUZDINE-CHAMEEVA T. (2001) Comparative Analysis of Several Models of Price Indices in Real Estate Transactions, *CEREFI-BordeauxBusiness School*, No 26-01.

20. THION B., FAVARGER P., HOESLI M. (2001) Repeat Sales,Indices and environmental changes, *Revue d'Économie Régionale et Urbaine*, No 5, Bordeaux.

21. WANG F., ZORN P. (1996) Estimating House Price Growth with Repeat Sales Data: What is the Aim of the Game? *Journal of Housing Economics*, 6, pp. 93-118.

22. WENZLICK R. (1952), As I see the fluctuations in the selling prices of single-family residences, *The Real Estate Analyst*, 21, December 24, pp. 541-548.

Footnotes

[i] In France, since 1965 average home prices have fluctuated around the disposable income per household and house price have been highly correlated (R>0,8) on most of the territory; the main cause of local differentiation has been that the real estate crisis of 1987-1995 took place only in the Paris region and in a few other places (Friggit 2001).

[ii] Interested readers can refer to some other new techniques developed within the repeat sales approach (see, for example, McMillen, 2003). However they do not contain notable improvements compared to the techniques presented above (BMN, RSR, WLS).

[iii] Another possibility is to base our method on the regression approach of BMN (see Thion, Chameeva, 2001). However this technique, while better compared to the BMN, suffers from the same problems related to regression issues.

[iv] Friggit (2001) uses a similar methodology. However for only one year, the year 1998, there are more than 2 million "repeat sales " in the notary database. Basing on the previous transfer values given in notary files, he constructed estimator index going back to the 1950s for the region of Paris and Province.