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The Paris Residential Market : Driving Factors and Market Behaviour 1973-2001

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The Paris Residential Market: Driving Factors and Market Behaviour 1973-2001[1]

Abstract

In this paper we investigate the driving factors associated with the Paris apartment market. We explore a database of nearly 230 000 transactions for residential properties in the Paris area over the 1973 – 2001 period. We develop a factorial model that may capture the systematic link between residential prices and a set of predefined economic variables or a linear combination of these economic variables. We assume that capital growth rates in real estate are related to the variables we defined in the last paragraph. We measure this link which underlines the 'true path' of the real estate market: in that way we can develop an index as a function of many other indices. The methodology we develop, based on a multifactor approach to apartment price movements in the long run, has two main advantages over traditional indices. Firstly, we are able to identify the main driving factors for the Paris residential market. And secondly, the factors thus derived can be used to generate a "factor model" useful in comparison to existing capital growth indices and that provides valuable intuition for forecasting residential prices.

Key words: Real estate indexes, repeat sales, risk factors

Résumé

Dans ce document nous cherchons à mettre en lumière les facteurs directeurs de l'évolution du marché immobilier d'habitation de la région parisienne. Pour ce faire, nous utilisons une base de données comprenant près de 230 000 transactions de biens immobiliers d'habitation en région parisienne sur la période 1973-2001. Nous élaborons un modèle factoriel qui permet d'appréhender le lien systématique entre le prix des biens immobiliers d'habitation et un jeu de variables économiques pré-définies ou une combinaison de ces variables. Nous faisons l'hypothèse que les taux de croissance des rendements immobiliers en capital sont liés à ceux des variables précitées. Puis nous mesurons ce lien, qui met en exergue les « fondamentaux » du marché immobilier. Nous élaborons ainsi un indice immobilier comme une fonction d'un certain nombre d'autres indices. La méthodologie fondée sur une approche multi-factorielle présente deux avantages principaux sur les indices immobiliers existants. En premier lieu, elle permet d'identifier les facteurs explicatifs de l'évolution des prix de l'immobilier d'habitation à Paris. En second lieu, ces facteurs peuvent être utilisés pour élaborer un modèle factoriel dont les résultats peuvent être comparés aux indices existants, et qui peut aboutir à des prévisions pour l'évolution des prix de l'immobilier d'habitation.

Mots-clés : indices immobiliers, ventes répétées, risque immobilier, facteurs de risque.

JEL Classification Code: C20, G00

[1] The authors wish to thank the Bureau Van Dijk for graciously providing us with the data base CD-Bien. The usual disclaimer applies.

Introduction

Every real estate investor faces an objective difficulty concerning the measurement of real estate investment performance and risk. The reasons explaining this difficulty are numerous: an absence of centralised trading, or even price lists, a low degree of buildings or apartments turnover in investor portfolios, a lack of transparency in transactions, the heterogeneity and indivisibility of real estate properties, and a tradition of confidentiality in the industry.

Does this imply that investors should disregard investing in real estate? This would be a mistake if real estate investments represented a consistent diversification vehicle from a global portfolio management perspective. This mistake would be even greater if real estate provided an efficient inflation hedge.[2]

Real estate markets are relatively often subject to price shocks whose amplitude prove to be very high and welfare decreasing. According to R. Shiller (1998), these shocks are as difficult to explain as those that affect equity or debt markets. One of the main problems in trying to measure real estate volatility in France is that there does not exist satifactory historically long time series for price and rent evolution (see Section 1 of the present paper). A possibility for creating such indices would be to use a methodology based on observed price transactions (Section 2). To achieve this goal we explore a rich transactions database containing information on single-family homes transactions, as well as office, mixed (professional and housing) and commerce properties for the Paris and its surrounding area.

Such indices may prove very useful, for example, in serving as "benchmarks" or in risk measurement. Indeed, real estate performance is today at the heart of investor focus, whome, after a period of withdrawl in the mid nineties, are flowing back, but with the concern of trying to better control for the risk and return of real estate investments. According to F. Savel (1998), delegated real estate management seems to benefit from a promising future, at the condition that this sector's risk be well identified and hedged. Section 3 presents a statistical analysis of our database and highlights interesting specific investor behavior.

Ling and Naranjo (1998), seeking for an evaluation of systematic risk using a multifactorial model on commercial property, show that unobservable factors may strongly influence investor behavior. They also emphasize in another paper with Nimalendran[3] that the measure of systematic risk from indexes must be robust because it may induce major differences in asset allocations.

Identifying risk factors for real estate enables the investor, be he or she a landowner, a multi-billion dollar institutional investor or a real estate debt holder, to measure and therefore hedge his (her) investment position. This process also permits the debt holder to assess the risk of a real estate loan. A unified approach to real estate risk is the only way to bring market participants to trade risks using real estate derivatives. In this context, we isolate real estate risk factors and construct a factorial model capable of synthetising real estate systematic price dynamics (Section 2). Our synthesis in the form of risk-returns comparisons is presented in Section 5. The last section gathers our concluding remarks.

1. Existing Indices Methodologies

1.1 Existing Indices

There are three measures capable of calibrating real estate risk in France (and in particular in the Paris area) today. They correspond to three indices of relatively different nature:

- The square metre index provided by the Chambre des Notaires (the notaries) de Paris and INSEE (Institut National de la Statistique et des Etudes Economiques). This index is computed every six months using and concern unoccupied apartments aged five years and over. The index for a given date is the weighted average of transactions prices per square metre. An hedonic approach has been

[2] For a study of the link between inflation and real estate in the US, see Sirmans and Sirmans (1987). For the case of France, see Friggit (1999).
[3] Ling, Naranjo, Nimalendran (2000).

included in the index construction since 1994. The price evolution is now calculated comparing each transaction to a reference sample.

- The IPD index (Investment Property Databank): This index is constructed using property appraisal estimates covering a representative sample of real estate properties owned by majors insurance and banking institutions in the Paris area. The methodology adopted consists in gathering a representative sample whose value is periodically appraised using expert valuation models. The aggregation of appraised values provides the index's value for a given date. For the case of France, IPD publishes such an index every year[4].
- The index for listed real estate is published each day by Datastream-Financial Times (code RLDEVFR) based on the listed prices of the following listed property companies: Gecina (now merged with Simco), Interbail, Klepierre, Locindus, Sefimeg, Silic, Simco (now merged with Simco), Société Foncière Lyopnnaise, Sogeparc, UIF, Unibail.

1.2 Apartment Price Indices and Systematic Risk Measurement

The following figure illustrates the evolution of the above-mentioned indices since 1983 (1986 for the IPD France Capital growth index for Paris residentials). The IPD and Notaires/INSEE indices represent the return on capital for housing, whereas the type of market sector represented by the listed real estate index depends on the type of assets the investment trusts holds. We have to notice that those indices are not derived in the same way: the listed real estate is a daily index, IPD is annual and the Notaires/Insee index is built annually (semi-annually now). But this figure focuses on the trend and shows clearly the prices growths are quite different according to the indices. For instance, the returns between December 1985 and December 1991 are the following: Notaires/INSEE 249%, Listed Real Estate 112%, and IPD 174%.

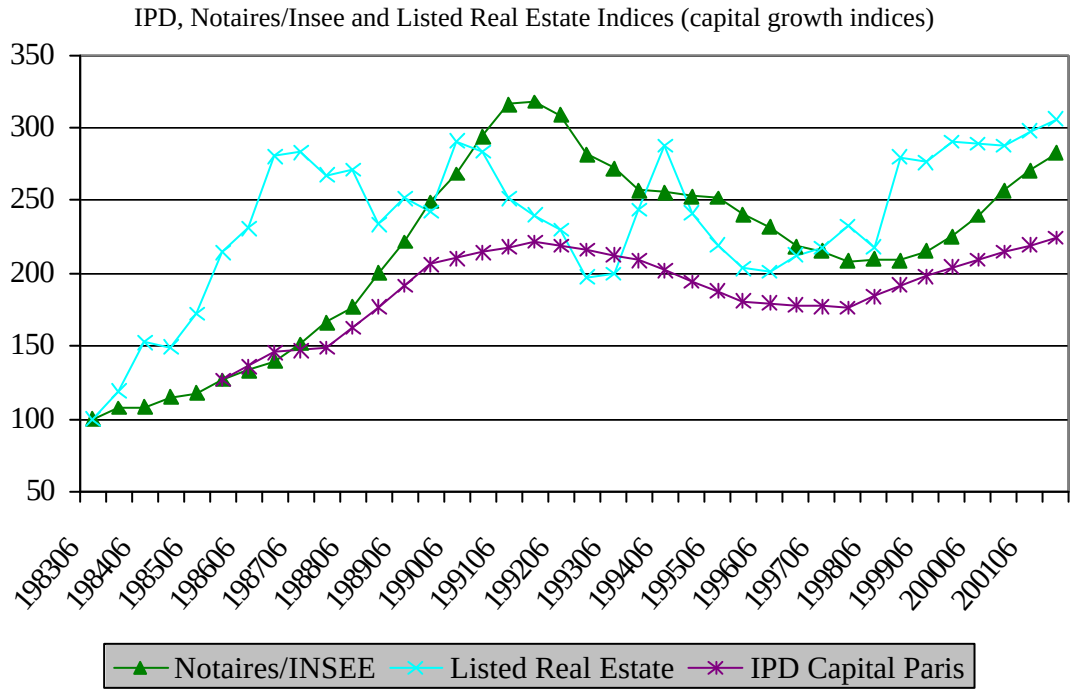

Figure 1: Three property indices for Paris

Concerning volatility, the Notaires/INSEE index is based on a weighted average of prices for heterogeneous residential properties. This implies that the volatility measurement is influenced by all sorts

[4] For more details on the IPD index as well as other related information browse the following web sites www.ipdindex.co.uk and www;ipdfrance.com for France.

of risks, including specific risks. For an investor, this measurement is not truly convenient in comparison with the risk of the portfolio.

For the case of the IPD capital growth index, ot is based on a database that covers institutional holdings of apartment buildings. It is not based on transactions prices, but rather on appraised values or market valuations produced by independent valuation companies. It is well known that such indices may produce a form of inertia that may take its source in:

- the fact that the valuers periodically appraising a property generally tend to adjust preceding valuations, conditioning valuations period to period (on appraisal smoothing, see for example Brown, 1985, Geltner, 1993, Brown and Matysiak, 2000, and Baum et al, 2001)
- the time period separating transactions information and the processing of this information in the form of an appraised value may be long, inducing a form of lag in the index. This bias is an increasing function of the index's periodicity (note for example that the IPD index is monthly in Great-Britain and annual in France).

These elements have a non negligible impact when one attempts to measure real estate risk, since they may both lead to an underestimation of volatility.

Listed real estate naturally contains real estate risk, but the total risk measured is simultaneously affected by two other sources of risk. One is linked to the relatively high liquidity (daily listing) of investment trusts, which is not representative of direct real estate whose markets are relatively illiquid in comparison. The second is linked to the role that these trusts play in global portfolio diversification, which implies that demand for these securities is directly linked to capital markets fluctuations. This risk is for example illustrated by the "kink" in the index during the year 1987, the same year securities markets began to experience rapid growth and developed liquid and organised derivatives compartments (MATIF, MONEP etc…). For these reasons, the listed real estate index may not represent the risk structure of the direct real estate.

The real estate investor therefore is in search of a transactions-based index, and hence a listing of transactions prices. One such database exists for the case of Paris and the neighbouring "Départements": the CD-Bien database.

2 The Database

To analyse capital growth rates, we have constructed a database containing not only capital returns but also returns from economic and financial variables as well as hedonic[5] information for each transaction. The latter are extracted from the CD-Bien database who lists all real estate transactions written in front of a notary for the Paris and near surrounding area (Hauts-de-Seine, Seine Saint-Denis, and Val de Marne). From this database, we extracted 229 450 transactions for which we had the information on both the initial price and date (post 1st of January 1973) at which the properties had been bought (T_1) as well as the price and date (T_2) for the following resale[6]. These repeat measures transactions represent around 25% of the total number of transactions.

To every observation in the database, the following hedonic characteristics can then be associated:

- *Holding period (duration)*: *duration* is simply the difference $T_2 - T_1$ expressed in days.
- *Type of purpose (purpose):* variable *purpose* may take any one of four values depending on the type of purpose declared: 1 for family housing, 2 for commerce, 3 for a mixed-purpose (housing and professional), and 4 for offices (commercial or professional).

[5] In this paper hedonic is to be taken in the loose sense of transactions characteristics.

[6] We have to note an important feature concerning the database's structure: we only observe those transactions whose second transaction has taken place after 1990. We will come back to this point and point out where it may be cause of concern in the course of the analysis presented below.

The quest for explanatory factors of real estate capital returns necessitates the selection of indicators that one a priori believes to have some form of explanatory power of price changes. Ten factors were selected based on two criteria. The first asked of potential factors to have a clear economic interpretation and presupposed links with real estate markets. The second was that it was necessary for the time series to run back as far as possible in time. The data we explored in Datastream ran back, for France, as far as the first of January 1973.

The indices selected to serve as factors were thus constructed with base 100 at the start of 1973. They are the following: *long term interest rate (LtR), short term interest rate (StR), consumer price index (Consum), MSCI*[7] *equity market index (Equity), listed real estate (ListRE), rents as measured by the INSEE/OLAP residential reletting index*[8] *(Rent), demographic index (Demog), unemployment (Unemp), savings as a percentage of disposable income (Saving), and interest rate spread (Spread).*

For each transaction, we than computed the corresponding growth rate of every potential (explanatory) factor for the period separating date T_1 from T_2. The whole set of rates was then transformed into semi-annual returns[9]. The resulting variables are thus the following: R_S, $Equity_S$, $Consum_S$, $Rent_S$, LtR_S, StR_S, $Demog_S$, $ListRE_S$, $Unemp_S$, $Saving_S$, $Spread_S$.

3 The Factorial Index

We develop a factorial model that may capture the systematic link between residential prices and a set of predefined economic variables or a linear combination of these economic variables. We assume that capital growth rates in real estate are related to the variables we defined in the last paragraph. We measure this link which underlines the 'true path' of the real estate market: in that way we can develop an index as a function of many other indices.

In this paper, the relation is supposed to be linear for the logarithm of return. We express the logarithm of real estate market at an instant as a linear function of the equivalent returns on all the other variables at the same instant. There are two steps in the procedure we develop and these steps are not situated in the same space:

- in the transaction dimension: we analyse the variables linked with the real estate market
- in the time dimension: we build a real estate index as a linear combination of the other existing indices: indices of the variables found in the first step.

This methodology is general and if we apply this approach in the real estate world, we can of course build indices for the different sectors: residential, commerce, mixed, and offices.

3.1 The Transaction Space: the Factors

3.1.1 The equivalent returns

We consider *n* repeat transaction. For each observation *i*, we have the first transaction date $T_1(i)$, the purchase price $P_1(i)$, and the second transaction date $T_2(i)$ as well as the corresponding price $P_2(i)$. From those elements one can deduce the price return related to the observation *i*:

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[7] We used the Morgan Stanley Capital International (MSCI) Index for France, which runs farther back in time than the CAC40 Index.

[8] The INSEE/OLAP (OLAP stands for Observatoire des loyers de l'agglomération parisienne) residential reletting index is based on a large sample of apartments that are regularly surveyed for which new lettings are systematically documented in order to produce the Paris and close suburban areas rent index.

[9] The choice of the semester as a unit period is linked to the fact that, as we will see in the next sections, this time step suits best our factorial model of index construction.

$$R_{re}(i) = \frac{P_2(i)}{P_1(i)} \tag{1}$$

We have k variables whose price returns are potentially linked to the apartment price returns. We have the information on the time series of those variables: for all $j = 1, \ldots, k$ we have, for all $t = 1, \ldots, T$, $X_j(t)$, the value of the jth variable at time t.

For each transaction i, we can compute the corresponding price return for all the k variables for the period that covers $T_1(i)$ to $T_2(i)$. The variables value are denoted $X_j[T_1(i)]$ and $X_j[T_2(i)]$ and the corresponding price return for the variable j is:

$$R_j(i) = \frac{X_j[T_2(i)]}{X_j[T_1(i)]} \tag{2}$$

To be able to compare returns between transactions, we can fix a reference period for the return, i.e. the year. We define p this reference period whose value is expressed in days. We denote $R_j^p(i)$ the corresponding price return for variable j and for the period related to transaction i:

$$R_j^p(i) = \left(R_j(i)\right)^{\frac{p}{T_2(i) - T_1(i)}} = \left(\frac{X_j[T_2(i)]}{X_j[T_1(i)]}\right)^{\frac{p}{T_2(i) - T_1(i)}} \tag{3}$$

3.1.2 The variable selection

We assume the following relationship in capital growth rates:

$$R_{re}^p(i) = a \prod_{j=1}^{m} R_j^p(i)^{b_j} \tag{4}$$

where m is the number of factors in the structural relation.

Thus, for the return logarithm, we establish the following linear relationship in logs:

$$LnR_{re}^p(i) = a + \sum_{j=1}^{m} b_j \, LnR_j^p(i) \tag{5}$$

where: $LnR_{re}^p(i)$ is the period p price return rate in logarithm,

the $LnR_j^p(i)$ are the period p equivalent price return for the variable j,

$a = \ln(a)$.

To find the m variables among the k available variables, two methods are applied here: the principal component analysis (PCA) and the stepwise in least squares regression.

The PCA enables us to group the variable with the same price return distribution. Then, we can analyse in a economic and financial way the relationships between all those variables. This is used in a descriptive statistics way.

If we consider the observed returns as random variables realisation, by assuming a multiplicative error term, we can formulate following regression model the capital growth rate:

$$LnR_{re}^p(i) = a + \sum_{j=1}^{m} b_j \, LnR_j^p(i) + e(i) \tag{6}$$

where $\forall i = 1, \ldots, n$, $\mathrm{E}[e(i)] = 0$, $\mathrm{V}[e(i)] = s^2$. The homoscedastic assumption should be tested in practice and if it is rejected a generalised least squares estimator (GLS) can be used. To get the m factors

we can at the beginning use all the *k* variables and then choose using a descending stepwise methodology the best *m* variables for equation (6). Hence, the GLS estimation gives us the *m* variables and their weightings.

3.2 The Time Series Dimension: the Index

The regression estimation will provide us with the factors weights (loadings) for factor *j* in the relationship between apartment prices and the set of proposed variables. As we have estimated the relation in logarithm, we have in transactions dimension:

$$\forall i = 1,\ldots,n,\ \widehat{LnR}_{re}^{p}(i) = \exp\left(\hat{a} + \sum_{j=1}^{m} \hat{b}_j \ln\left(\frac{X_j[T_2(i)]}{X_j[T_2(i)]}\right)\right) \tag{7}$$

And then in the time series dimension, we can express the capital growth rate using the *p* variables time series $X_j[t]$,

$$\forall t = 1,\ldots,T,\ \widehat{R}_{re}^{p}(t) = \exp\left(\hat{a} + \sum_{j=1}^{m} \hat{b}_j \, Ln\left(\frac{X_j(t)}{X_j(t-1)}\right)\right) \tag{8}$$

which is

$$\forall t = 1,\ldots,T,\ \widehat{R}_{re}^{p}(t) = \prod_{j=1}^{m} \exp(\hat{a}) \left(\frac{X_j(t)}{X_j(t-1)}\right)^{\hat{b}_j} \tag{9}$$

The unit for *t*, the time interval, may be the year, the semester, the quarter, … There is no a priori constraints between *p* and index periodicity. And we have for the index,

$$\widehat{\text{Index}}(t) = \widehat{\text{Index}}(t-1) \times \widehat{\text{Return}}(t) \tag{10}$$

and Index(0) = 100.

4 Statistical Analysis of the Residential Database: The Broad View

4.1 Descriptive statistics

Let us begin by pointing out to the presence of a significant number of extreme values for variable LnR_{re}^{S} in the CD-Bien database. We choose to eliminate all the observations which do not represent a market price transaction. It corresponds to transactions using a symbolic 1 euro or French Franc price.

	Minimum	***Maximum***	***Mean***	***Standard. Deviation***	***Skewness***	***Excess Kurtosis***
LnR_{re}^{S}	**-14.010**	**16.950**	**0.024**	**0.160**	**9.956**	**2014.975**
LnEquits	-1.020	0.890	0.062	0.055	-0.657	31.948
LnConsums	-0.030	0.040	0.012	0.007	1.178	1.245
LnRents	0.000	0.040	0.019	0.009	0.079	-1.101
LnLtRs	0.020	0.050	0.036	0.007	-0.054	-0.797
LnStRs	0.010	0.060	0.032	0.010	-0.317	-1.096
LnDemogs	0.000	0.010	0.002	0.001	-0.290	-0.350
LnListREs	-0.650	0.590	0.013	0.038	-1.147	38.215
LnUnemps	-0.130	0.140	0.003	0.024	-1.171	2.492
LnSavings	-0.030	0.040	0.003	0.009	0.164	1.456
LnSpreads	-2.100	1.000	0.015	0.074	-2.007	68.182

Table 1 : Descriptive statistics for price growths and main factors (after non-sensical values elimination)

The above table (expressed in logarithm) illustrates the major differences between transactions based capital growth rates (variable LnR_{re}^{s}) and those of other variables namely on the grounds of the extent or dispersion (standard-deviation), of the asymmetric feature or skewness (numerous returns above the average), of the presence of persistent extreme values (excess kurtosis [10]).

4.2 « No-Loss » Behaviour and Real Estate Crisis

Let us now turn to a very striking feature we discovered in the data. The histogram for variable LnR_{re}^{s}, for values comprised between –0.10 and 0.20 is the following.

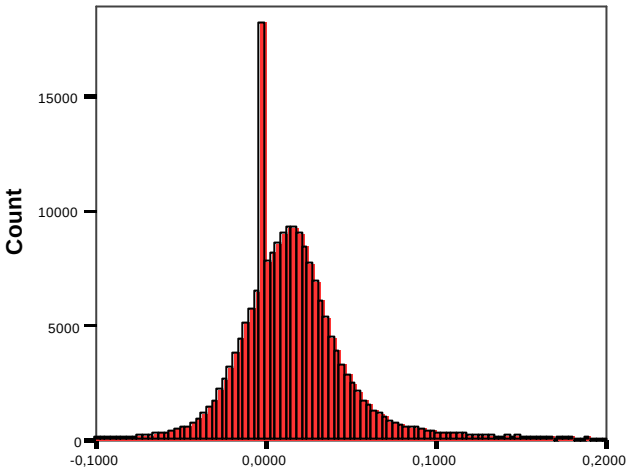

Figure 2: Apartment price growth distribution

The above figure points to an anomaly corresponding to a large number of transactions at a rate of return of zero. Taking a close-up of the 20 994 observations whose returns lie between -0.002 and 0.002, yields the following results:

	Minimum	***Maximum***	***Mean***
LnR_{re}^{s}	-0.002	0.002	0.000023
Date 1	01/01/1973	01/11/2001	**01/01/1994**
Date 2	01/11/1991	01/12/2001	**01/07/1998**
Price1	14 000	130 000 000	802 519
Price2	14 000	131 000 000	803 001
Duration (in days)	28	10 227	1 730

Table 2: Variables characteristics for $\left|LnR_{re}^{S}\right| < 0.002$

This proportion of transactions represents around 12% of the total number of our repeat measures transactions, and corresponds to the histogram's truly abnormal peak. Remark that all these transactions exhibit a resell date T_2 after November 1991; i.e. after the beginning of the real estate crisis in France. The observation of the column labelled *Average* of this table helps characterise these transactions. The average acquisition date of these properties is January 1994, whereas the average resale date is July 1998.

[10] Skewness measures the tendency of a distribution to give more weights to values greater than (positive skewness) or lower than (negative skewness) the mean. Kurtosis measures the degree of flatness of a distribution. A normal distribution has a kurtosis of 3 or equivalently an excess kurtosis of 0. A positive (negative) excess kurtosis indicates a distribution with fat (thin) tails with respect to the normal distribution, which indicates the presence (absence) of extreme values.

If one considers the Notaires/INSEE index during the same period, its level dropped by 22.3% during that period. One may conclude that an important number of property sellers exhibited some sort of "No-loss" behaviour during this crisis period, in which they refused to sell their property at a price lower than the one they paid for it (Genesove et Mayer, 2001). The behaviour described here exhibits a relatively high resistance to price drops even in the context of a rough downside market. One may also interpret this behaviour as being one of owners willing to sell only at the condition that they do not loose in terms capital, or accepting to sell with no gain rather than waiting for a hypothetical market upturn. This behaviour also illustrates the relatively still dominant position of the seller over the acquirer for this type of property.

4.3 Investor Behaviour During the "Crisis"

The second conclusion worth mentioning here concerns the market behaviour of "retired" individuals during the 1987-1997 period. The database contains information on the status active/retired of the acquirer and seller; we were able to see that the retired population massively entered the direct real estate market during the end of the 1980s, early 1990s. Indeed, during this period, more than 25% of the market entrants were retired individuals. What's more, it is the retired who marched out of this same market during the period 1996-1997, probably to profit from the bullish equity markets France experienced at that time.

We may also note that only 7% of market participants with an investment horizon lower than three and a half years are property traders (the so-called *marchands de biens* in France). Hence, it appears that the market participants that have the possibility of profiting from arbitrage opportunities from the capital markets are not the legal entities, but the individual entities, and more precisely retired individuals. We will come back to this point when presenting our results on factorial models and their link with listed real estate.

4.4 Temporal Structure of the Database

The following figure represents the distribution of transaction dates for repeat sales in the CD-Bien database (*date1*, *date2*, and the total number of transactions). As can be seen, starting in January 1973, the database does contain an increasing number of acquisitions for which we do have a resell price and date. However, it does not contain any resell date prior to June 1994.

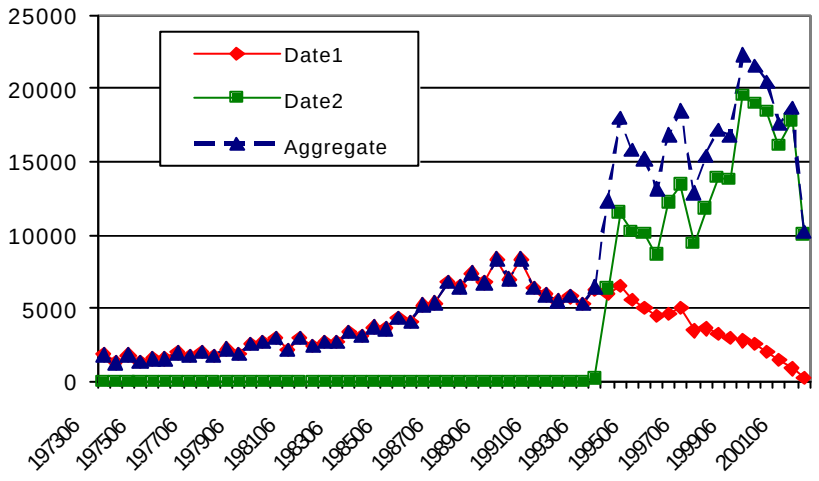

Figure 3: Number of observations per semester - 1973:06 to 2001:12

This particular feature of the CD-bien database may potentially induce a form of bias in the sense that the proportion of long holding period transactions is over-represented in the data.

Variable *date1's* distribution illustrates, to a certain extent, the real estate market's activity. The graph's observation leads us to a time partition into three broad phases: a relatively low but increasing volume of

apartment acquisitions from 1973 to the mid-1980s, a moderate increase in market activity (acquisitions) from 1985 to 1990, followed by a brutal decline in acquisitions coinciding with the real estate bust of 1991, with the mention that the slow acquisitions activity has lasted till the end of 1998.

4.5 Bivariate Analysis: Dates, Semi-annual Price Growths and Holding Periods

The following figure plots the log of semi-annual price growths as a function of acquisition dates and holding periods[11]:

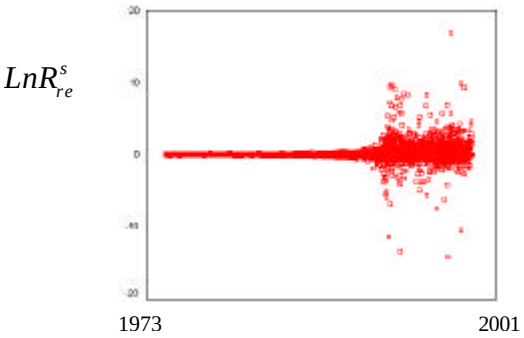

Figure 4: Apartment price growths as a function of acquisition dates

We can clearly view two distinct periods: A low price growth volatility prior to 1993, and a much more volatile market after that date. This is to be related to the next figure that highlights the very string link between holding periods and transaction price volatility.

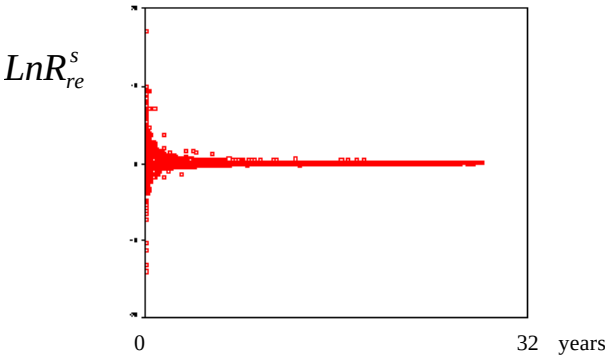

Figure 5: Apartment price growths as a function of holding periods

5 Common Factors

5.1 How Many Real Estate Risk Factors the Paris Residential Market?

Let us now turn to the search for systematic relationships between capital growth rates and macroeconomic, financial and hedonic variables. Principal Component Analysis (PCA[12]) indicates that only four factors (linear combinations of 12 variables) are sufficient to capture more than 81% of total variance of our dataset. The first factor is able to explain roughly 47% of total variance, followed by

[11] For graph readability, we have randomly selected a set of 10% of transactions for Housing (from a total amount of 220 000). Note that this does not imply any loss of generality of the qualitative and quantitative insights these graphs enable us to draw.

[12] PCA is a data analysis method used in a number of management disciplines (marketing, finance, insurance…). Consider a table containing individuals (lines) and many variables measured on each individual (columns), PCA aims at creating a restricted number of linear variable combinations (called factors) capable of summarising the essence of information contained in the initial table.

Factor 2 (16%), Factor 3 (10%), and finally Factor 4 (8%). The following table indicates linear correlations between variables and factors:

Variables	*Factor 1*	*Factor 2*	*Factor 3*	*Factor 4*
Duration	**0.788**	0.295	-0.109	-0.010
$LnConsum_S$	**0.883**	0.223	-0.092	-0.001
$LnRent_S$	**0.947**	0.021	-0.145	0.002
$LnLtR_S$	**0.977**	-0.017	-0.046	0.000
$LnStR_S$	**0.966**	-0.125	-0.009	0.000
$LnDemog_S$	**0.882**	-0.127	-0.110	0.005
$LnUnemp_S$	**0.742**	-0.153	0.469	-0.014
$LnSaving_S$	-0.235	**-0.711**	-0.223	0.009
$LnEquity_S$	-0.278	**0.743**	0.048	-0.002
$LnListRE_S$	-0.034	**0.806**	0.187	-0.008
$LnSpread_S$	0.081	-0.258	**0.906**	-0.025
Numgeo	0.015	0.010	0.032	**0.999**

Table 3: Factor Loadings

5.2 Interpretations

The first factor comprises interest rate –linked (long and short term rates) as well as economic variables (consumer price, rents, demographic index, unemployment, and to a lesser extent savings rate and listed real estate). We can note three of them are highly linearly correlated: rents, long-term and short-term rates. Hence, the information given by these three variables could be summed up nearly perfectly in only one. Remark that all of these variables are linked to holding duration. The second factor contains the savings rate and reflects the volatility of equity market returns, including listed capital growth rates, and may be interpreted as a financial factor not specifically linked to *duration*. The third factor captures only the interest rate spreads. Finally, the fourth factor sorts returns using the geographical variable.

6 Towards a Factor Model of Direct Real Estate

A factor model enables to "generate estate index capable of representing systematic risk. The selected methodology is that of a multi-factor model resulting from a linear regression on the selected explanatory variables presented above. We will now analyse, thanks to a "stepwise" regression method, the relationship between direct real estate, macroeconomic, financial, and idiosyncratic factors. For each transaction *i*, the estimator for LnR_{re}^{s} is thus:

$$LnR_{re}^{S}(i) = a + \sum_{j=1}^{m} b_j LnF_j^{S}(i) + e(i) \qquad (11)$$

where α is the regression's constant estimator, $F_j^S(i)$ represents the semi-annual price return for variable F_j during period $[T_1, T_2]$ separating the two transactions of property i (see footnote n°9), b_j is the loading of the j^{th} variable $LnF_j^S(i)$, and finally $\varepsilon(i)$ is a normally distributed random variable with mean 0 and constant variance σ^2. It represents the error term for transaction i. We assume away any correlation between any two transactions' error terms.

6.1 Heteroscedasticity

The above proposed modelling assumes that the variance associated to each purpose does not depend on observation (i). If these assumptions are not validated, the model must be amended so that its

specification corresponds to our data structure. Inside each purpose class, the White test[13] clearly indicates heteroscedasticity. To study its correct nature (the search for variables that are at the source of heteroscedasticity), we make use of the Goldfeld-Quant (GQ) test.

We begin by ordering regression residuals as functions of variables, and then study whether residual variance is constant across classes. Several variables may be candidate sources for heteroscedasticity: the ones contained in the table above, which were identified by the White test, as well as temporal variables such as *duration*, *date1*, and *date2. Table 4* below indicates the GQ *p*-values for different variables.

	duration	***date1***	***date2***	***LnUnempl$_s$***	***LnRent$_s$***
Residential factorial model	0	0	e-66	e-80	0

Table 4: GQ p-values for the different variables

For more reduced samples, the smallest GQ *p*-values are always obtained with variable *duration*, which suggests that heteroscedasticity could be due to this variable. This is reinforced by bivariate analysis results (see 4.5).

The modification of the residuals specification enables us to define a new regression modem based on (11) in which $\varepsilon(i)$ is now considered to be a random variable that follows a normal distribution with zero mean and variance equal to $\sigma^2/duration(i)$.[14] This model can then be estimated using GLS. In modifying the model's specification to take into account this variance's modelling, we are able to eliminate the sources of heteroscedasticity that appeared in *Table 4*. Indeed, the White test does not detect any other source of heteroscedasticity based on our GLS estimates. Similarly, all the GQ *p*-values become high. Our conclusion is that the test results in *Table 4* for all variables were significant only because of their correlation with *duration.*

6.2 The unbiased GLS Factor Model

The following table summarises selected model as well as the corresponding GLS coefficient estimates[15]. The value in parentheses represent the Student-*t* estimates for each coefficient[16]. We report the non centered *R* squared (R^2_{nc}) as there is no constant in the GLS regression (the constant is transformed by the form specified for the heteroscedasticity).

	Constant	***LnRent$_s$***	***LnUnempl$_s$***	R^2_{nc} ***(%)***	***N***
Residential	-0.0322	2.538	-0.733	65.89	220 679
	(-143)	(229)	(-113)		

Table 5:Model's coefficient estimates

The conclusion here is that apartment prices in Paris tend to systematically react to two very strong factors: the level of rents (as captured by variable *LnRent$_s$*) and the level of unemployment (as measured by *LnUnempl$_s$*). Please recall here that this factor is highly correlated to the interest rate factors, as shown in *Table 3*. We then study the index estimation robustness according to the selected observations. To do so, we use two different approaches.

[13] The tests presented thereafter are described in detail in Greene (1997).

[14] It may be possible to try and find α in the specification $\sigma^2(i) = \sigma^2/duration(i)^\alpha$ using the maximum likelihood method. We cannot reject the hypothesis α equals 1.

[15] Note here again that all coefficients are significant to the 99.9% confidence level.

[16] Note here that all coefficients are significant to the 99.99% confidence level.

First, we drop the most influential observations using the Atkinson's criteria [17] (see *Table 6*). The graph in *Appendix A* shows the presence of outliers and the graph in *Appendix B* shows the modification of residuals and influential observations after using a filter (observations with Atkinson's measure greater than 0.04 are excluded).

Then, we extract random subsamples of 90%, 75%, 50% and 25% (see *Table 7*).

	Constant	***LnRent$_s$***	***LnUnempl$_s$***	***R^2_{nc}(%)***	***N***
	-0.0322	2.538	-0.733	65.89	220 679
	(-143)	*(229)*	*(-113)*		
Atkin < 0.06	-0.0322	2.536	-0.730	66.53	220 661
	(-146)	*(232)*	*(-114)*		
Atkin < 0.05	-0.0322	2.536	-0.730	66.75	220 641
	(-146)	*(233)*	*(-115)*		
Atkin < 0.04	-0.0322	2.537	-0.730	67.06	220 577
	(-148)	*(235)*	*(-116)*		
Atkin < 0.03	-0.0324	2.545	-0.736	67.67	220 352
	(-151)	*(240)*	*(-118)*		
Atkin < 0.02	-0.0326	2.559	-0.753	69.36	219 160
	(-159)	*(253)*	*(-127)*		

Table 6: Model's coefficient estimates robustness according to influential observations

	Constant	***LnRent$_s$***	***LnUnempl$_s$***	***R^2_{nc}(%)***	***N***
All	-0.0322	2.538	-0.733	65.89	220 679
	(-143)	*(229)*	*(-113)*		
90%	-0.03183	2.522	-0.731	65.71	198 597
	(-134)	*(215)*	*(-107)*		
75%	-0.0319	2.529	-0.734	65.39	165 537
	(-122)	*(196)*	*(-97)*		
50 %	-0.0324	2.556	-0.744	65.82	110 332
	(-102)	*(163)*	*(-81)*		
25 %	-0.0323	2.535	-0.727	66.58	55 168
	(-73)	*(116)*	*(-57)*		

Table 7: Model's coefficient estimates robustness according to the number of observations

[17] To detect those values we use the Atkinson's measure (Atkinson, A.C., *Plots, Transformations and Regression*, UK, 1985, Clarendon Press). The idea is to compare the estimation of the endogeneous variable with the i^{th} observation and without, and this, for all the observations. If we have n observations, p exogeneous variables, by noting h_{ii} the i^{th} diagonal element of the hat matrix, the Atkinson's measure for observation i is:

$$A_i = \left\{ D_i (n-p) s^2 / s(i)^2 \right\}^{1/2}$$

where $D_i = \left(\frac{\hat{u}_i}{s(1-h_{ii})^{1/2}} \right)^2 \left(\frac{h_{ii}}{1-h_{ii}} \right) \frac{1}{p}$ and the externally variance $s^2(i) = \frac{(n-p)s^2 - \hat{u}_i^2 / (1-h_{ii})}{n-p-1}$

According to *Table 6* and *Table 7* we can conclude that the estimation is quite robust to the choice of the observations selected for the regression. The correspond indices are quite the same, their values are presented in *Appendix C*.

6.3 Visualisation of indices

The factorial index moves significantly away from the listed real estate index starting from the beginning of 1982. One may however remark that notwithstanding the July 1990-July 1994 period corresponding to the real estate crisis, the direct real estate changes in trend seem to be portended by the listed index, in the sense that the trend kinks seem to be 'anticipated' by a whole year or even more by the listed index.

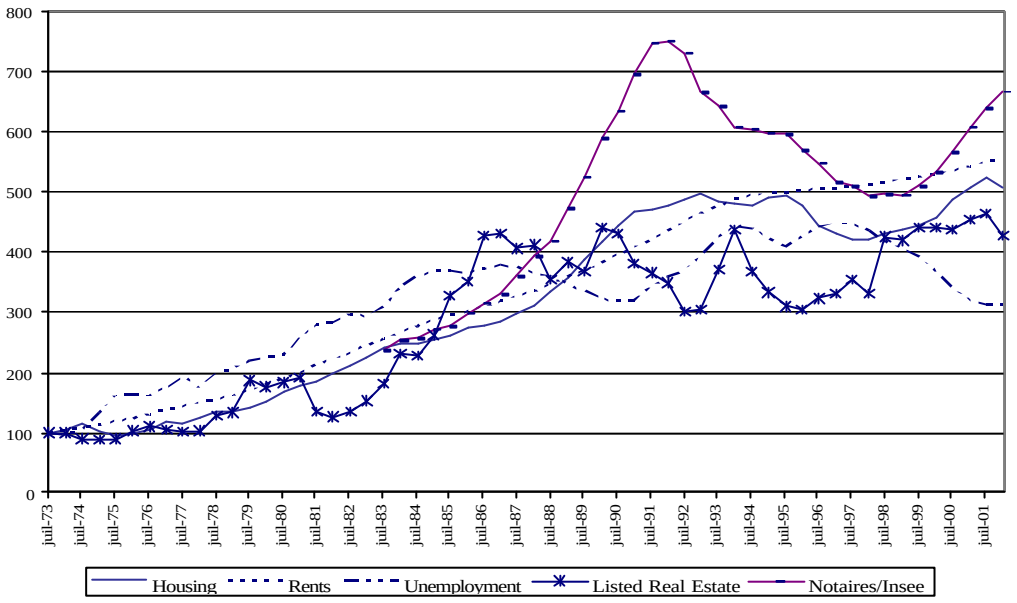

Figure 6: Housing Factor Index - Notaires/INSEE Index - Factor Variables

Representing the Paris Residential Factor Index, the Notaires/INSEE index and the factor variables (rents, unemployment and listed real estate), yields the following figure.

It seems interesting to note that the Paris Price Factor Index's trend is driven by the Rents Index whereas its departures from its central trend are linked to Unemployment Index. Whenever the latter drops (rises), the Factor Index climbs (drops). This feature is particularly notable for the period 1987-1990, when real estate price experienced growth.

Note that the Notaires/INSEE Index depicted in a rather exaggerated manner this fast growth. An explanation of this feature may be that the Notaires/INSEE index includes all types of transactions, and does not control for those with very short holding periods (*duration*) which we have corrected for in our treatment of heteroscedasticity, since they corresponded to significantly different investment behaviours. Therefore, our factor model may be seen as representing the more fundamental real estate market evolution. Note finally that the Notaires/INSEE index moves away from the Factorial Index only during the 1987-1994 period which is precisely the time when the so called "real estate bubble" formed and deflated.

Finally, comparing the above results to inflation behaviour during the 1973-2001 period confirms the traditional view that real estate is a hedge for inflation risk. Indeed, average inflation was 5.72% annually which is very close, while being slightly lower than average direct capital growth rates. What's more, note in *Table 8* the very strong correlation between direct real estate multi-factor indices and inflation during the 1973-2001 period. This feature is present to a lower extent if one uses the INSEE/Notaires Index, and is quite absent if one were to use the IPD Index.

Correlation Coefficient	*Housing Index*	*INSEE/Notaires Index*	*IPD Index*
Price Index	0.959	0.731	0.204

Table 8: Linear correlations between real estate indices and price index

Conclusion

Our study has enabled us to answer a number of questions concerning real estate risk:

- Are we capable of identifying real estate risk factors for the Paris residential market? Yes.
- Can we distinguish between systematic risk and idiosyncratic risk in real estate? Expressed differently, amongst the risk factors identified, can we point to those that investors really value? Yes.
- What is the maximum number of systematic factors? Two.
- Is it necessary to proceed to separate analysises depending on property purposes? Yes.
- Can a thourough analysis of transactions data put to light certain specific market participant behaviour? Yes.
- Has there been a real estate speculative bubble during the late 80s-early 90s? Yes and no depending on the investment horizon.

In this paper we have tried to exhibit systematic sources of risk on the basis of real estate transactions data. We have started by studying the particularities of the semi-annual capital return variable. Interesting behaviours appeared, and in particular one which opposes market participants whose investment horizon is rather short and are keen on arbitrage opportunities (with capital markets for instance), to those with a much longer investment horizon who await a return linked to more fundamental factors such as rents and unemployment.

We then explored the possibility of deriving a factor model of capital growth rates, capable of capturing the market's fundamental movements. Our methodology, backed by both Principal Component Analysis and "stepwise" GLS regression techniques, was aimed at bringing forward consistent explanatory factors.

The results are globally encouraging. Firstly, they provide intuition and explanations as to the role played by such variables as rents, listed real estate, and unemployment in return formation. Next, they indicate that there exist combinations of a priori explanatory variables capable of representing in a satisfactory manner systematic apartment capital growth rates for the Paris Market.

What's more, the results obtained point to the geographical variable as being of little use in explaining real estate risk or return. This might seem surprising to certain categories of real estate professionals. It seems here that location may indeed play a role in the determination of the *transaction price level* but not in capital growth rate*s or rates of return*.

Our study, grounded in observed transactions prices and timing, has the merit of exposing risk factors, but is not totally operational from the point of view of the real estate investor. These are two reasons to this. The first is that the specific dynamics of risk are neglected since they are considered diversifiable. For such a huge and fragmented market, diversification is not always possible or feasible, in particular when specific risk represents nearly half total risk as it seems to be the case here. The second is linked to the predictability of the factor model which is not necessarily an easy exercise. This question is also linked to the question of whether such a factor model could prove useful in elaborating hedging strategies in real estate investment management.

In sum, the real estate investor is in need of an index representing, in a precise manner, the direct market's movements. Such an index has to be grounded in a method that is both able to capture and separate the systematic as well as the specific market dynamic and that would not be too sensitive to the choice of explanatory variables. Our focus is now turned to this precise direction.

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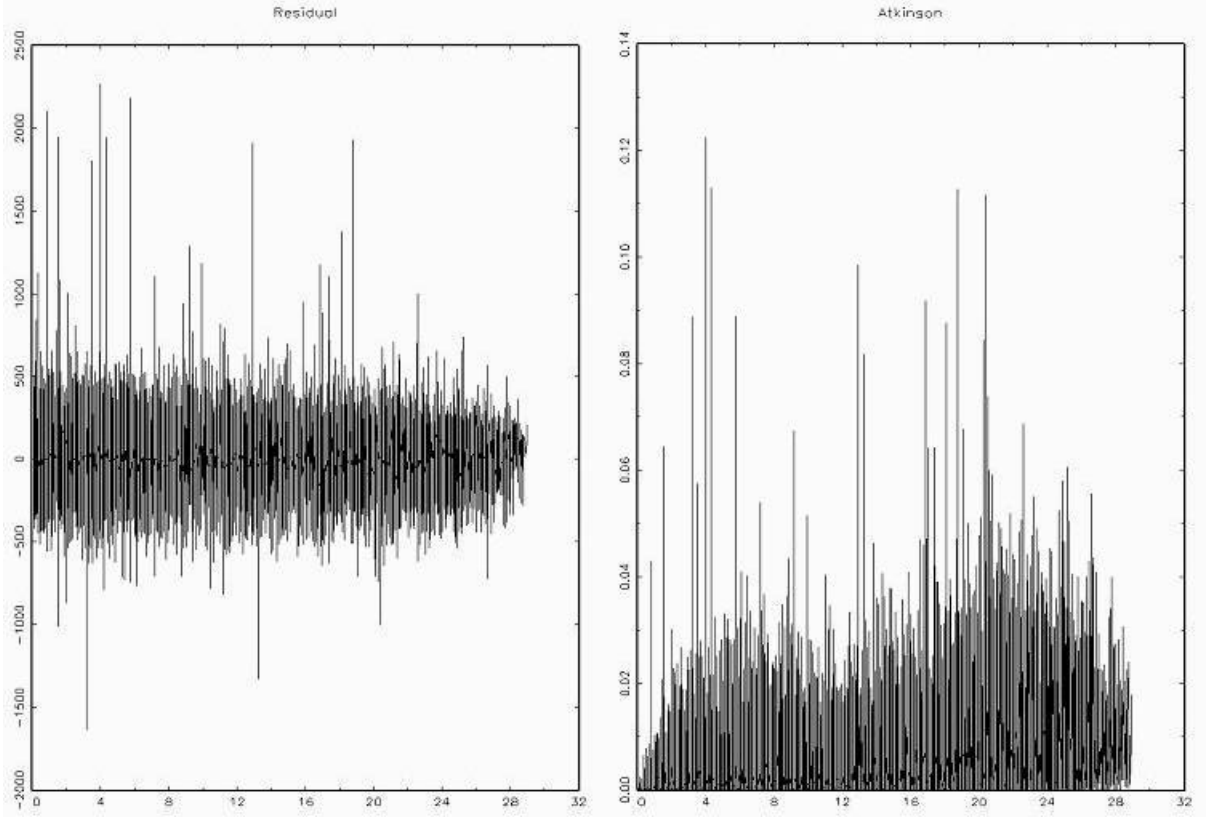
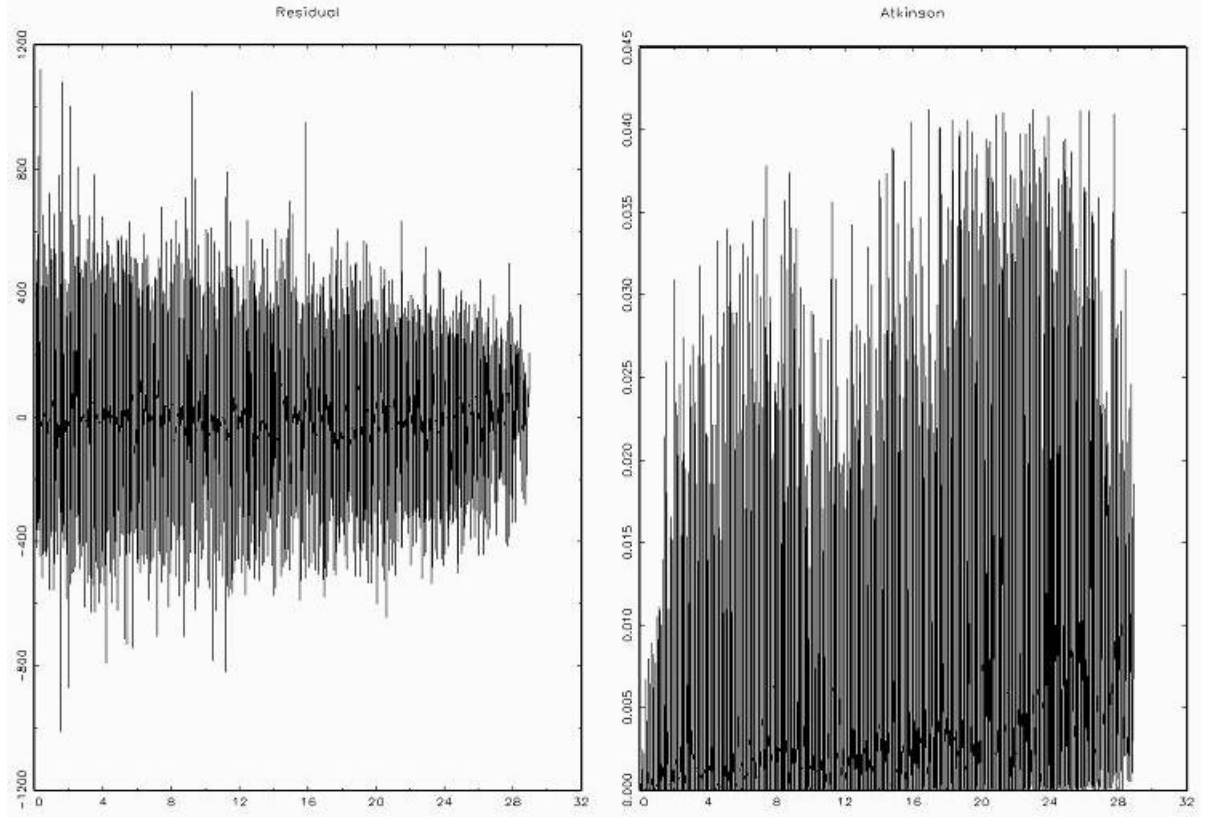
APPENDIX

Appendix A: GLS residuals and influential analysis for Paris residential market (220 679 observations)



Appendix B: GLS residuals and influential analysis by excluding observations with Atkinson > 0.04



Appendix C: indices robustness according to the observations used for the estimation

	All	Atkinson				Subsample			
DATES	observations	< 0.05	< 0.04	< 0.03	< 0.02	90%	75%	50%	25%
june-73	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
dec-73	104,83	104,83	104,84	104,83	104,80	104,83	104,83	104,84	104,86
june-74	115,63	115,60	115,61	115,65	115,72	115,58	115,60	115,63	115,74
dec-74	101,91	101,96	101,96	101,86	101,49	102,01	101,94	101,93	101,85
june-75	94,31	94,41	94,41	94,22	93,57	94,51	94,38	94,35	94,16
dec-75	98,49	98,60	98,60	98,40	97,68	98,70	98,56	98,54	98,35
june-76	105,74	105,86	105,86	105,65	104,84	105,96	105,80	105,79	105,62
dec-76	119,18	119,30	119,30	119,11	118,30	119,39	119,23	119,23	119,16
june-77	113,67	113,83	113,83	113,57	112,51	113,96	113,75	113,74	113,56
dec-77	125,73	125,87	125,88	125,64	124,59	125,99	125,78	125,80	125,71
june-78	132,75	132,90	132,91	132,66	131,55	133,02	132,80	132,84	132,77
dec-78	132,92	133,10	133,11	132,81	131,53	133,24	132,99	133,02	132,92
june-79	141,23	141,42	141,44	141,12	139,70	141,58	141,30	141,34	141,26
dec-79	152,11	152,32	152,34	152,01	150,46	152,47	152,17	152,23	152,21
june-80	168,42	168,63	168,66	168,34	166,66	168,78	168,46	168,54	168,64
dec-80	178,41	178,65	178,69	178,32	176,40	178,81	178,44	178,53	178,67
june-81	184,12	184,41	184,45	184,02	181,82	184,59	184,17	184,26	184,38
dec-81	196,54	196,85	196,90	196,44	194,01	197,05	196,58	196,68	196,88
june-82	209,34	209,67	209,72	209,25	206,65	209,87	209,37	209,50	209,78
dec-82	223,08	223,42	223,48	223,00	220,21	223,62	223,09	223,25	223,63
june-83	241,77	242,12	242,19	241,72	238,78	242,31	241,75	241,96	242,50
dec-83	246,93	247,32	247,40	246,86	243,59	247,54	246,92	247,14	247,66
june-84	246,94	247,37	247,45	246,82	243,27	247,64	246,96	247,18	247,61
dec-84	255,26	255,71	255,79	255,13	251,35	256,00	255,28	255,52	255,99
june-85	262,70	263,15	263,24	262,56	258,65	263,46	262,71	263,00	263,50
dec-85	274,25	274,70	274,79	274,12	270,11	275,01	274,25	274,59	275,18
june-86	278,17	278,63	278,72	278,02	273,88	278,96	278,17	278,56	279,13
dec-86	284,19	284,65	284,74	284,02	279,77	285,00	284,19	284,62	285,22
june-87	295,37	295,83	295,92	295,21	290,82	296,19	295,36	295,85	296,52
dec-87	311,35	311,80	311,90	311,20	306,71	312,16	311,31	311,88	312,70
june-88	334,91	335,33	335,44	334,79	330,19	335,67	334,81	335,49	336,55
dec-88	357,78	358,18	358,30	357,69	352,96	358,51	357,63	358,42	359,72
june-89	386,54	386,89	387,02	386,51	381,72	387,19	386,31	387,25	388,88
dec-89	418,16	418,46	418,61	418,20	413,40	418,71	417,84	418,96	420,98
june-90	443,89	444,16	444,32	443,97	439,03	444,39	443,51	444,76	447,08
dec-90	467,36	467,60	467,78	467,47	462,36	467,83	466,92	468,31	470,89
june-91	472,02	472,31	472,48	472,08	466,57	472,59	471,60	473,04	475,56
dec-91	477,71	478,05	478,22	477,73	471,82	478,39	477,32	478,80	481,28
june-92	486,13	486,50	486,68	486,10	479,78	486,89	485,74	487,28	489,76
Dec-92	495,53	495,94	496,12	495,46	488,73	496,38	495,15	496,75	499,24
june-93	484,96	485,43	485,61	484,78	477,66	485,97	484,65	486,23	488,44
dec-93	479,05	479,58	479,75	478,80	471,34	480,20	478,81	480,39	482,39
june-94	477,89	478,40	478,55	477,58	470,10	479,06	477,65	479,31	481,23
dec-94	491,32	491,77	491,93	491,02	483,61	492,43	491,05	492,86	494,92
june-95	492,79	493,17	493,32	492,45	485,21	493,85	492,50	494,43	496,47
dec-95	475,96	476,35	476,48	475,53	468,31	477,10	475,74	477,66	479,41
june-96	444,46	444,90	445,00	443,91	436,64	445,74	444,35	446,17	447,42
dec-96	430,57	431,00	431,08	429,94	422,76	431,88	430,50	432,32	433,35
june-97	420,29	420,71	420,78	419,61	412,46	421,63	420,26	422,10	422,95
dec-97	420,01	420,39	420,45	419,30	412,25	421,34	419,98	421,90	422,71
june-98	430,47	430,79	430,85	429,74	422,77	431,75	430,41	432,47	433,37
dec-98	436,12	436,40	436,45	435,36	428,44	437,38	436,05	438,23	439,14
june-99	444,05	444,26	444,31	443,27	436,48	445,26	443,95	446,28	447,25
dec-99	456,00	456,13	456,17	455,21	448,60	457,13	455,86	458,36	459,46
june-00	487,46	487,45	487,49	486,70	480,32	488,43	487,22	490,04	491,51
dec-00	507,36	507,24	507,27	506,60	500,37	508,22	507,05	510,11	511,80
june-01	523,44	523,23	523,26	522,68	516,60	524,22	523,08	526,37	528,22
dec-01	505,22	505,07	505,09	504,36	498,07	506,13	504,94	508,15	509,67

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