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## Towards the hedonic modelling and determinants of real estates price in Morocco

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### ABSTRACT

In this paper, we propose a new approach to modeling a real estate price index in Morocco, based on the hedonic regression approach. The basic idea of this paper is to verify the importance of the characteristics of the real estate in the real estate price. Thus, based on data from the three major cities of the capital region of Morocco (RABAT Region), we estimated a hedonic model that takes into account spatial autocorrelation. The results obtained through this modeling generally confirm that the surface area and location of the real estate (land, house, villa and apartment) have a significant influence on the price of real estate.

### 1. Introduction

Today the real estate sector in Morocco is one of the most important sectors for the development of the country. The desire to promote and develop this sector since the end of the 1990s has been decisive in increasing the property supply to meet the demand already in place. However, the lessons from the 2008 financial and economic crisis made it possible to re-read what could result from the weak regulation of this sector (see Tables 1 and 2).

The formation of real estate prices responds to the same logic as that of financial assets where speculation is a common behavior. Indeed, demographic growth and also the urbanization policy suggest euphoria in property prices in most Moroccan regions.

In Morocco, two phases characterize the evolution of the real estate market. The first phase is the one before the 2000s, when real estate prices were stagnating with real estate supply significantly exceeding the needs of the population. From the 2000s and precisely during the year 2003, the real estate sector benefited from several tax and regulatory advantages that boosted the real estate market. In addition, the banking sector has found in this sector an opportunity to increase the use of banking by the population by facilitating bank loans to the real estate sector (also the profit rate of the sector becomes attractive to investors). For example, bank credit statistics for 2006 and 2008 show a two-digit increase in the growth rate of loans to real estate.

This observation and this choice to promote the real estate sector, the durability of which depends on the country's overall strategy, requires

the establishment of regulatory mechanisms to avoid any likely slippage in this sector. In this perspective, the Central Bank of Morocco (BKAM) launched during this period a major project to develop a real estate price index. Beyond its usefulness in the formulation of the monetary policy and the financial stability, this index aims to allow a continuous and advised follow-up of the evolution of the prices in the Moroccan real estate market. The objective being twofold, at first glance, it is a matter of following the potential concordance between supply and demand on the market, by examining the tensions in prices. Secondly, this index will help prevent risks that may be unbeknown to this sector. Moreover, macro prudential policy requires the existence of such an index for better financial regulation.

The method adopted in the property price index by the Central Bank of Morocco for Morocco is that of repeat sales. The index based on this approach consists of selecting all the properties that, during the period considered, gave rise to two or more transactions. The difference in price of a building between its purchase and its resale determines the growth of the price of this property during the period. Thus, the index of repeated sales over a period requires observing the goods that are trading during a given time interval. This market-based approach is sound in the sense that it captures all transactions made on the asset in question. However, it neglects the economic aspects and the factors that favor the realization of the sale and the purchase.

To this end, we propose in this paper a new approach to the development of a real estate index. This is indeed the hedonic approach whose design is based on theoretical considerations about the determinants of

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**Table 1**  
**Spatial test (Geary Test).**

Region	Observed	STD	Z	Pr>  Z
Rabat Center	0.6752396	0.00255	-127.143	<.0001
Rabat Hay Riad Agdal	0.97504	0.00203	-12.323	<.0001
Témara	0.992505	0.00123	-6106	<.0001

Source: own study.

real estate prices. The hedonic index is based on a simplified idea of the world where the value of a property is determined by intrinsic factors. The usefulness of this approach lies in the identification of the factors that explain the prices on the Moroccan market. These determinants will have a double role, firstly they will make it possible to understand how the prices are formed and secondly, they will allow to build an index better describing the evolution of the real prices in Morocco.

In the context of housing, this set of characteristics may include attributes relating to both the structure of buildings and the location of the real estate. There is no market for the characteristics since they cannot be sold separately and, as a result, their prices are not observed independently. The demand and the supply of goods implicitly determine the marginal contributions of their characteristics to their price. These marginal contributions or virtual prices can be estimated using regression techniques. The hedonic method can in particular make it possible to estimate the capacity to pay the price of the different characteristics or the marginal cost of the production thereof.

Hedonic price models have been used in housing studies since (Lancaster, 1976; Rosen, 1974) to explore the determinants of housing prices. In the last three decades, this form of modeling has been used to evaluate the value of real estate worldwide. In this design, the choice of housing confers not only the consumption of the property and the structural characteristics of the dwelling, but the consumption of all the characteristics of the property's location such as proximity to environmental benefits and utilities.

The hedonic price model (HPM) breaks down the price into attributes (Lancaster, 1976; Rosen, 1974). In the real estate field, the hedonic price model typically uses regression analysis to estimate the effects of various attributes or characteristics of housing; including structural, accessibility and neighborhood (Wilhelmsson, 2002). This approach has been largely adopted for real estate valuations in real estate markets around the world to measure the contribution of property attributes, as well as other external factors that could affect the value of a property (Jim & Chen, 2007; Selim, 2008). HPM analysis (Lentz and

Wang, 1998) can be used to analyze the property transaction data of a partial market, therefore, the utility of each of these variables in relation to the price indicated by the buyer of the property (Malpezzi, 2001). The general form of HPM supports the value of real estate to the sum of internal and external characteristics (Chau & Chin, 2002; Sirmans et al., 2005). Thus, the hedonic method recognizes that heterogeneous goods can be described by their attributes or characteristics, that is, a good is essentially a set of characteristics.

This paper aims to model the determinants of real estate prices in Morocco based on the characteristics of goods sold and bought on the Moroccan market. The article is structured as follows: in a first part, we present an empirical literature review on the issue. Then, a presentation of the methodology and the data used allows understanding the nature of the variables retained and the technique used for the development of the new index. Finally, the last part of the article focuses on the presentation of the results and possible interpretations of the new index.

## 2. Literature review

Early work applying the hedonic modeling approach to real estate prices started in the early 1920s, despite the fact that there is no consensus as to the actual date of their introduction.

For example, Colwell and Dillmore (1999) reported that Haas' work in 1922 is the pioneering study to evaluate farmland in Minnesota (USA). Similarly, Bruce and Sundell (1977) have argued that this technique was used in real estate valuation research in 1924. In addition, Wallace (1969) adopted the HPM technique in U.S. cropland. Ridker and Henning (1967) used HPM for the evaluation of air quality and air quality's impact on the residential property values.

However, researchers often refer to Court (1939) as a pioneer of the hedonic approach. He developed a hedonic price index for cars where the demand for automobiles can be explained by the many variables that include the wheels, the weight and the horsepower of the car. Then other works (for example, Muth, 1966; Wallace, 1969) adopted it for the real estate sector. Later, Rosen (1974) developed the theoretical underpinning of this approach for the real estate sector.

Studies focus more on the hedonic approach (see Hill, 2013). Meese and Wallace (1991) estimate house price indexes for Oakland and Fremont, California, from 1968 to 1990. They suggest that the hedonic model provides a better valuation than the repeat sales method. Hill's recent survey (2013) also concludes that the hedonic index appears to dominate the current literature. Meese and Wallace (1991) uses estimates of repeat sales that may be a modified version of the hedonic

**Table 2**  
**Econometrics Result of Cross section regression (all regions).**

Variable	Rabat-Center <sup>a</sup>			Hay-Riad			Temara		
	Coefficient	t-Statistic	Prob.	Coefficient	t-Statistic	Prob.	Coefficient	t-Statistic	Prob.
LOGPRICE (-1)	0.354	28.00	0.00	0.474	55.7	0.00	0.545	99.77	0.00
LOGMETRE	0.812	37.79	0.00	0.770	46.57	0.00	0.821	54.41	0.00
AGE	0.000	7.44	0.00	0.000	3.47	0.00	0.000	8.21	0.00
Hall	0.056	1.65	0.09	0.163	1.94	0.05	0.026	1.77	0.07
N° floor	0.042	3.25	0.001						
Space	-0.026	-2.34	0.01				0.073	4.84	0.00
Level of floor	-0.000	-1.88	0.05				0.000	2.45	0.01
D1	-0.021	-3.80	0.00	0.068	9.25	0.00	0.116	1.95	0.00
D3	-0.060	-1.26	0.00						
D4	-0.056	-2.21	0.02						
Parking				0.100	4.14	0.00	0.025	0.46	0.64
D5							0.157	1.88	0.00
D8							0.114	7.57	0.00
Private parking							0.387	3.01	0.00
Pool							-0.516	-5.68	0.00
R-squared	0.54			0.66			0.65		
J-statistic	12.647			7.140			1.007		

Source: own study.

<sup>a</sup> Estimates were made using the two-stage instrumental variables approach to correct the low exogeneity bias.

model in which it is assumed that: (i) homes that are sold are twice present on the market and (ii) virtual prices of attributes are constant over time, so they cannot influence the price index. The results reject the claims for 50 000 homes in the cities of Oakland and Fremont. In addition, the results suggest that repeated sales index tend to be more volatile. Clap, Kim, and Gelfand (2002) has obtained similar results.

Zheng et al. (2010) use hedonic models to examine the relationship between house prices, investment, wages, and pollution and found that Chinese cities under go a transition from 'producer cities' cities of euphoria. Hou (2010) analyzed housing market prices in Beijing and Shanghai and concluded that the housing price bubble seems to have appeared in Beijing from 2005 to 2008 and in Shanghai from 2003 to 2004. Although the theory of hedonic models prices has been widely applied to analyze housing prices in countries like the U.S. (Sander & Polasky, 2009), France (Gouriéroux and Laferrère, 2009), Norway (Osland, 2010), Japan (Shimizu et al., 2010), Austria (Helbich et al., 2013), and the Netherlands (Ozyurt, 2014), studies in developing countries are almost non-existent.

A review and a detailed theoretical development of the HPM approach is presented by Chau and Chin (2002) and Malpezzi (2001, p. 10). In addition, Sirmans et al. (2005) conducted a meta-analysis of articles that adopted the hedonic approach, to extract the variables that determine the values of a property. They have, in fact, analyzed 125 articles published in the United States between 1995 and 2004 to establish the research tools. A total of 360 independent variables were identified and can be classified into eight categories, including the building structure, internal features of the house, home amenities, external environment, neighborhood and location, utility, marketing, occupancy and capacity of sales.

Other studies have tried to explain the time required to sell a house and the reasons for this decision. Indeed, two approaches have been adopted namely: duration models and linear regression models. The use of duration models is justified by the significance of time in determining selling prices in the real estate market. The basic assumption is that the more the good is in the market, the more its value increases. Sirmans et al. (2005) found that most studies use the hedonic approach and verified the relevance of the temporal variable.

The physical characteristics of a property affect not only its composite price, but also the likelihood of selling it. Haurin (1988) uses a duration model to explore the impact of asset heterogeneity in sales time. The results obtained by the author assert that the uncertainty related to the value of a good impacts the possibility of its resale. Thus, it will take even longer to sell an atypical property than a normal good. In addition, whether a property is vacant or occupied will have a significant impact on the price. Zuehlke (1989) examines the impact of this factor on real estate prices. Thus, an empty property will have a higher price. He finds that while empty goods are weakly sold at the beginning, they are more in demand. In addition, the risk is higher for occupied property.

Other factors have been cited in empirical studies, such as the choice of a current price and the choice of involving a broker. Belkin et al. (1976) were among the first. They segmented housing data and found a negative relationship between the selling price and the current price. In other words, the more there is a gap between the price and the good take time to sell. Kang and Gardner (1989) found the same result. Yavas and Yang (1995) examined this relationship with a two-step regression model. Their results were ambiguous, but managed to confirm the results reported by Belkin et al. (1976). Empirical work has also confirmed the predominant role brokers play in reducing resale time due to their intense networks (Haurin, 1988; Forgey et al., 1996; Knight, 2002; Yavas & Yang, 1995).

Due to the price dependence of negotiations between buyers and sellers, the use of the hedonic approach does not allow this element to be taken into account. Harding et al. (2003) estimated the effects of trading by including in the hedonic equation a vector of buyer and seller characteristics. Turnbull and Dombrow (2006) study the spatial situation of

real estate to describe the impact of the neighborhood on the price of housing. Their results show that the spatial effect dominates and depends on the market trend. To account for the spatial phenomenon, many authors have begun to apply the hedonic model to spatial factors. Dubin (1998) uses the geostatistical method to evaluate the covariance structure of the model. Can (1990) proposes to use models with spatial delay.

In addition, other works have indicated the impact of the season of the year on the real estate prices. For example, prices are often higher during the summer periods because of better household availability and the possibility of hiding property failures during this season (Haurin, 1988; Forgey et al., 1996; Harding et al., 2003; Knight, 2002).

Lu (2000) uses Lazear's (1986) theory as the basis for a price revision strategy for the real estate seller. He uses numerical analysis to describe how salespeople learn from the rate of customer arrivals about the market value of their properties and then incorporate that information with changes in reservation prices.

Merlo and Ortalo-Magne (2004) have not only data on current price changes, but also data reflecting the number of views by potential buyers, and all proposals made on a property between the list and the sale. They find that the size of the price reduction is related to the period the house has been on the market. Regarding the bids received on a property, they find that the supply is lower and a house has been long on the market, a fact consistent with Taylor's theories (2003). Their data also provides evidence that the recorded transaction price is typically not the same as the first bid was, although properties are typically sold to the first potential buyer making a bid. These points to a weakness in existing trading models of complete information that take the price as something fixed.

Although the early work on the hedonic approach was linear in form, Rosen (1974) emphasized that this relationship may be non-linear, and even more so, the actual relationship between the attributes and the price on the market is unknown. Goodman. (2003) proposed a non-linear form to capture the complex effects of price attributes. Moreover, Box and Cox (1964) propose a generalization that makes it possible to compare several forms of functions and to determine the most appropriate one. Halstead et al. (1997) use this approach.

Indeed, despite the power of the Box and Cox's approach, several authors have detected some limitations of the approach: the difficulty of interpreting coefficients due to functional transformations (see: Maurer et al., 2004). In addition, it has been found that Box and Cox's regression cannot be applied when the variables are binary or multinomial (see: Linneman, 1980). Thus, several other specifications have been proposed in literature, namely: linear, semi-logarithmic and logarithmic (Dube and Legros, 2014).

The decision on the functional form can be made based on a nested specification and a likelihood ratio test, or with other relevant statistics (Akaike, 1974). The first family of tests was based on the predictive abilities of the functional forms adopted. One of the most common tests is that of Ramsey (1969) relating to the stability of the adopted form. Similarly, the use of the coefficient of determination makes it possible to validate the adopted specifications. In addition, predictive performance methods are commonly used, namely the in and out of samples predictions based on the mean squared error. On the other hand, authors suggest the use of residue tests to verify the existence of heteroscedasticity phenomena (White, 1980) and spatial autocorrelation (Meese & Wallasace, 1991). Thus, the use of a functional form is justified by the intrinsic validation of the econometric prerequisites. In their comparison work, Jean Dubé and Legros (2014) state that the log-linear form is superior to the other alternatives offered by linear and semi-logarithmic forms.

### 3. Data and methodology

This paper analyzes the formation of real estate prices in the Rabat-Témara area, which is an important area in Morocco's real estate

heritage. In addition to its nomination as capital of the country, the Rabat region is the cultural center of the Kingdom. All the communes of the Rabat region were analyzed, only those of Kenitra were not included in the analysis because of the unavailability of the data. We have taken into account all the real estate belonging to this area, be it bare land, apartments, villas and other types of derived habitats.

The graph below shows the geographic distribution of the dwellings used in this research. For reasons of precision, only urban areas were analyzed, rural areas (blank in the graph) were not considered due to the unavailability of data for this type of habitat.

According to the graph, housing in urban areas in the Rabat region has different prices. The Hay Riad-Agdal area is the most expensive area in the capital. In the other areas, the prices do not differ much, except for the Harhoura area and downtown Rabat.

Moroccan official land register "Agence de Conservation Foncière" supplies the real estate data. It holds all the information on the characteristics of the goods and the sales and purchases transactions. We were able to access their 2014 database for the Rabat region. Indeed, our analysis focuses on the central regions of the capital, Témara and Hay Riad-Agdal. These three zones constitute the most important regions in the greater region of the capital of Morocco.

The database consists all types of property, including independent houses, villas, land, apartments, etc. Data from the urban area of central Rabat (Annex Table 1), which constitutes the heart of the capital, are dominated by apartments (11 124 units) in the first place, followed by built-up land (931 units). There are only few second hand houses in this base (423 units). For apartments in the center of Rabat, the total value of the housing stock is 6.4 billion dirhams or about 0.6% of Morocco's GDP. On average, the price of the apartment is around 530 000 MAD.

The majority of real estate properties registered in the Hay Riad area are luxury apartments (Table 2 in annex). This area is considered one of the most prestigious areas of the Rabat region. This explains why the value of the properties is quite high compared to that of the other zones studied.

With regard to the Témara area (Annex Table 3), also the apartments constitute the majority of the properties in the area. However, prices on average are much lower than in the other two areas in the region. The city of Temara is considered a popular area apart from a few neighborhoods that are classified as standing.

A hedonic price index is established through the estimation of the hedonic function. A hedonic function is an econometric relation between the price of a dwelling and the quantities of the characteristics of a dwelling. In general, the establishment of a hedonic function consists in estimating a statistical model in the form:

$$\ln(p_j) = \alpha + \sum_{i=1}^n \beta_i X_i + \varepsilon_j$$

'P<sub>j</sub>' is the price of dwelling *j* and 'X' is the quantity of characteristic *n* of dwelling *j*. In the empirical literature, the endogenous variable is either the price of the whole house or its price per square meter. The exogenous variables should describe the price in the hedonic model, the often included ones are: the geographical location, the size and type of housing, age or various housing facilities or amenities in the surrounding area.

However, in practice, the availability of data strongly limits the possibilities of modeling. Moreover, it is often a question of finding a compromise between a statistically valid functional form and a model that retains a reasonable economic interpretation. In a log-linear model, for example, the coefficients are interpreted as the percentage change in the price for the incrimination of an additional unit of the characteristic, all else being equal.

The estimation of the hedonic model according to the specificities of the data facilitates the transition to the hedonic index that explains the evolution of real estate prices in the Moroccan regions. Theoretically, this passage can be carried out according to two approaches: One

approach is the time dummy method where we add temporal indicators to the model. Another approach is based on a fixed reference stock over time, the index is the result of the comparison of the prices of the current sample with the valuation of the initial sample (Diewert et al., 2008).

In general, the estimation method adopted in hedonic models is ordinary least squares, since the model is generally linear and satisfies the required conditions. However, real estate is of a specific nature where the valuation of property depends on several parameters in addition to the intrinsic characteristics. Thus, one of the important factors is the value of neighboring properties. In fact, the higher the value of a good, the greater the probability that a neighboring good will have such a high price (phenomenon of real estate mimicry). In this design, it is necessary to take into account the spatial autocorrelation that measures neighborhood effects. House prices depend also on the prices of surrounding dwellings. Spatial autocorrelation is defined as the correlation, positive or negative, of a variable with itself arising from the geographic location of the data.<sup>1</sup>

In order to capture this phenomenon of spatial autocorrelation Paelinck (1970) put forward five principles to be respected in the formulation of econometric modeling, which are: the principle of spatial interdependence, the principle of asymmetry, the principle of allotropy, the geographic principle, and the principle of distinction. In the case of Morocco, we tried to take into account the principles of spatial interdependence and allotropy (spatial causality) by adopting a delayed endogenous variable model. This demands to take into account the spatial effects on the behavior of real estate prices.

The adoption of the spatial autocorrelation model makes the ordinary least squares (OLS) method unsuitable: the estimators obtained by this method are not convergent when there is an endogenous offset variable and they are inefficient in the presence of autocorrelation spatial errors (Paelinck and Klaassen, 1970). Other estimation methods are then needed to find convergent and efficient estimators. The most commonly used method is a maximum likelihood regression with complete information but it is also possible to use the instrumental variable method (IV) or the generalized method of moments (GMM). Indeed, the endogenous variable is correlated with the errors and the parameters of the model cannot therefore be estimated in a convergent and efficient way by the LS (Kelejian & Prucha, 1998), then there is an abolition of the hypothesis strict exogeneity. In this respect, Kelejian and Prucha (1998; 1999a) proposed a GMM approach. They develop a set of conditions on the moments allowing the estimation of the equations for the parameters in the model with self-correlated errors.<sup>2</sup>

#### 4. Regression results

Before presenting the results of the hedonic regression, some special analyzes are needed to present the behavior of real estate prices in the analyzed region. First, autocorrelation tests are used to take into account the effect of spatial autocorrelation in the Rabat-Témara region. These can be divided into several categories. First, the Moran test is the oldest one and it is still the most used one. It tests the spatial autocorrelation of residuals when errors follow an autoregressive or moving average process. In addition, the Lagrange Multiplier tests have been developed and they can be either unidirectional, when a simple assumption is tested assuming a correct specification for the rest of the model, or multidirectional when more than one type of spatial dependency is tested. To test this spatial autocorrelation we opted for the Geary index (1954) which measures the local spatial dependence between real estate.

<sup>1</sup> Julie Le Gallo. *Econométrie spatiale (1, Autocorrélation spatiale)*. [Rapport de recherche] Laboratory of economic analysis (LATEC). 2000, p. 45, Table, ref. bib.: 5 p. <hal-01 527 290>.

<sup>2</sup> The tree condition are:  $E[u'u/N] = \sigma^2 E[u'W'Wu/N] = \sigma^2 \left( \frac{1}{N} \right) \text{tr}(W'W)E[u'u/N] = 0$

The value obtained from the Geary index is less than one, making it possible to reject the hypothesis of non-existence of spatial autocorrelation. In this respect, we can say that real estate prices in Rabat-Hay Riad and Témara are autocorrelated in space. In other words, the value of goods is influenced by prices in the neighborhood (see Fig. 1).

This finding requires one to measure the degree of spatial correlation via geostatistical analysis (Variogram, Fig. 2) that will validate and measure the level of correlation in the studied area. The following chart measures the distance between the correlations of real estate price pairs taking into account the distances between the different properties. The price distribution in the region seems to be well arranged describing an increased spatial correlation as it is validated by the Geary test. Analysis of the variogram shows that the spaces between the different points are very small, resulting in a very high level of spatial autocorrelation. This implies that prices in the neighborhood have a mutual influence on price determination.

In addition, the results show that the degree of correlation is as important in the city center as it is in the Hay Riad area or the city of Témara knowing that the latter two are close to the city center.

An examination of the distance distribution in terms of correlation also indicates that properties that are close to 3 to 5, depending on the degree of neighborhood, are highly correlated. This implies a possible price dependence at the neighborhood level of the Rabat region, Hay Riad and Témara. Thus, the crossover of the pairs of properties studied reflects a dependence on the limit of five neighborhood delays. In other words, their counterparts in up to five neighborhoods (see Fig. 3) can influence real estate price in a neighborhood in the area.

The existence of the spatial correlation,<sup>3,45</sup> up to the fifth neighborhood in the region corroborates the hypothesis of the influence of the prices in the neighborhood on the real estate sales value. Therefore, we propose a model that takes into account this spatial dependence effect estimated using the instrumental approach to correct the low exogeneity bias. Models were estimated according to the following specification (log-log):

$$y_{ij} = \beta y_{i-j} + \sum_{i=1}^{n,m} \alpha_{ij} + \beta_{ij} X_{ij} + \varepsilon_{ij} \varepsilon_{ij}$$

The exogenous variables are: the square meter, the number of floors, the nature of the property, the address, the number of bedrooms, the floor no. of the property if it is an apartment, the existence of a garage, pool or other services. Parameter  $i$  is the individual dimension describing real estate and  $j$  is the nature of the property. We have distinguished different categories of real estate (apartment, villa, land, etc.). Therefore, we have 8 property categories and more than 11 000 properties in the region of Rabat-center, 6500 properties in Hay Riad and 20 400 in the city of Témara.

In the three models estimated, we considered all the potentially explanatory characteristics of real estate prices, while taking into account the specific effects of each type of property.

It should be noted that the estimation was made via a log-log model, which implies that the coefficient of the metric is a partial elasticity of the price with respect to the size of the dwelling. Thus, for all the zones studied, the coefficient describing the surface area is greater than 0.7, which implies that a 1% change in the footage leads to a 0.7% increase in prices on the market. This indeed affirms the importance of the area in determining prices. It is the same for the coefficient of inertia, which is also of seminal importance because of its ability to describe the spatial dependence of real estate.

<sup>3</sup> The degree of spatial correlation measures the influence of neighboring prices on the selling price.

<sup>4</sup>  $Y$  is the adopted price measure and  $\alpha$  and  $\beta$  are respectively the constants and also the sensitivity coefficients.

<sup>5</sup>  $\varepsilon_{ij}$  is a combination of supposedly random residues and effects specific to types of real estate.

For the central Rabat area, it is estimated that real estate meter is the most influential variable in the formation of real estate prices. Also, we introduced spatial correlation via the autocorrelation effect of endogenous variable in space to demonstrate that the prices in the neighborhood influence the sales price of real estate. Similarly, real estate characteristics can influence the price only marginally, including the 'balcony' and the number of floors of the property's building. These two elements contribute positively to the valuation of goods in the city center of the capital. Moreover, the floor on which the property is located and the courtyard negatively influence the value of the good, the higher the floor is, the lower the price is. In addition, we have chosen to introduce some dummy variables describing the communal zoning of properties and houses located in zones D1, D3 and D4. This may contribute to the fall in real estate prices.<sup>6</sup>

In the Hay Riad area, due to the architectural specificity of this area in the capital region, only a few features are significant. Indeed, the level, the age of the real estate, the existence of a balcony, and the garage are the factors that determine the price significantly. Also, being located in the Hay Riad area, influences the price, thus, Agdal area has a positive effect on the real estate valuation.

As for the area of Témara, several characteristics influence the price of real estate, the most important of which are: the size of the properties, the existence of a cellar and being located in some luxury zones of the city of Témara, namely Harhoura and others. It should not be overlooked that the existence of a yard in the house has a positive effect on the selling price of the property unlike in the other areas studied.

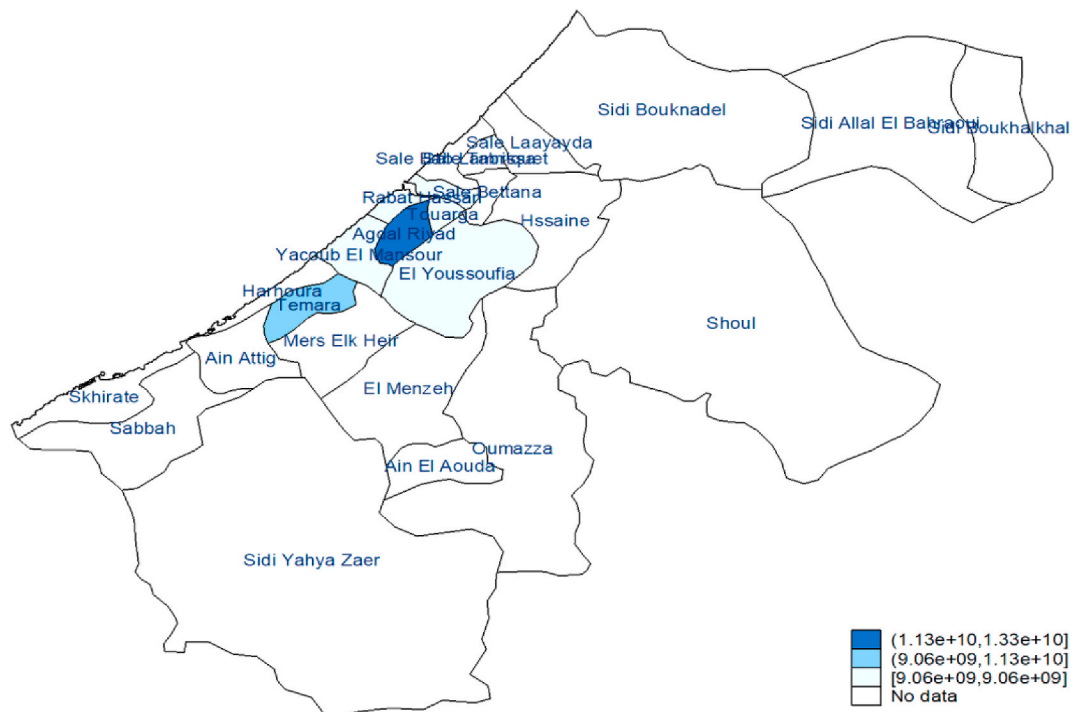
In general, the prices of real estate in the Rabat region are determined by several factors in a heterogeneous way, however, the influence of autocorrelation is remarkable in all the areas analyzed. In fact, the neighborhood's price effect has a significant influence on the valuation of real estate. It is sufficient that the neighboring property is valued at an 'x' price so that all neighbors are influenced by this information, which largely explains the price spike in this area in Morocco.

## 5. Conclusion

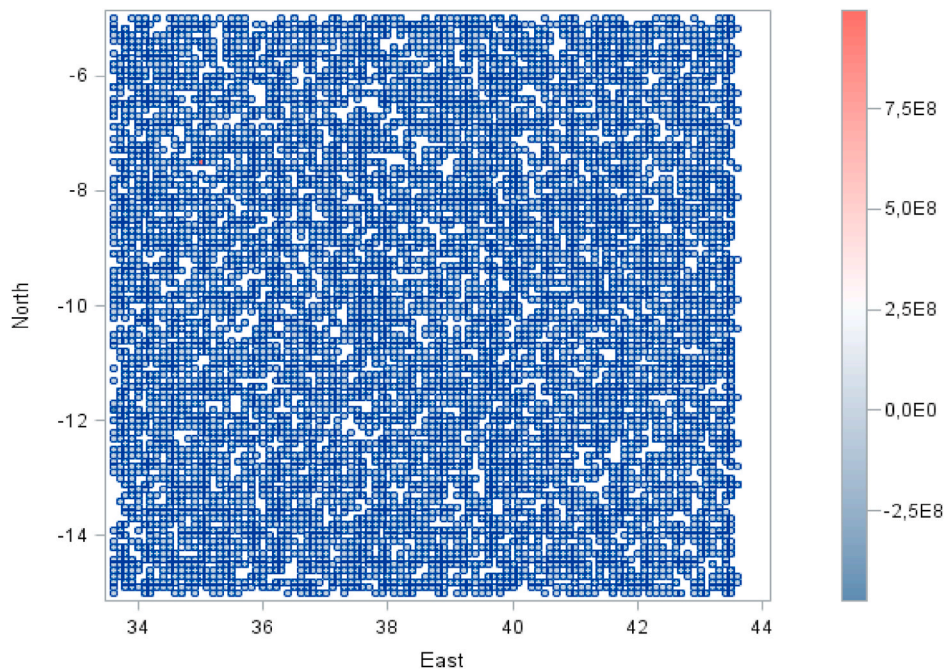
Due to the importance of the real estate market in Morocco, public action has spread over the development of a range of indicators for the monitoring of this sector, which is one of the most important sectors in Morocco. In this perspective, two elements are essential, first, the need to understand the factors determining the evolution of property prices in Morocco, and then implement a new, economic approach to the construction of real estate indexes that can be complementary to that in use at the central bank.

The mean idea of this paper is to propose a new technique for forecasting the property price index. This approach can be used to supplement the tools available to the central bank in monitoring the Moroccan real estate market. Our approach is based on two steps: the first step is to determine the intrinsic factors that determine the price in the study area. In this step we use hedonic modeling on data in cross section. Then, the estimated coefficients will make it possible to calculate the parameters essential for conducting a Monte Carlo simulation (the rate of return and the volatility). In this paper, we have developed a hedonic model to identify factors or characteristics that can explain the formation of real estate prices. Our analysis was spread over the Rabat region where three areas were studied namely: the area of the center of Rabat, the residential and administrative district of Hay-Riad-Agdal and the city of Témara. The results indicate that the spatial correlation factor and the footage are the two major determinants of real estate pricing in the Capital Region. Thus, the mimetic impact of the neighborhood largely affects the price of goods in the Rabat region and the spatial character described by the square meter is decisive in the negotiations on the

<sup>6</sup> As an indication, there are 5 communes in the city center of the capital. Three have a negative impact on the value of real estate.



**Fig. 1.** Value of real assets of rabat region (data for 2014).



**Fig. 2.** Variogram of real estate's prices  
*Source:* own study.

market.

However, scientific research in the area of house prices is fraught with uncertainty. The approach we propose in this paper can be widely criticized because of its conception based on the theory of prices in financial markets. However, its use in combination with other approaches can prove useful for financial and monetary policy makers.

Finally, we note that the existence of an intrinsic approach will allow the development of a new real estate index other than the one used today in Morocco and which is based on the repeat sales approach. This will be

the subject of previous research.

## CRedit authorship contribution statement

**Firano Zakaria:** Conception, design of study, acquisition of data, Formal analysis, interpretation of data, Drafting the manuscript, revising the manuscript, critically for important intellectual content.  
**Filali A. Fatine:** Conception, design of study, Formal analysis, interpretation of data, Drafting the manuscript, revising the manuscript,

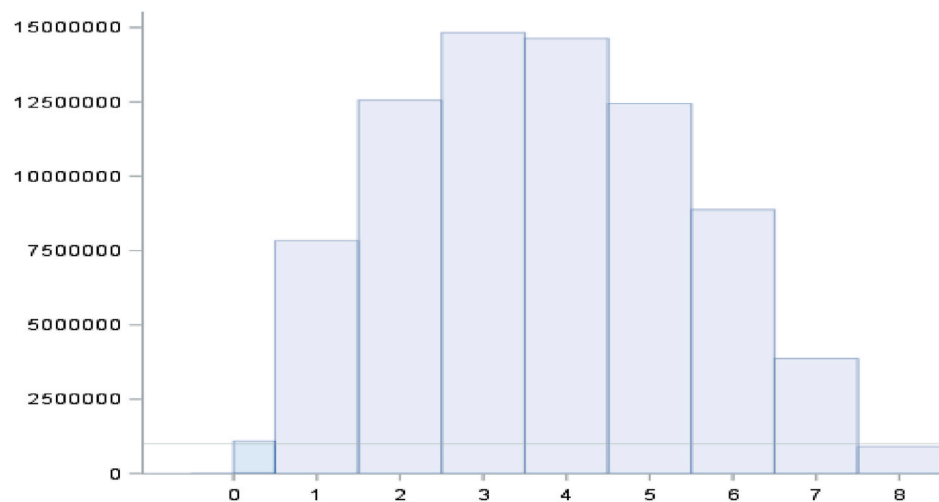


Fig. 3. Distribution matched delays

Source: own study (y-axis is the price of neighborhood and x-axis is the degree of lag).

critically for important intellectual content.

## Annexes.

Table 1A

Statistics of Rabat Center

Rabat center		Mean	Max	Min	STD	Sum	N
Land	Value	7 646 816	127 000 000	200 000	22 147 212	244 698 121	32
	Superficies en m2	750	5105	0	1095	23 999	32
	Age	64	95	17	27	1994	31
	level	0	0	0	0	0	32
	Number of level	0	4	0	1	11	32
house	Value	865 343	18 498 600	24 900	1 431 806	366 040 050	423
	Superficies en m2	103	1625	0	128	43 405	423
	Age	42	99	4	23	17 649	421
	level	0	0	0	0	0	423
	Number of level	1	4	0	1	317	423
Villa	Value	2 309 469	33 498 000	61 000	4 072 378	602 771 495	261
	Superficies en m2	342	982	0	156	89 159	261
	Age	35	97	7	28	9045	257
	level	0	0	0	0	0	261
	Number of level	1	2	0	1	163	261
Apartement	Value	583 660	23 000 000	37 700	853 808	6 492 634,477	11 124
	Superficies en m2	84	418	0	32	934 647	11 124
	Age	50	118	6	32	553 335	11 057
	level	3	99	-1	8	31 995	11 124
	Number of level	0	0	0	0	0	11 124
House two level	Value	3 925 000	6 000 000	1 900 000	2 282 360	15 700 000	4
	Superficies en m2	483	608	318	133	1933	4
	Age	76	88	42	23	304	4
	level	0	0	0	0	0	4
	Number of level	0	0	0	0	0	4
building	Value	5 077 156	22 000 000	425 000	4 350 127	304 629 346	60
	Superficies en m2	395	1087	56	201	23 689	60
	Age	74	97	19	22	4358	59
	level	0	0	0	0	0	60
	Number of level	2	6	0	2	148	60
land with building	Value	1 112 982	77 000 000	24 850	2 908 532	1 036 186,620	931
	Superficies en m2	140	4533	0	226	130 021	931
	Age	40	99	4	16	37 363	929
	level	0	0	0	0	0	931
	Number of level	1	6	0	1	882	931
Duplexe	Value	700 000	700 000	700 000		700 000	1
	Superficies en m2	202	202	202		202	1
	Age	32	32	32		32	1
	level	1	1	1		1	1
	Number of level	0	0	0		0	1

Source: Agency of Conservation.

**Table 2A**  
Statistics of Hay Riad Agdal

Zone de Hay Riad		Mean	StdDev	Max	Min	Sum	N
Land	Value	128 370 000	128 148 719	300 000 000	13 480 000	513 480 000	
	Superficies (m2)	7422	4926	11 090	674	29 686	4
	Level number	0	0	0	0	0	4
	Age	48	30	77	22	190	4
House	Value	6 213 170	31 911 248	210 000 000	45 000	267 166 300	43
	Superficies (m2)	584	2253	14 333	49	25 129	43
	Level number	0	1	2	0	15	43
	Age	46	26	95	3	1982	43
House with floor	Value	5 292 625	4735 156	42 000 000	38 100	3 170 282 100	599
	Superficies (m2)	1010	1034	9986	132	604 858	599
	Level number	0	1	2	0	251	599
	Age	35	18	95	7	21 067	594
Apartement	Value	1 352 768	2236 432	20 550 000	43 800	8 879 567 500	6564
	Superficies (m2)	108	48	499	0	710 704	6564
	Level number	0	0	0	0	0	6564
	Age	32	29	118	4	204 217	6325
Villa with two floor	Value	7 200 000	4986 983	12 500 000	2 600 000	21 600 000	3
	Superficies (m2)	1122	1275	2572	177	3367	3
	Level number	0	0	0	0	0	3
	Age	69	21	85	45	208	3
House two level	Value	14 311 000	8 745 633	26 000 000	6 555 000	71 555 000	5
	Superficies (m2)	406	99	500	300	2032	5
	Level number	4	0	4	3	19	5
	Age	82	4	85	76	411	5
Land with building	Value	1 761 783	5 252 889	64 000 000	45 000	338 262 400	192
	Superficies (m2)	291	849	8015	0	55 948	192
	Level number	0	1	4	0	87	192
	Age	41	17	96	12	7789	192
Duplex	Value	3 168 727	1 719 946	6 163 000	545 000	34 856 000	11
	Superficies (m2)	167	85	323	92	1841	11
	Level number	0	0	0	0	0	11
	Age	39	25	89	20	429	11

Source: Agency of conservation.

**Table 3A**  
Statistics of Témara city

		Mean	StdDev	Max	Min	Sum	N
Land	value	2 858 456	6095 742	26 000 000	100 000	51 452 200	18
	Superficies m2	4507	13 160	52 401	60	81 117	18
	Number of level	0	0	1	0	1	10
	Age	28	17	76	8	508	18
House	value	1 089 000	115 858	1 220 000	1000 000	3 267 000	3
	Superficies m2	189	142	352	95	567	3
	Number of level	1	1	2	0	2	2
	Age	26	4	29	21	78	3
House with floor	value	1 709 865	2676 654	40 000 000	59 100	665 137 600	389
	Superficies m2	831	3390	54 998	131	323 269	389
	Number of level	0	0	0	0	0	215
	Age	20	13	84	6	7269	357
Apartement	value	433 207	415 704	10 800 000	8000	8 871 209 100	20 478
	Superficies m2	71	65	8800	0	1 453 726	20 478
	Number of level	0	0	0	0	0	20 328
	Age	17	15	118	3	344 659	20 475
Villa with two floor	value	3 350 000		3 350 000	3350 000	3 350 000	1
	Superficies m2	289		289	289	289	1
	Number of level						0
	Age	33		33	33	33	1
House two level	value	195 000		195 000	195 000	195 000	1
	Superficies m2	162		162	162	162	1
	Number of level						0
	Age	17		17	17	17	1
Land with building	value	707 282	1 067 770	22 650 000	20 000	1 700 305 400	2404
	Superficies m2	162	1125	43 463	25	389 501	2404
	Number of level	0	0	1	0	1	525
	Age	21	11	108	4	47 748	2277
Duplex	value	480 000		480 000	480 000	480 000	1
	Superficies m2	54		54	54	54	1
	Number of level	0		0	0	0	1
	Age	14		14	14	14	1

Source: Agency of conservation.

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**Update**

**Social Sciences & Humanities Open**

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## Erratum regarding missing Declaration of Competing Interest statements in previously published articles

Declaration of Competing Interest statements were not included in the published version of the following articles that appeared in previous issues of Social Sciences & Humanities Open.

The appropriate Declaration/Competing Interest statements, provided by the Authors, are included below.

1. "The potential role of European professors in the context of Rwandan civil engineering education: Reflections after a teaching experience"(SSAHO, 2020; 2/1: 100019) <https://doi.org/10.1016/j.ssaho.2020.100019>

Declaration of competing interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

2. "Chatbot personality preferences in Global South urban English speakers"(SSAHO, 2021; 3/1: 100131) <https://doi.org/10.1016/j.ssaho.2021.100131>

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3. "Locked up under lockdown: The COVID-19 pandemic and the migrant population"(SSAHO, 2021; 3/1: 100126) <https://doi.org/10.1016/j.ssaho.2021.100126>

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4. "The multifold intertextuality in Lee Chang Dong's burning"(SSAHO, 2021; 3/1: 100119) <https://doi.org/10.1016/j.ssaho.2021.100119>

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5. "Anti-Chinese stigma in the Greater Toronto Area during COVID-19: Aiming the spotlight towards community capacity"(SSAHO,

2021; 4/1: 100232) <https://doi.org/10.1016/j.ssaho.2021.100232>

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6. Branding in social media. Using LinkedIn in personal brand communication: A study on communications/marketing and recruitment/human resources specialists perception"(SSAHO, 2021; 4/1: 100174) <https://doi.org/10.1016/j.ssaho.2021.100174>

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7. "Burnout, self-efficacy and job satisfaction among primary school teachers in Morocco"(SSAHO, 2021; 4/1: 100148) <https://doi.org/10.1016/j.ssaho.2021.100148>

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8. "Ghana's rice value chain resilience in the context of COVID-19"(SSAHO, 2021; 4/1: 100210) <https://doi.org/10.1016/j.ssaho.2021.100210>

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9. "Indonesian post-migrant workers: A challenging problem for human security"(SSAHO, 2021; 4/1: 100223) <https://doi.org/10.1016/j.ssaho.2021.100223>

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10. Readings of the coloniality of power in the COVID-19 global dynamics: A brief reflection on Global South's socio-political

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locations”(SSAHO, 2021; 4/1: 100161) <https://doi.org/10.1016/j.ssaho.2021.100161>

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11. Rethinking theories of lesson plan for effective teaching and learning”(SSAHO, 2021; 4/1: 100172) <https://doi.org/10.1016/j.ssaho.2021.100172>

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12. The association between polygyny statuses of currently married and in-union women and attitude towards intimate partner violence against women in Ghana”(SSAHO, 2021; 4/1: 100207) <https://doi.org/10.1016/j.ssaho.2021.100207>

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13. The coronavirus trade-off – Life vs. economy: Handling the trade-off rationally and optimally”(SSAHO, 2021; 4/1: 100215) <https://doi.org/10.1016/j.ssaho.2021.100215>

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14. “The possibility to be creative is the reason I want to teach”: Pre-service teachers’ perceptions of creative teaching and philosophical education”(SSAHO, 2021; 4/1: 100190) <https://doi.org/10.1016/j.ssaho.2021.100190>

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15. Towards the hedonic modelling and determinants of real estates price in Morocco” (SSAHO, 2022; 5/1: 100176) <https://doi.org/10.1016/j.ssaho.2021.100176>

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