

# *HEDONIC BROWNIAN MOTION INDEX FOR MOROCCO*

*Recent trends in the real estate market and its analysis. 2019 edition.  
Conference*

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Presentation December 2019

## Overview

- 1 Objectifs
- 2 Introduction
- 3 Litterature review
- 4 Data and methodology
- 5 Results and interpretation
- 6 Conclusion and knowledge

# Synopsis

- 1 Objectifs
- 2 Introduction
- 3 Litterature review
- 4 Data and methodology
- 5 Results and interpretation
- 6 Conclusion and knowledge

# Basis

## Where we go!!!!

- Develop a new real estate price index
- Move towards an approach based on the characteristics of real estate
- Allowing continuous monitoring of property prices
- Have an index based on a structural approach
- Making a better analysis in terms of monetary and macro prudential policies

# Synopsis

- 1 Objectifs
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# Basis

## In general

- Today the real estate sector in Morocco is one of the promoters sectors on which several economic policies.
- In Morocco, two phases characterize the evolution of the real estate market in Morocco. The first phase is the one before the 2000s, when real estate prices were stagnating with real estate supply out of phase with 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 and banking credit boom.

# Basis

## In general

- In this perspective, the Central Bank of Morocco (BKAM) launched during this period a major project to develop a real estate price index. The method adopted in the property price index in Morocco is that of **repeat sales**.
- 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 more or less based on the theoretical training of real estate prices. The hedonic index is based on a very simplistic idea of the world where each property is determined by intrinsic factors that value the property on the market

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# Basis

## Several Works

- Early work applying the hedonic modelling 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 Dilmore (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 (1926) adopted the HPM technique in US cropland. Ridker and Henning (1967) used HPM for the evaluation of air quality and air quality on residential property values.

# Basis

## Several Works

- 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, Oates 1969) adopted it for the real estate sector. Later, Rosen (1974) developed the theoretical underpinning of this approach for the real estate sector.

# Basis

## Several Works

- Wallace and Meese (1997) estimate house price indices for Oakland and Fremont California from 1968 to 1990.
- Hill's recent survey (2013) also concludes that the hedonic index appears to dominate the current literature of studies.
- Meese (1997) uses estimates of repeat sales that may be a modified version of the hedonic model. The results reject the claims for 50,000 homes in the cities of Oakland and Fremont. In addition, the results suggest that repeated sales indices tend to be more volatile. Clapp (2002) has found similar results.

# Basis

## Several Works

- Zheng, Kahn, and Liu (2010) use hedonic models to examine the relationship between house prices, investment, wages, and pollution and found that Chinese cities undergo a transition from "producer cities" cities of euphoria.
- Hou (2010) analysed 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 have been widely applied to analyse housing prices in countries like the USA (Sander & Polasky, 2009), France (Gourieroux and Laferrere, 2009), Norway (Osland, 2010), Japan (Shimizu, Takatsuji, and Nishimura, 2010), Austria (Helbich, Brunauer, Vaz, & Nijkamp, 2013), and the Netherlands (Ozyurt, 2014), studies in developing countries are almost non-existent.

# Basis

## Several Works

- The intrinsic 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 impact the possibility of resale of the latter.
- 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. Kang and Gardner (1989) find the same result. Yavas and Yang (1995) examined this relationship with a two-step regression model. Their results were ambiguous, but manage to affirm the same results reported by Belkin (1976)

# Basis

## Several Works

- In addition, other works have indicated the importance of the sales season of real estate on sales prices (Haurin 1988, Forgey et al. Knight 2002, Harding et al., 2003).
- Lu (1988) uses Lazear's (1986) theory as the basis for a price revision strategy for the real estate seller.

# Basis

## Several Works

- Merlo and Ortalo-Magne (2004) find that the size of the price reduction is related to the length of time the house has been on the market.

# Basis

## Several Works

- Goodman et al. (1995) 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. Halstead et al. (1997), use this approach.
- Thus, several other specifications have been proposed in literature, namely : linear, semi logarithmic and logarithmic (Jean Dube et al (2011)).



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# What we use ?

## Techniocal approach

- Data sources : (ANCF).
- We were able to access their 2014 database for the Rabat region.
- The database consists of all types of property (8 types), including independent houses, villas, land, apartments, etc.

# What we use ?

## Techniocal approach

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

$$\ln(p_i) = \alpha + \sum_{(i=1)}^n \beta_i \cdot X_{(i,j)} + \varepsilon_i^a$$

<sup>a</sup>In practice, the availability of data strongly limits the possibilities of the functional form. 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.

# What we use ?

## Techniocal approach

- The estimation of the hedonic model according to the specificities of the data facilitates the transition to the hedonic index that transcribes the evolution of real estate prices in the Moroccan regions. Theoretically, this passage can be carried out according to two approaches :
  - A first approach is to add to the models of the temporal indicators, the variation of the prices being determined by the coefficients of these additional variables.
  - A second approach is based on a fixed reference stock over time, through which the index is calculated compared to current stocks (Diewert, Heravi and Silver 2007).

## What we use ?

### Techniocal approach

- Because of the particularities of the data at our disposal, whose price and housing characteristics are observed in cross-sectional ways, and then neither the first and the second method are applicable in the case of Morocco  $\implies$  In this sense, we propose a new approach based on the idea that real estate prices **can follow a Brownian geometric movement, similar to other asset prices.**
- We start elementarily by considering that the value of a reference stock (here the year of the database, i.e. 2014). To set up the index, it is necessary to have the current year of which we have no data ; this configuration will calculate the real estate price index, according to the following training :

$$IPHB = \frac{\text{Current value}}{\text{Initial value}}$$

## What we use ?

### Technical approach

- On the basis of this formulation, we can consider that in the absence of real estate asset prices for future years and periods, it is possible to consider that asset prices follow a geometric Brownian motion, where :

$$\ln(S_t) = \ln(S_0) + (\mu - 0.5 * \sigma^2) * t + \sigma W_t \quad (1)$$

$$\Rightarrow IPHB = \frac{S_t}{S_0} = \frac{\ln(S_0) + (\mu - 0.5 * \sigma^2) * t + \sigma W_t}{\ln(S_0)}$$

## What we use ?

### Techniocal approach

- In this sense, it is necessary to estimate the three main parameters, **the price according to the hedonic model, the average of the returns and the volatility**. Thus, and in order to determine the value of real estate price returns, we have resorted to the theory of prices in the financial markets, including real estate markets.
- We know that prices are determined by their intrinsic value, so are the economic determinants of price that can explain its evolution, according to Euler's training we can write that :

$$P_t = \delta(E_t P_{(t+1)} + E_t D_{(t+1)})$$

if accept the transitivity Hyp  $\implies S_t^* = \sum_{(i=1)}^n \delta_i E D_{(t+i)} = \sum_{(i=1)}^n \beta_i \cdot X_{(i,j)}$



## What we use ?

### Technical approach

- Then the coefficients estimated in the hedonic equation, all else being equal, describe the factors of actualization.
- 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 neighbouring properties**.

# What we use ?

## Techniocal approach

- Spatial autocorrelation is based on the observation that spatialized observations in cross sections are not independent. Spatial autocorrelation is defined as the correlation, positive or negative, of a variable with itself arising from the geographic location of the data. .
- In order to capture this phenomenon of spatial autocorrelation Paelinck and Klaassen (1970) put forward five principles to be respected in the formulation of econometric modelling. 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 amounts to taking into account the spatial effects on the behaviour of real estate prices.

## What we use ?

### Techniocal approach

- 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.
- In this respect, Kelejian and Prucha (1998, 1999a) proposed a generalized moments estimation (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.

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# Results

## Many results

- Before presenting the results of the hedonic approach, some special analyzes are needed to present the behaviour of real estate prices in the region of analysis. First, and to take into account the effect of spatial autocorrelation at the Rabat-Témara region, autocorrelation tests are used ( Geary index).

FIG.: *Spatial autocorrelation test (Geary Test)*

Region	Observed	STD	Z	Pr >  Z
Rabat Centre	0.6752396	0.00255	-127.143	<.0001
Rabat Hay Riad Agdal	0.97504	0.00203	-12.323	<.0001
Témara	0.992505	0.00123	-6.106	<.0001

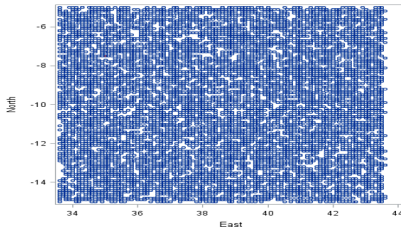
- The value obtained from the Geary index is less than one, making it possible to reject the hypothesis of non-existence of spatial autocorrelation.

# Results

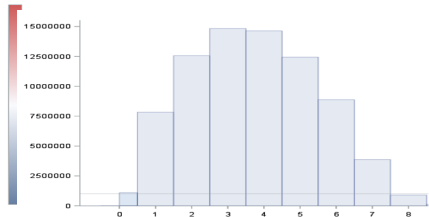
## Many results

- This finding requires a measure of the degree of spatial correlation via geostatistical analysis (Variogramme) that will validate and measure the level of correlation in the study area.

**FIG.:** Variogram graph for spacial analysis



**FIG.:** Number of lags testing from variogram



## What we use ?

### Techniocal approach

- Therefore, we proposed 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 :

$$y_{(i,j)} = \beta y_{(i-t,j)} + \sum_{(i=1;j=1)}^{(n,m)} \alpha_j + \beta_{(i,j)} X_{(i,j)} + \varepsilon_{(i,j)}^a$$

<sup>a</sup>Where i is the individual dimension describing real estate and j is the nature of the property. Indeed, we have distinguished in the estimation between the different categories of real estate (apartment, villa, land,... etc.). Therefore, we have 8 categories of property and more than 11,000 properties in the region of Rabat-center, 6,500 properties on Hay Riad and 20,400 on the city of Temara.

# What we use ?

FIG.: *Econometrics results of estimations (GMM Approach)*

Variable	Rabat-Centre <sup>6</sup>			Hay-Riad			TEMARA		
	Coefficient	t-Statistic	Prob.	Coefficient	t-Statistic	Prob.	Coefficient	t-Statistic	Prob.
LOGPRICE (-1)	0.354213	28.00295	0.0000	0.474743	55.71992	0.0000	0.545158	99.77354	0.0000
<b>LOGMETRE</b>	<b>0.812602</b>	<b>37.79219</b>	<b>0.0000</b>	<b>0.770388</b>	<b>46.57118</b>	<b>0.0000</b>	<b>0.821840</b>	<b>54.41956</b>	<b>0.0000</b>
AGE	0.000615	7.446784	0.0000	0.000419	3.474022	0.0005	0.000850	8.214648	0.0000
BALCON	0.056413	1.652031	0.0986	0.163186	1.944212	0.0519	0.026991	1.772235	0.0764
N°ETAGE	0.042172	3.251869	0.0011						
COURS	-0.026646	-2.341135	0.0192				0.073186	4.846090	0.0000
ETAGE	-0.000396	-1.885191	0.0594				0.000843	2.458912	0.0139
D1	-0.021123	-3.804266	0.0001	0.068631	9.254140	0.0000	0.116537	19.56736	0.0000
D3	-0.060075	-12.62286	0.0000						
D4	-0.056507	-2.212520	0.0269						
Garage				0.100649	4.144788	0.0000	0.025104	0.466069	0.6412
D5							0.157300	18.85926	0.0000
D8							0.114777	7.577319	0.0000
CAVE							0.387825	3.015558	0.0026
Piscine							-0.516307	-5.683270	0.0000

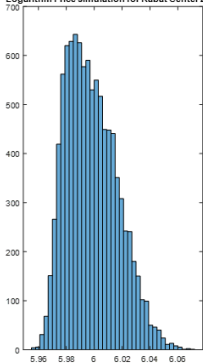


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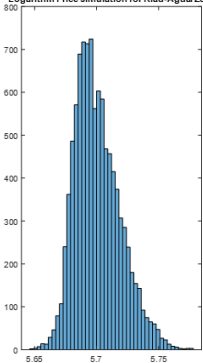
## Technical approach

- After estimation we use the BM approach to estimate the price index. We use for this reason the Monte carlo simulation :

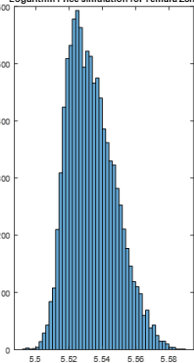
Logarithm Price simulation for Rabat Center Zone



Logarithm Price simulation for Riad-Agdal Zone



Logarithm Price simulation for Temara Zone



# What we use ?

## Techniocal approach

- We applied the standard Brownian motion approach where the price is decomposed into drift and volatility. We considered that the coefficients explaining the influence of the intrinsic and fundamental variables are the factors of actualization.

FIG.: IPHB versus Repeat sales (Central Bank)

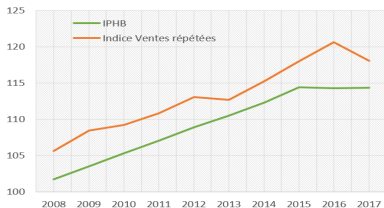
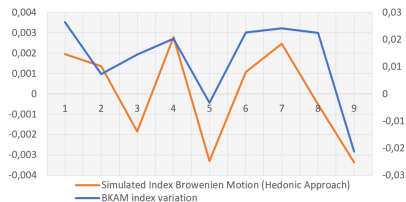


FIG.: Variation of BKAM index and hedonic index for Rabat Region



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# Conclusion

## Techniocal approach

- The hedonic approach allowed identifying the factors explaining the evolution of the prices, but also it served us to simulate the real prices on the Moroccan market.
- From this perspective, we used the stochastic approach where prices follow a geometric Brownian motion.
- The idea is based on the financial theory of markets where prices can be described as an Itô process. In this register, we were able to forecast prices between 2014 and 2018 and interpolate for periods prior to 2014. The results obtained compared to the official index of the central bank confirm that the two indices describe the same trends. The rates of change of the two indices have a very important correlation of 77%.

# Conclusion

## Techniocal approach

- The new real estate price index based on the hedonic and stochastic approach is more user-friendly in the analysis of the evolution of the prices on the real estate market and will allow in case of its use to have to examine the intrinsic behaviour of the prices and **detect if necessary the possibility of bubble birth on the real estate market.**
- In addition, the IPHB index is able of being planned analytically, which allows for preventive analyses of the potential evolution of prices.

Thank you

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*Thank you for your attention*

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