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Use of Hedonic Prices to Estimate Capitalization Rate

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In this paper, a model of income capitalization is developed where hedonic prices play a key role in estimating the going-in capitalization rate. Precisely, the hedonic functions for rental and selling prices are introduced into a basic model of income capitalization. From the modified model, it is possible to derive a direct relationship between hedonic prices and capitalization rate. An advantage of the proposed approach is that estimation of the capitalization rate can be made without considering rental income data. Empirical evidence is provided for the theoretical result.

Keywords

Income Capitalization Approach, Hedonic Models, Hedonic Prices, Capitalization Rate

1. Introduction

The income capitalization approach and hedonic models are methods usually used to estimate the selling or the rental price. In the former, the capitalization rate is used to calculate a rent-to-value ratio to transform the value of an owned home into a market rent or vice versa; while another way of directly calculating the rental income (or house price) is by estimating rent (or price) with a hedonic regression model and then estimating imputed rents for owners (or home value for renters) by applying the renter (owner) coefficients to owner (renter) characteristics (Garner and Short, 2009). Furthermore, the two methods can be combined (see for e.g., Phillips, 1988; Linneman and Voith, 1991). A "double" hedonic function, namely the “hedonic rental price function” and “the hedonic home value price function” (Linneman and Voith, 1991), can be used to correct the direct estimate of the capitalization rate. The ratio between rental income and house price (the capitalization rate), in fact, should compare the rent and value of identical homes; ideally, it is possible to do this by applying the estimated coefficients of hedonic models to a vector of characteristics that defines a standard home of constant quality (Hamilton and Schwab, 1985).[1]

In this paper, a model of income capitalization is developed where hedonic prices play a key role in estimating the capitalization rate. Precisely, hedonic price functions are introduced into a standard equation of income capitalization, thus deriving a direct relationship between hedonic price and capitalization rate. This relationship allows us to neglect data on rental income. Indeed, in this work, only information on selling prices is exploited. As far as I am aware, no existing related work in the literature have considered ways to estimate the capitalization rate without using data on rental income. Selling prices and their implicit (hedonic) prices incorporate all of the information required to correctly estimate the capitalization rate. The selling price, in fact, takes into account factors that are different from housing characteristics (such as the bargaining power of the parties, insufficient or incomplete information, etc.), while implicit prices allow us to adjust the capitalization rate to the intrinsic characteristics of housing. Finally, the obtained capitalization rate can be used both to build a discount rate and estimate the going-out capitalization rate.

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[1] However, in order to avoid inefficient estimates, it is necessary to control for selectivity bias in the hedonic models by using the Heckman two-step approach (Linneman and Voith, 1991; Garner and Short, 2009). Owners and renters, in fact, have systematically different endowments and preferences. In particular, the intrinsic preference for homeownership is very important, since an individual may be willing to pay more to own a particular trait bundle than to rent it (Linneman and Voith, 1991). Heston and Nakamura (2009) find that for similar housing features, owner occupied housing would rent for about 14 percent above market rents. This premium may be attributed to a mix of “owner pride” and unobserved quality differences.

Obviously, it is always preferable to estimate the capitalization rate by just using comparable transactional data. Nevertheless, the model developed in this paper has two main advantages. From an empirical point of view, the method developed in this paper is especially useful when: 1) the rental income data are missing and/or not entirely reliable (due to the phenomenon of a shadow economy, for example); 2) the data on rental income and house price are related to different homes (the capitalization rate, in fact, should compare the rent and value of identical homes); and 3) there are many binary variables, including submarket dummy variables.[2] In all of these cases, therefore, the method can be a valuable alternative to direct estimation. From a theoretical point of view, instead, the model is able to highlight in a straightforward manner the close relationship between hedonic prices and capitalization rate. Indeed, as far as I am aware, this important link has been overlooked by housing market studies which deal with real estate appraisals.

Also, in order to provide empirical evidence for the theoretical model, an empirical analysis is developed. By using data from the Canadian housing market, it is found that the theoretical results appear to be consistent with the observed capitalization rate.

The remainder of the paper is organized as follows. Section 2 briefly presents the income capitalization approach and the two related methods: yield and direct capitalization. The modified model with hedonic prices is presented in Section 3, while Section 4 shows the data, some descriptive statistics and the results of the empirical analysis. Section 5 concludes the work.

2. Income Capitalization Approach: A Basic Model

Two main methods are usually used to convert income flows into an estimation of the house value: the *yield capitalization* model or *discounted cash flows (DCF)* analysis and *direct capitalization* model. In the *DCF* method or *yield capitalization* model, the house value (price), *P,* is the present value of all the expected future cash flows, including the proceeds from the sale at the end of the investment (see among others, Phillips, 1988; Wang et al., 1990; Appraisal Institute, 2001; Sevelka, 2004; Clayton and Glass, 2009):[3]

[2] Bourassa et al. (2007) show that the gains in accuracy from including submarket variables in a hedonic model are greater than any benefit from using geostatistical or lattice methods. This conclusion is of practical importance, as a hedonic model with submarket dummy variables is substantially easier to implement than spatial statistical methods.

[3] Indeed, the reversion value is the larger share of the total return of a property investment.

$$P = \sum_{t=1}^{n} \frac{NOI_t}{(1+r)^t} \tag{1}$$

where $NOI \equiv R - C$ is the net operating income; R the gross rental income; C is the financing and operating cost, r is the discount rate or the opportunity cost of capital or the (risk-adjusted) required total return,[4] and n is the economic life of the property. Equation (1) is usually broken down into three components (see Phillips, 1988, p. 279):

$$P = \frac{(R_1 - C_1)}{1+r} + \sum_{t=2}^{k} \frac{(R_t - C_t)}{(1+r)^t} + \sum_{t=k+1}^{n} \frac{(R_t - C_t)}{(1+r)^t} \tag{2}$$

where the first term is the net rental income at the end of the first period; the second term is the discounted net rent during the property holding period k; and the third term is the present value of the remaining future cash flows, namely, the expected resale price or reversion value at the end of the holding period k.[5]

Instead, in the *direct capitalization* model, the so-called *overall capitalization rate* (c) plays a key role. The cap rate is defined as the ratio between the net rental income at the end of the first period and the house price (see Phillips, 1988; Wang et al., 1990; Appraisal Institute, 2001; Clayton and Glass, 2009):

$$c = \frac{(R_1 - C_1)}{P} \Rightarrow P = (R_1 - C_1) \cdot \left(\frac{1}{c}\right) \tag{3}$$

where the reciprocal of the cap rate is not the gross rent multiplier (*GRM*).[6] Precisely, the cap rate is used to convert – in one direct step – the income expectancy of a single year into an estimation of the house value.

To see the close link between the *yield capitalization* and *direct capitalization* models, it is sufficient to assume a constant net rental income, namely, $(R_t - C_t) = (R - C) \ \forall \ t$. In this case, Equation (2) becomes:

$$P = \frac{(R - C)}{r} \cdot \frac{(1+r)^n - 1}{(1+r)^n} \tag{4}$$

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[4] The risk-adjusted required total return is usually given by $r = r_{free} + RP$, where r_{free} is the risk-free rate and RP is the real estate risk premium (Clayton and Glass, 2009). The discount rate is the rate of return on capital which considers all future expected benefits, including the revenue from sales at the end of the holding period (Appraisal Institute, 2002).
[5] The first term *à la* Phillips (1988) of Equation (2) is useful in order to present the cap rate in Equation (3).
[6] In fact, the gross rent multiplier links gross rent and price ($GRM = P / R$), while the capitalization rate links net operating income (net rent) with price (Colwell, 2002).

In the special case where indefinite holding of the property is expected (i.e. the economic life of the property tends to infinity), the following expression is obtained from which an estimation of the capitalization rate can be obtained:[7]

$$\lim_{n\to\infty} P = \frac{(R-C)}{r} \Rightarrow c = r \quad (5)$$

Thus, *yield capitalization* and *direct capitalization* are interrelated valuation models and applying either approach to the same income-producing property should generate a similar estimate of the market value (Sevelka, 2004). However, the relationship $c = r$ only holds exactly under the simplifying assumptions of Equation (5). Indeed, *r* and *c* should be equal *"in a non-inflationary environment with no expectation of appreciation in income and property value [...]"* (see Sevelka, p. 138, 2004); otherwise $c \approx r$.[8] Also, Equation (3) reveals the *"going-in capitalization rate"*, i.e. the expected first year income on a property investment (Wang et al., 1990; Sevelka, 2004). Thus, it can not be used to discount the cash flows after the end of the holding period *k*. The appropriate discount rate to estimate the expected resale price or reversion value, i.e. the *"going-out capitalization rate"*, can be derived from Equation (3) by using the relationship proposed by Wang et al. (1990):[9]

$$\text{caprate}_{out} = \text{caprate}_{in} \cdot \delta \quad (6)$$

where δ is a (negative) function of both the income-growth rates (before and after the holding period) and the property appreciation rate after the holding

[7] With a constant growth rate (*g*) of the *NOI*, Equation (5) is nothing but a modified version of the *dividend discount model* (*DDM*). Precisely (see Pagliari and Webb, 1992): $P = (NOI_t)/(r-g) \Rightarrow r = [NOI_{t-1}(1+g)]/P + g$, where $[NOI_{t-1}(1+g)]/P$ is the cap rate. Since the *DDM* assumes an infinite holding period or a finite holding period with the property sold at the same rate of capitalization (i.e. going-in cap rate = going-out cap rate), Pagliari and Webb (1992) introduce the changes in going-in versus going-out cap rate or pricing movements (*m*). Hence, the full model is: $r = [NOI_{t-1}(1+g)]/P + g + m$. The expected overall rate of return (i.e. the capitalization rate plus the expected rate of house price increase) is also termed the conversion rate (see Chang-Moo and Chung, 2010).

[8] For example, in the *DCF* model with income-growth, the discount rate cannot be interchanged with the capitalization rate. Equivalency between *c* and *r* can be achieved when the discount rate equals the capitalization rate increased by the income growth rate (*g*), i.e. $r = c + g$ (see also Hamilton and Schwab, 1985). Furthermore, an inflation-adjusted capitalization rate is synonymous with a discount rate, i.e. $r = c + \pi$, where π is the inflation rate (Sevelka, 2004).

[9] *"[...] the going-in and the going-out capitalization rates should be the same if there is no reason to assume that income growth rates, required rates of return, or property appreciation rates are different during and after the projected holding period"* (Wang et al., p. 235, 1990). Indeed, the going-out capitalization rate can be also seen as the going-in capitalization rate of the next purchaser (Sevelka, 2004).

period, but it is a (positive) function of the rates of return.[10] As a result, the *going-out capitalization rate* can be higher (if $\delta > 1$), lower (if $\delta < 1$) or equal (if $\delta = 1$) to the *going-in capitalization rate* (Wang et al., 1990).

Finally, there is an important difference between the discount and the capitalization rates. The discount rate is a "prospective" measure of financial performance which reflects the future expectations of real estate investors; the capitalization rate is a "partial" measure of financial performance. It follows that only capitalization rates can be directly extracted or obtained from observed property transactions and market rents (Sevelka, 2004; Clayton and Glass, 2009).

3. Income Capitalization Approach: Model with Hedonic Prices

In order to develop a direct relationship between hedonic prices and capitalization rate, I introduce standard hedonic price functions *à la* Linneman and Voith (1991) in Equation (4):

$$P(x) = \frac{R(x) - C}{r} \cdot \left[1 - (1 + r)^{-n}\right] \tag{7}$$

where $P(x)$ is the *hedonic price function of the home value*, $R(x)$ is the *hedonic rental price function*, and x is the set of housing characteristics. It follows that a generic implicit or hedonic price (p) can be obtained from Equation (7):

$$p(x) \equiv \frac{\partial P(x)}{\partial x} = \frac{\partial R(x) / \partial x}{r} \cdot \left[1 - (1 + r)^{-n}\right] \tag{8}$$

For binary variables, such as the presence or absence of an elevator, the implicit or hedonic price $p(x)$ is the price difference between the properties with an elevator and those without that characteristic, namely, $p(x) = P^1 - P^0$. By following Del Giudice (1992), the price difference is assumed to be equal to the discounted rental income difference. Hence, a special case of Equation (8) would be as follows:

$$p \equiv \left(P^1 - P^0\right) = \frac{\left(R^1 - R^0\right)}{r} \cdot \left[1 - (1 + r)^{-n}\right] \tag{8'}$$

[10] The explanation for the negative relationship between income-growth rates and the cap rate is as follows: higher property income growth means larger expected cash flows in subsequent years. Hence, the house price is higher and cap rate is lower.

Since the price (rental income) difference is positive,[11] I assume that when indefinite holding of the property is expected, i.e. the economic life of the property tends to infinity, the (desired and relevant) housing characteristics become increasingly important. Mathematically, I spell out this assumption in the following way:

$$\lim_{n\to\infty}\left(P^1 - P^0\right) \approx P^1$$

Hence, for each relevant (i.e. statistically significant) housing characteristic, it must be true that:

$$P^1 = \frac{\left(R^1 - R^0\right)}{r} \tag{9}$$

Therefore, by using Equations (8') and (9), an explicit expression can be obtained for estimating a "partial" capitalization rate associated with each (binary variable) housing characteristic *i*:[12]

$$\begin{cases} r \cdot P^1 = \left(R^1 - R^0\right) \\ p = \dfrac{\left(R^1 - R^0\right)}{r} \cdot \left[1 - \left(1+r\right)^{-n}\right] \end{cases} \Rightarrow c_i = r = \left(1 - \frac{p}{P^1}\right)^{-\frac{1}{n}} - 1 \tag{10}$$

which is positive for each $n < \infty$, since $0 < \frac{p}{P^1} < 1$.[13] In order to obtain an "overall" capitalization rate, Equation (10) must be calculated for each relevant housing characteristic *i*. It follows that:

$$c = \prod_{i=1}^{m}(1 + c_i) - 1 \tag{11}$$

Data on housing characteristics typically consist of many ordered and unordered categorical variables. Thus, by transforming the ordered housing characteristics into binary variables, it is possible to extend the procedure to the full dataset with the exception of the continuous regressors (such as the lot

[11] Since we talk about "desired" housing characteristics (such as the presence of an elevator), the price difference is positive, namely, $p(x) = P^1 - P^0 > 0$. In fact, *ceteris paribus*, the mean price of properties with an elevator is higher than that without that characteristic (see the Canadian dataset, for example). It also follows that the rental income difference must be positive.

[12] By using real house prices, the inflation rate is implicitly included in Equation (10).

[13] In fact, P^1 is the (mean) price of the properties where the (desired) characteristic is present, while $p(x)$ is the implicit/hedonic price of that housing characteristic. At the limit, when the relevant and desired housing characteristics become increasingly important, we get $\lim_{n\to\infty} (P^1 - P^0) \approx P^1$. Hence, $p(x) < P^1$ in general and $p(x) \approx P^1$ only when $n = \infty$.

size).[14] With regards to the lot size, for example, a simple way to include it into the model is as follows:[15]

- both the full hedonic price model and a univariate regression (price vs. lot size) are estimated;
- the ratio of the adjusted R-square of the two regression models (univariate vs. full model) is calculated, thus obtaining a “weight” ($\omega_{lotsize}$); and
- the share of the cap rate attributable to the hedonic price of the lot size and the “final” cap rate are, respectively, given by:

$$c^{lotsize} = c \cdot \omega^{lotsize} \qquad (12)$$

$$c^{final} = (1+c) \cdot (1+c^{lotsize}) - 1 \qquad (13)$$

4. Empirical Testing

In order to provide empirical evidence for the theoretical result obtained in the previous section, I have developed an empirical analysis. I employ data from the Canadian housing market. The dataset used is especially useful since it is characterised by many binary variables. Precisely, the dataset contains 546 observations on the sale prices of houses sold during July, August and September 1987 in the city of Windsor. Details on this dataset are reported in Table 1 (source: Anglin and Gençay, 1996).

With regards to the discrete variables “bathrms” and “stories”, I use the number 1 as a threshold value for creating binary variables (“bathrms_d” and “stories_d”). In fact, the mean of both variables is lower than 2 and higher than 1. The same reasoning applies to the discrete variable “bedrooms” where the threshold value for creating “bedrooms_d” is 2 (since the mean is 2.965201).

The first step is the estimation of the *hedonic price function of the home value* in order to obtain the implicit/hedonic prices. From the popular Ramsey RESET test, I find that the statistically correct econometric model is semi-logarithmic. For details on the estimation results, see Table 2.

Indeed, since the housing characteristics are expressed by dummy variables and the model used is semi-logarithmic, the procedure proposed by Halvorsen and Palmquist (1980) must be applied in order to correct the estimated regression coefficients. Precisely, the implicit/hedonic price of each housing characteristic *i* is given by:

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[14] We will see that it is possible to also extend this procedure to the discrete variables.
[15] The procedure used for the lot size can be applied to other continuous variables.

$$p_i = \overline{P} \cdot \left(e^{\beta_i} - 1\right) \tag{14}$$

where $\overline{P}$ is the average price (68,121.60), β_i is the estimated regression coefficient, and $\left(e^{\beta_i} - 1\right)$ is the correction factor. The hedonic prices are reported in Table 3.

Table 1 Summary Statistics

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
price	sale price of a house	546	68121.6	26702.7	25000	190000
lotsize	lot size of a property in square feet	546	5150.27	2168.16	1650	16200
bedrooms	number of bedrooms	546	2.9652	0.73739	1	6
bathrms	number of full bathrooms	546	1.28571	0.50216	1	4
stories	number of stories excluding basement	546	1.80769	0.8682	1	4
driveway	dummy, 1 if the house has a driveway	546	0.85897	0.34837	0	1
recroom	dummy, 1 if the house has a recreational room	546	0.17766	0.38257	0	1
fullbase	dummy, 1 if the house has a full finished basement	546	0.34982	0.47735	0	1
gashw	dummy, 1 if the house uses gas for hot water heating	546	0.04579	0.20922	0	1
airco	dummy, 1 if there is central air conditioning	546	0.31685	0.46568	0	1
garagepl	number of garage spaces	546	0.69231	0.86131	0	3
prefarea	dummy, 1 if located in a preferred neighbourhood of the city	546	0.23443	0.42403	0	1
"new"						
bedrooms_d	dummy, 1 if the number of bedrooms is higher than 2	546	0.74725	0.43499	0	1
bathrms_d	dummy, 1 if the number of bathrooms is higher than 1	546	0.26374	0.44106	0	1
stories_d	dummy, 1 if the number of stories is higher than 1	546	0.58425	0.4933	0	1

Table 2 Estimation Results [16]

Full model		Univariate regression	
Explanatory variable	**ln_price**	**Explanatory variable**	**ln_price**
ln_lotsize	0.321 (11.58) ***	ln_lotsize	0.542 (16.61) ***
bedrooms_d	0.072 (2.73) ***		
bathrms_d	0.209 (9.15) ***		
stories_d	0.107 (4.66) ***		
driveway	0.117 (4.05) ***		
recroom	0.065 (2.43) **		
fullbase	0.073 (3.37) ***		
gashw	0.175 (3.87) ***		
airco	0.184 (8.50) ***		
garagepl	0.048 (4.07) ***		
prefarea	0.126 (5.37) ***		
_cons	7.901 (34.96) ***	_cons	6.469 (23.37) ***
Obs.	546	Obs.	546
Prob > F	0.0000 ***	Prob > F	0.0000 ***
Adjusted R-square	0.6619	Adjusted R-square	0.3352

Note: t-statistics in parentheses. * denotes significance at 10% level, ** at 5% level, and *** at 1% level (* Prob < 0.10; ** Prob < 0.05; *** Prob < 0.01).
Source: Author's calculations

Table 3 Hedonic Prices

Variable	Coefficient	Correction Factor	Hedonic price
garagepl	0.048	0.049	3,350.59
recroom	0.065	0.067	4,574.70
bedrooms_d	0.072	0.075	5,077.36
fullbase	0.073	0.076	5,160.14
stories_d	0.107	0.113	7,719.56
driveway	0.117	0.124	8,457.86
prefarea	0.126	0.134	9,153.62
gashw	0.175	0.191	13,010.32
airco	0.184	0.202	13,791.52
bathrms_d	0.209	0.233	15,865.54

[16] The only hedonic model which overcomes the fundamental Ramsey Reset test, i.e., which does not reject the null hypothesis of no omitted variables, is the semi-log (Prob > F = 0.3348). Indeed, a semi-logarithmic functional form for hedonic house price models is also used in Hamilton and Schwab (1985), Phillips (1988), Linneman and Voith (1991), and Garner and Short (2009). Furthermore, the adjusted R-square of the semi-log hedonic model with the lot-size in the natural logarithm is higher than that with the lot size in level.

The next step is to calculate the P^1 of Equation (9). P^1 is the (mean) price of the properties where the characteristic is present. Hence, for each characteristic in Table 3 , P^1 is calculated by dropping in the dataset the observations where the characteristic is absent, thus obtaining both the (mean) price of the properties where the characteristic is present and the fundamental ratio between the hedonic price and the P^1 of Equation (10) (see Table 4).

Table 4 Ratio (p / P^1)

Variable	Hedonic price (p)	P^1 (mean)	Ratio (p / P^1)
garagepl	3,350.59	79,047.53	0.0424
recroom	4,574.70	82,755.67	0.0553
bedrooms_d	5,077.36	73,677.43	0.0689
fullbase	5,160.14	74,894.50	0.0689
stories_d	7,719.56	74,199.19	0.1040
driveway	8,457.86	71,333.90	0.1186
prefarea	9,153.62	83,986.37	0.1090
gashw	13,010.32	79,428.00	0.1638
airco	13,791.52	85,880.59	0.1606
bathrms_d	15,865.54	90,366.61	0.1756

Obviously, since the hedonic prices are positive, i.e., all of the housing characteristics are desired, the mean of P^1 is always larger than the mean of the "overall" price P .

With regards to the continuous variable "lot size", a univariate regression is run (see Table 2 again). The adjusted R-square is exactly half of that of the full model (0.33/0.66). Hence, the share of the cap rate attributable to the hedonic price of the lot size is $\omega_{lotsize} = 0.5$.

The final step is to calibrate the model. Unfortunately, the value of *n* is difficult to unequivocally calibrate since the very concept of the "economic life of the property" is open to different interpretations and real estate is a highly heterogeneous good (in other words, it varies across goods and individuals). In order to overcome this problem, the cap rate is calculated for different but realistic periods of economic life or holding of the property. Indeed, a range (minimum and maximum) of *n* is considered, rather than establishing a single value of *n*.

Precisely, Equations (10), (11), (12) and (13) are defined for different *n* (from 8 to 55) and the average capitalization rate for several ranges is computed. Intuitively, a larger range of *n* means a higher average cap rate (see Table 5).

Table 5 Going-in Cap Rates in Canada during the Second Half of the Eighties: A Comparison between Theoretical Results and Observed Data

Canada (1987)		Canada (1985 - 1988)	
Average Cap Rate [1]	Range of *n* (min – max)	Cap Rate – Observed Data [2]	Index
6.01 %	25 – 35	6.52 %	office
6.28 %	20 – 40	8.51 %	warehouse
6.78 %	15 – 45	8.62 %	retail
7.76 %	10 – 50		
8.83 %	8 – 55		

Note: 1. Source: Theoretical model ; 2. Source: Pagliari et al. (1998)

I compare the theoretical results with data on Canada (period of 1985-1988) reported in Pagliari et al. (1998). The result appears to be consistent with the observed data since the capitalization rate in Canada during the 1985-1988 period varied from 6.52% to 8.62% (see Table 5 again). Indeed, with a few exceptions, the capitalization rates remained within a range of 6.75% to 8.75%, never getting too far from their long-run average of 7.6% (Kaiser, 1997; Clayton and Glass, 2009).[17]

However, this is a first and simple attempt to test the theoretical model developed here and it would be desirable to verify these results with another dataset.

5. Conclusion

In this paper, a unified model that uses income capitalization and a hedonic method is developed for estimating the capitalization rate. Precisely, I introduce standard hedonic functions for rental and selling prices into a basic model of income capitalization. From the modified model, it is possible to derive a direct relationship between hedonic prices and capitalization rate. An advantage of the proposed procedure is that the estimation of the capitalization rate can be made without considering data on rental income. Indeed, selling and implicit (hedonic) prices incorporate all of the information required to correctly estimate the capitalization rate. Furthermore, this model can be particularly useful when the data that refer to rents are not entirely reliable. The obtained capitalization rate can be used both for building the discount rate as well as estimating the going-out capitalization rate. A first attempt to test the theoretical model has produced satisfactory results since the theoretical results appear to be consistent with the observed data.

[17] Indeed, capitalization rates seem to vary across property type and over time in a somewhat predictable manner (Kaiser, 1997; Clayton and Glass, 2009).

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