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Hedonic prices, capitalization rate and real estate appraisal

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Abstract

Studies on real estate economics neglected the relationship between hedonic prices and capitalization rate, thus considering the hedonic models and the income approach as two separate and alternative appraisal methods. In this short theoretical paper we show that integration is possible and relatively simple and the combined model allows to estimate the capitalization rate using only hedonic prices. Also, the developed model brings out a peculiarity of real estate asset, namely the negative relationship between economic life of the property and capitalization rate.

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1. Introduction

The capitalization rate (henceforth "cap rate") is one of the most important variables of real estate market. It allows to convert the value of an owned home into a market rent and vice versa. Alternatively, the real estate value can be estimated with a hedonic model by applying the hedonic prices to the characteristics of the property. Indeed, income approach and hedonic models are the two methods usually used in the real estate appraisals (Garner and Short, 2009).[1]

However, studies on real estate appraisals omitted a possible and important link between the income approach and the hedonic models.[2] In order to pull it out, this short theoretical paper combines the two methods. Precisely, the hedonic functions of price and rent are introduced into the standard model of income capitalization, thus deriving a direct relationship between hedonic prices and discount rate. Also, the model takes advantage of the relationship between *yield capitalization* and *direct capitalizatio*n to obtain a mathematical relation that allows to estimate the cap rate using only hedonic prices. From an empirical point of view, therefore, this model turns out to be especially useful when the rental market is not very dynamic, i.e. data on rents are not enough to rely on the direct estimation (rent-to-value ratio). Furthermore, the developed model brings out a peculiarity of real estate asset: the negative relationship between economic life of the property and cap rate. A property investment more durable, in fact, would be less risky and thus less profitable than one with a shorter economic life. This would confirm the peculiarity and specificity of real estate asset with respect to any other financial asset. We provide an economic rationale of this important result.

The next section (Section 2) very briefly introduces the basic model; while the blended model and the main results are presented in section 3. Section 4 concludes.

2. The basic model

We start with the model usually used to convert the income flows into an estimation of the house market value (see e.g. Phillips, 1988; Wang *et al.*, 1990; Appraisal Institute, 2001; Sevelka, 2004; Clayton and Glass, 2009). The house market value or house price (V) is the present value of all the expected future cash flows:[3]

$$V = \sum_{t=1}^{n} \frac{(R_t - C_t)}{(1+r)^t} \qquad (1)$$

where $(R_t - C_t)$ is the net operating income (R is the gross rental income and C are the financing and operating costs), r is the discount rate or the opportunity cost of capital, and n is the economic life of the property.[4] In order to highlight the different components of the house value, it is possible to rewrite equation (1) as follows (see e.g. Phillips, 1988):

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

[1] In broad sense, the hedonic models include not only the multiple regression analysis (MRA) but also the sales comparison approach (SCA), since the key issue in both methods is the estimation of hedonic or implicit prices.

[2] Linneman and Voith (1991) use a pooled hedonic model to estimate both the hedonic prices and the cap rate. Nevertheless, they do not derive a direct relationship between the income approach and the hedonic models.

[3] «*Market value is a concept in economic theory and cannot be observed directly. Sales prices provide the most objective estimates of market values and under normal circumstances should provide good indicators of market value.*» (IAAO, 2013, p. 7).

[4] «*The total period of time over which an asset is expected to generate economic benefits.*» (IVSC, 2012, p. 2).

where the first term is the net operating income at the end of the first period, the second term is the discounted net operating income during the property holding period k, and the last term is the proceeds from the sale, namely the present value of the net rental flow for the property's remaining useful life. Indeed, the expected resale price is often the larger share of the total return of a property investment.

By assuming a constant, immediate and postponed net annuity, equation (2) is simplified, thus becoming:

$$V = \frac{R-C}{r} \cdot [1-(1+r)^{-n}] \tag{3}$$

Equation (3) is the starting point for the new (combined) model used in this paper.

3. The blended model

We only insert into equation (3) the standard hedonic functions (see e.g. Linneman and Voith, 1991):

$$V^* = \frac{R^*-C}{r} \cdot [1-(1+r)^{-n}] \tag{4}$$

where $V^* = V(z) + v$ is the *hedonic home value price function*, $R^* = R(z) + u$ is the *hedonic rental price function* (with v and u stochastic error terms), and z is the set of housing characteristics. Therefore, through the partial derivative (in case of continuous variables) or the variation in the discrete time (in case of discrete or binary variables), a direct relationship between the hedonic prices of a generic housing characteristic z_i and the discount rate r can be obtained from equation (4):[5]

$$V_{z_i} = \frac{R_{z_i}}{r} \cdot [1-(1+r)^{-n}] \tag{5}$$

where V_{z_i} is the implicit or hedonic price and R_{z_i} is the implicit or hedonic rent. Equation (5) is the key point of the model. Basically, it applies to all statistically significant housing characteristics, since V_{z_i} and R_{z_i} can be obtained/derived from the estimated regression coefficients of the respective hedonic models.[6]

For the binary variables (presence or absence of the characteristic), notably, the hedonic price identify a price differential. Hence, a special case of equation (5) is the following:

$$(V_1 - V_0) = \frac{R_{z_i}}{r} \cdot [1-(1+r)^{-n}] \tag{5'}$$

where V_1 and V_0 are, respectively, the average price of the properties with and without that characteristic. Since we talk about "desired" housing characteristic (such as the presence of an elevator), the price difference is always positive, namely $(V_1 - V_0) > 0$. A similar reasoning can apply to the hedonic rent, namely $R_{z_i} = (R_1 - R_0)$, with $(R_1 - R_0) > 0$.

3.1. Hedonic prices and cap rate

[5] Obviously, the problems related to the use of hedonic models, first of all the choice of the best functional form, remain. The semi-logarithmic form, however, seems to provide a good tradeoff between simplicity and non-linearity of the relationship between price and housing characteristics (see, for example, Hamilton and Schwab, 1985; Phillips, 1988; Linneman and Voith, 1991; Garner and Short, 2009).

[6] Recall that only in the linear model the estimated (obtained) regression coefficients coincide with the hedonic prices (in euro or dollar). In the log-linear model, for example, the estimated regression coefficients represent percentage changes in the price (rent) and thus the hedonic price (rent) in level must be derived.

In order to derive a relationship between hedonic prices and cap rate, we exploit the link between discount rate and cap rate. Indeed, exact equivalency between $cap\ rate$ and r can be achieved in the *direct capitalization* model, namely in the special case where indefinite holding of the property is expected (i.e. the economic life of the property tends to infinity) and there is no income-growth. In this specific case, from equation (5) we get:

$$\lim_{n\to\infty} V_{z_i} = \frac{R_{z_i}}{r} \cdot [1-(1+r)^{-n}] \xrightarrow{yields} V_{z_i} = \frac{R_{z_i}}{r} \tag{6}$$

with $r = cap\ rate$. However, with income-growth the discount rate cannot be interchanged with the cap rate. Equivalency between cap rate and r can be achieved when the discount rate equals the cap rate increased by the income growth rate g, namely cap rate $= \mathrm{r} - \mathrm{g}$ (Corgel, 2003; Sevelka, 2004; Clayton and Glass, 2009).

However, if the housing characteristic z_i provides a positive differential (see equation (5')), owning the property without that characteristic is not "cost-effective". Hence, it will need to endow (if possible) the property of that feature. Otherwise, there will be a depreciation of the property value. In both cases, therefore, V_0 will decrease over time.[7] Mathematically, looking at equation (5'), this assumption leads to a modified version of equation (6):[8]

$$V_1 = \frac{R_{z_i}}{r} \tag{6'}$$

Eventually, using equations (5) and (6') we can obtain an explicit expression for estimating a "partial" cap rate associated with each (statistically significant) housing characteristic z_i:

$$r = cap\ rate_{z_i} = \left(1 - \frac{V_{z_i}}{V_1}\right)^{-\frac{1}{n}} - 1 \tag{7}$$

Equation (7) is the key equation of the model. Note that the empirical estimation of equation (7) only needs of data on the *hedonic home value price function* V^*. Therefore, this model can be especially useful when the rental market data are not enough to rely on the direct estimation.

3.2. Properties of equation (7)

For any finite (and positive) value of n, the cap rate is a positive percentage value, since $\left(1 - \frac{V_{z_i}}{V_1}\right)^{-\frac{1}{n}} > 1$ and $0 < \left(1 - \frac{V_{z_i}}{V_1}\right) < 1$. Indeed, $V_{z_i} < V_1$, with the two prices that tend to be equal only to the limit (i.e. for $n \to \infty$).

As regards the relationship between cap rate and hedonic price, it is positive:

$$\frac{\partial cap\ rate_{z_i}}{\partial V_{z_i}} = -\frac{1}{n} \cdot \left(1 - \frac{V_{z_i}}{V_1}\right)^{-\frac{1}{n}-1} \cdot \left(-\frac{1}{V_1}\right) > 0 \tag{I}$$

Intuitively, the (partial) yield associated with the property investment is increasing in the value (hedonic price) of housing characteristic.

As in the standard equation, namely $cap\ rate = \frac{R}{V}$, the cap rate is decreasing in the house value:

[7] In short, we assume that the desired and relevant housing characteristic z_i becomes increasingly important over time. One could even assume that if the characteristic is very important, in the future homes without that characteristic are no longer built.

[8] Recall that the net rent is assumed to be constant over time. Thus, $R_{z_i} = (R_1 - R_0)\ \forall t$.

$$\frac{\partial cap\ rate_{z_i}}{\partial V_1} = -\frac{1}{n} \cdot \left(1 - \frac{V_{z_i}}{V_1}\right)^{-\frac{1}{n}-1} \cdot \frac{V_{z_i}}{(V_1)^2} < 0 \qquad \text{(II)}$$

Instead, the relationship between cap rate and economic life of the property seems counter-intuitive, since it is negative:

$$\frac{\partial cap\ rate_{z_i}}{\partial n} = \ln\left(1 - \frac{V_{z_i}}{V_1}\right) \cdot \left(1 - \frac{V_{z_i}}{V_1}\right)^{-\frac{1}{n}} \cdot n^{-2} < 0 \qquad \text{(III)}$$

since $\ln\left(1 - \frac{V_{z_i}}{V_1}\right) < 0$, being $0 < \left(1 - \frac{V_{z_i}}{V_1}\right) < 1$.

We provide an economic rationale of this last and very important result. For securities and financial assets, basically, an increase in the investment time horizon n implies, *ceteris paribus*, an increase in the rate of return as the risk increases and investors will demand a higher premium.[9] However, this reasoning might not apply to property investment, which would confirm its peculiarity and specificity with respect to any other financial asset. A real estate investment more durable (with higher n), in fact, could be less risky and thus less profitable than one with a shorter economic life. This would be confirmed by the fact that the cap rates of residential real estate (apartment) are usually lower than the cap rates of the property types such as retail, industrial and office (see e.g. Clayton and Glass, 2009). Also, it is well known that the useful life of residential real estate is very high. Instead, office and commercial buildings and real estate for industrial use typically have an economic life that is shorter than their physical life (IVSC, 2012, p. 18), since functional and economic obsolescence plays a key role. In a nutshell, property types with a shorter economic life require a higher rate of return in order to make the investment profitable.[10]

3.3. Extension of equation (7)

Equation (7) identifies a "partial" cap rate. Hence, in order to obtain an "overall" cap rate, equation (7) must be calculated for each relevant housing characteristic z_i. It follows that:

$$cap\ rate_{overall} = \prod_{i=1}^{m}\left(1 + cap\ rate_{z_i}\right) - 1 \qquad (8)$$

where m is the number of the statistically significant housing characteristics. Equation (8), however, raises an important empirical question: *How should one estimate V_1 in case of housing characteristics that are not binary variables?* A simple way to deal with this issue is the following. First of all, recall that data on housing characteristics typically consists of many ordered and unordered categorical variables. Thus, transforming the ordered housing characteristics into binary variables, it is possible to extend the procedure to all the ordered and unordered housing characteristics. Consider, for example, an unordered categorical variable that assumes the following scale: "excellent", "good" and "poor". It is possible to define a binary variable that takes the value 1 if the scale of the housing characteristic is "excellent" or "good", and 0 otherwise. In case of continuous variables (such as the lot size) and discrete variables (such as the number of bathrooms), instead, it needs to define a "threshold value" of the housing characteristic (which may be the average of the values taken by the housing characteristic) and then estimating V_1 as the average price of the properties where the characteristic has a value higher than the threshold value.

[9] The cap rate depends (positively) on the discount rate that is usually divided into two components: the risk free rate and the risk premium (see e.g. Corgel, 2003; Clayton and Glass, 2009).

[10] Obviously, the value of n crucially depends on the intended use of the property. Thus, it should be calibrated case by case.

Conclusions

Studies on real estate economics omitted the relationship between hedonic prices and cap rate, thus considering the hedonic models and the income approach as two separate and alternative methods. This theoretical paper, instead, shows that integration is possible and relatively simple. Precisely, the hedonic functions of price and rent are introduced into the standard equation of income capitalization. Eventually, the combined model is able to estimate the cap rate using only information about hedonic prices. Thus, the model can be useful when the rental market data are not enough to rely on the direct estimation. Also, the developed model brings out a peculiarity of real estate asset, namely the negative relationship between economic life of the property and cap rate. In a nutshell, a real estate investment more durable would be less risky and thus less profitable than one with a shorter economic life. Indeed, the cap rates of residential housing (where the useful life is very high) are usually lower than the cap rates of the special properties such as the real estate for industrial use (where the economic life is lower).

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