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Bringing the Hedonic Price Method into Fashion when Valuing Landscape Quality

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ABSTRACT

The objective of this article is to measure the implicit price of landscape quality. As a revealed preference method, the hedonic price method is used in order to analyse tourists' preferences regarding the landscapes of six alpine resorts in the Swiss Canton of Valais. The use of multi-criteria decision analysis techniques, i.e. silent negotiation and MACBETH, made it possible to generate cardinal data reflecting the aesthetic quality of the selected landscapes. Integrated as vector of environmental characteristics, this data makes it possible to assert that for an improvement or a degradation of the aesthetic quality of the landscape of 10 points (on the MACBETH scale [0-100]), the rents levied in these resorts are subject to an increase or decrease of over 3%. This experiment thus shows that it is possible to obtain environmental data that can be directly exploited in a hedonic analysis. Calling upon this technique is therefore not devoid of chances of success in a terrain that to date has been largely dominated by the contingent valuation method.

Keywords: Cardinal data, hedonic prices, landscape quality, landscape value, MACBETH

RESUME

L'objectif de ce papier est de mesurer le prix implicite de la qualité du paysage. Comme méthode de référence, la méthode des prix hédonistes est utilisée afin d'analyser les préférences des touristes concernant le paysage de six stations alpines du Canton du Valais. L'utilisation de techniques d'analyse multicritères d'aide à la décision, ex. négociation silencieuse et MACBETH, a permis de générer les données cardinales reflétant la qualité esthétique des paysages sélectionnés. Intégrées comme vecteur de caractéristiques environnementales, ces données permettent d'avancer que pour une amélioration ou une dégradation de la qualité esthétique du paysage de 10 points (sur l'échelle de MACBETH [0-100], les loyers pratiqués dans ces stations subissent des augmentations ou des diminutions de plus de 3%. Cette expérience montre ainsi, qu'il est possible d'obtenir des données environnementales directement exploitables dans une analyse hédoniste. Avoir recours à cette technique offre cependant toutes les chances de réussir sur un terrain où l'établissement des données a souvent été effectué par la méthode d'évaluation contingente.

Mots-clés : Données cardinales, prix hédonistes, qualité du paysage, valeur du paysage, MACBETH.

TABLE DES MATIERES

1. INTRODUCTION

Stated preference methods and revealed preference methods analyse environmental amenities such as air or water quality, noise pollution, or landscapes. It is nevertheless worthy of note that the stated preference methods, and for example that of contingent valuation, are used to a far greater extent than the revealed preference methods, and for example that of hedonic prices. This difference is all the more marked when an amenity such as the landscape is considered. Is it thus necessary to draw the conclusion that an analysis of landscape quality using hedonic prices is doomed to failure? Must the fact that this method is only attached to evaluating individuals' willingness to pay in order to benefit from an open view from their home prevent it from being applied to the quality of that same view, and thus to the aesthetic quality of the landscape? In fact, although it has been demonstrated that the view (whether open or not) has a significant impact on the variation in the value of real estate, the hypothesis that the landscape quality also exerts an influence cannot, *a priori,* be rejected since social anthropology asserts that individuals express preferences for a quality landscape. The entire problem thus resides in measuring the "quality of the landscape", for which a cardinal measurement of quality is usually lacking. In fact, there is no system or scale for measuring an environmental amenity such as the landscape. The subjectivity inherent to this concept, notably thanks to the large number of definitions assigned to it, also raises the question of antagonism between the objective and the subjective measurement of an amenity. In fact, the amenities for which estimations have already been carried out are those for which "objective" scales and measurements exist. This notably concerns noise, measured in decibels, or the quality of air measured, for example, with the help of particle concentration levels.

For this reason, the objective of this article is *(a)* to provide a form of cardinal measurement for landscape quality that can be used to apply the hedonic price method and *(b)* to evaluate the implicit price of a relative improvement or a degradation of landscape quality. This approach should thus make it possible to revalorise the hedonic price method in order to estimate the value of environmental goods.

Section 2 reviews economics literature relating to landscape evaluation. The following section presents the data used in this study and the method that permitted us to obtain data expressing the quality difference between each type of landscape selected. The results of our estimation of the hedonic function are described in section 4. The last section provides a synthesis of our results as well as some thoughts for further research.

2. REVIEW OF LITERATURE

Landscape as an environmental amenity has already been the subject of analysis seeking to estimate its value in monetary terms. The methods used for this purpose do not focus on evaluating the same components of landscape. These methods can be categorised according to the approach adopted, which can be stated or revealed. The contingent valuation method is among the stated preference methods. Landscape has thus been the subject of contingent valuations, by questioning individuals about their willingness to pay (WTP) for this amenity. We can cite, for example, studies by Cobbing & Slee (1992), Willis & Garrod (1993), Hanley *et al.* (1998), or that by Schläpfer & Hanley (2003).

As far as the hedonic price method is concerned, this seeks to establish an indirect estimation of the value of an environmental amenity via preferences revealed by individuals on a substitute market, and most frequently that of real estate. The number of hedonic studies is nevertheless low in relation to analyses carried out using the contingent valuation method. Moreover, a distinction should be made between hedonic analysis aimed at estimating individuals' WTP in order to benefit from a *view* and that which is aimed at estimating individuals' WTP for the quality of the landscape visible. It should be noted that even studies on the WTP for a view are very few in number. Bourassa *et al.* (2003) list 35 hedonic studies that seek to analyse the implicit price of the existence of a view over various sites (river, lake, ocean, mountain, forest, road, etc.). In most of these studies, the existence of a view thus exerts a positive impact on the value of the real estate analysed[1]. Among these studies, the view has in the great majority of cases been handled by means of *dichotomic variables* alone (the existence or lack of a view), and most research concerns the USA. The only non-US studies were carried out in England (Darling 1973), Australia (MacLeod 1984), Finland (Tyrväinen & Miettinen 2000), Canada (Kulshreshtha & Gillies 1993), New Zealand (Kask & Maani 1992), Hong Kong (Tse 2002), Japan (Hidano 2002) and Scotland (Lake *et al.* 1998, 2000 a, b).

[1] Some studies reveal a non-significant impact (Davies 1974; Brown & Pollakowski 1977; Correll *et al.* 1978). These nevertheless appear to be marked by certain shortcomings in terms of concept definition, too few observations, or they appear to be the victims of measurement errors.

Hedonic studies of the intrinsic value of the visible landscape are even rarer. This comes from the difficulty of constructing a variable that reflects quality. Li & Brown (1980) use a variable measuring the quality of views from each site on a five-point scale. Des Rosiers *et al.* (2002) examine the impact of the landscape characteristics of the properties analysed and their immediate environment in Quebec (31 attributes are taken into account)[2]. Bourassa *et al.* (2003) seek to measure the implicit price of the various components of a view. They introduce indicators reflecting the panorama and the view over expanses of water for conurbations of the city of Auckland, New Zealand, as well as a series of variables measuring the average landscape quality in the neighbourhood and the average quality of the buildings in the immediate neighbourhood.

Although hedonic studies relating to the existence of a view and of an open view are few in number, those seeking to analyse the *aesthetic quality of the landscape* as an environmental amenity are even less numerous. As we have seen above, this area of research has to date been the prerogative of stated preference methods, and notably the contingent valuation method. The principal difficulty when seeking to estimate the implicit price of an improvement or a degradation of landscape quality in fact resides in obtaining data that expresses, in a formalised and numeric way, the difference in quality between each type of landscape, i.e. *cardinal data*. Ordinal variables are not sufficient, since they only provide information on the position of one landscape versus another. In Switzerland, Tangerini *et al.* (2004), prior to the study for which the results are presented in section 4, obtained a cardinal scale for the aesthetic quality of the landscape of six ski resorts. Salvi *et al.* (2004) carried out a measurement of the theoretical view (in km^2) from their sample of properties by means of data collected thanks to geographic information systems (GIS), i.e. *numerical variables*. They take into account not only the exposure of each observation but also its topographical situation[3]. A house can thus be exposed to the south but be located facing a slope. Its theoretical view will thus have a value that is extremely low. On the contrary, a property that is exposed to the south and located at a dominant point, for example on a hill, will benefit from a much higher theoretical view.

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[2] Here, it is nevertheless a question of the landscape as a characteristic of the property rather than one of an amenity in the sense in which we are analysing and considering it in this paper.

[3] It is nevertheless necessary to note that the immediate neighbourhood (for example a house, an apartment building or trees) for each observation is not taken into account. It is moreover for this reason that the term "theoretical view" is used.

These authors thus note that a theoretical overall view of between 50 and 100 km^2 leads to an increase in the value of the property of 2.2%. They also note that the theoretical view over the Lake of Zurich exerts an even greater influence; if the view is above 40 km^2, the price increases by over 11%.

3. DATA AND METHOD

Our analysis is based on a sample of 402 apartments rented out to tourists in six alpine resorts in the Canton of Valais, Switzerland, during the 2002-03 winter season (Anzère, Champéry, Grimentz, Haute-Nendaz, Ovronnaz, Verbier). The data collected for the needs of this study comes from four sources. Firstly, real estate agents in each resort were called upon in order to benefit from data relating to the structural characteristics of the buildings and apartments. We were thus able to collect 57 variables for the 402 apartments in our sample[4]. The local tourist offices and authorities permitted us to establish 20 variables relating to the local characteristics of the resorts. Thirdly, the characteristics of the neighbourhoods, i.e. the distances separating the buildings from several "strategic" locations in the resort (ropeways, centre of the resort and grocery shops) were noted, when this was possible, thanks to GIS tools. When this was not possible, fieldwork was necessary. Finally, the main challenge within this study lay in obtaining numerical values reflecting the aesthetic quality of the natural landscape of these six resorts.

In order to determine the implicit price of a relative variation in the landscape quality, only cardinal data made it possible to carry out an econometric analysis that was mathematically rigorous. For this reason, we used two complementary methods that were developed within the framework of multi-criteria decision analysis[5]. MACBETH (Measuring attractiveness by a categorical based evaluation technique) is used in order to define numerical values based on verbal expressions. It is completed by silent negotiation, which proposes a heuristic that is intended to seek a consensus within a group. The information obtained finally served as basic data in order to apply the MACBETH technique (Tangerini

[4] Of these, 17 concern apartment buildings and 40 concern apartments.

[5] Bana E Costa (2001), Bana E Costa *et al.* (2003), Pictet & Bollinger (2004).

et al. 2004). The dominant landscape of each resort was thus the object of an evaluation session involving a group of experts during the winter of 2002-03.

Six views representing the dominant landscape in these resorts were presented to the group. After comparing these photographs in relation to each other and classifying them by order of preference, the group was asked to define the qualitative difference between each pair of landscapes by means of a verbal scale ranging from "no difference" to "extreme difference". The handling of these results in the form of MACBETH scores is expressed in the following table. We are thus in possession of environmental data relating to the aesthetic quality of the landscape. The first line entry presents the classification of the resorts in ordinal form. The second indicates the transformation of the verbal expressions into numerical values, i.e. the scores given by MACBETH to each resort. These scores are established on a scale ranging from zero (the least appreciated natural landscape) to one hundred (the best-appreciated landscape). This makes it possible to assess the qualitative gap between the beauty (or the aesthetic quality) of each natural landscape[6].

Table I
Results of the evaluation of the quality of the natural landscape

Resort	**Score**
Champéry	100.00
Verbier	75.00
Ovronnaz	56.25
Grimentz	43.75
Anzère	18.75
Haute-Nendaz	0.00

Obtaining cardinal data reflecting the relative quality of natural landscapes permits us to estimate a hedonic function of the rent paid by the tourists who chose to stay in the resorts of our sample. On the basis of the model developed by Rosen (1974), the hedonic price function can thus be expressed as follows:

[6] Since this is a relative evaluation, it should be noted that the position achieved by Champéry does not provide any basis for the assumption that its natural landscape is the most beautiful (in absolute terms), or that the natural landscape of Haute-Nendaz is the ugliest (in absolute terms). It is merely possible to state, for example, that there is a difference between the quality of the natural landscape of the latter and that of Anzère, or that there is a difference between the quality of the natural landscape of Champéry and that of Verbier. This difference is expressed by the difference between their scores.

$$P_a = P_a(X_1, X_2, ..., X_n, Pn) \quad (1)$$

where Pa represents the rent price for the apartment, $X_1, X_2, \ldots, X_n$ the various characteristics that compose the rent, and Pn the environmental attribute. The function P_a represents the implicit or hedonic price of the apartment (*a*).

Thus, although the price of this property may be evaluated on the basis of its characteristics, the price of any characteristic can be calculated on the basis of knowledge of its characteristics and the rent. The marginal implicit price (or hedonic price) of a characteristic can thus be calculated by means of the partial derivate of the hedonic function (1); for example in the case of an environmental amenity such as the aesthetic quality of the natural landscape.

$$\partial P_a / \partial Pn = P_{Pn}(Pn) \quad (2)$$

This makes it possible to measure the increase in rent necessary in order to obtain an apartment that offers a supplementary unit of Pn, *ceteris paribus*.

4. ESTIMATION OF THE HEDONIC PRICE FUNCTION

The results of the hedonic function estimation are presented in the table below. They were obtained in two ways. The first estimation is based on the general transformation proposed by Box & Cox (1964) in order to determine the functional form that maximises the likelihood of the hedonic function[7]. The results of this operation indicate a λ_1 coefficient of -0.07. The dependent variable is thus transformed by this coefficient in order to maximise the likelihood of the function. Depending on the function that maximises the likelihood, the parameter λ_1 has a probability of 95% in the range $-0.18<\lambda_1<0.03$. We estimate that the value of this coefficient is sufficiently close to zero to take the liberty of logarithmising the dependent variable and thus to use the ordinary least squares (OSL) method with the objective of estimating a second hedonic function. This method makes a

[7] The general transformation, here of the dependent variable (Pa) proposed by Box & Cox (1964), is the following:

$$P_a^{(\lambda)} = \left[(P_a + \lambda_2)^{\lambda_1} - 1\right] / \lambda_1$$

where λ_1 is a Box-Cox parameter determined to normalise the error distribution and allows a great deal of flexibility in the search for an appropriate functional form. It is possible for the transformation to be linear (λ_1=1) or a natural logarithm (λ_1=0). A second Box-Cox parameter, λ_2, must be introduced in cases where the dependent variable equals zero. The search for the values of both Box-Cox parameters that maximised the likelihood function requires a complex procedure. A value of 1 for λ_2 is therefore arbitrarily added to the dependent variable. Mitchell & Carson (1989, p. 372), in a contingent valuation context, propose adding 1 US$.

more intuitive interpretation of the estimated coefficients possible on the one hand, and enables us to verify the consistency of the results obtained with the aid of the two methods.

Table II (page 23) has three columns. The first line entry identifies all the variables contributing to the model's explicative potential. The second makes it possible to assess the result of the regression by means of the value of the coefficients estimated and the statistic T, when the dependent variable is logarithmised (OLS).

The last column shows the results of the regression when the rent is transformed in a way that maximises the likelihood of the hedonic relation (maximum likelihood estimation - MLE). The usual thresholds of significativity are applied, while taking into consideration the risks of multi-colinearity that were noted.

The sense of the relation corresponds to the expected sign for each of the characteristics, and the coefficients estimated are significative on various levels, thus making it possible to reject the zero hypothesis to an extent of 99% in the best cases and to 95% in the worst ones. The matrix of simple regression coefficients, which is annexed, moreover confirms the absence of marked dependence among the variables in our model.

Assessed in accordance with the usual statistical criteria, the results of our analysis appear sound. The 10 independent variables retained in the hedonic function explain 80% (R^2 *corrected*) of the variance of the rent (i.e. its value in logarithmic form) [8,9]. Furthermore, the value of coefficient F (153.14 for OLS and 153.12 for MLE) does not make it possible to reject the zero hypothesis of the coefficients on the threshold of 1%. This permits us to advance the assumption that the group of independent variables significantly influences the dependent variable.

Finally, and whatever estimation method is considered, the estimated coefficients only value marginally, with the exception of [GARDEN], whose threshold drops to 95% for the estimation of the function by means the MLE estimate.

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[8] These variables were retained on the basis of the three following criteria: *(a)* the variables present the sign that was theoretically expected or noted on several occasions in previous studies; *(b)* the variables express a sufficient degree of significativity level; *(c)* the variables do not present a too high noted risk of multi-colinearity.

[9] It is worthy of note that an interesting variable was removed from the presentation of results because its level of significativity was too low. This is a variable which expresses the surface of landscape visible, measured in square decametres, within a radius of 20 metres from each façade of the building occupied by the apartment selected.

For this reason, the interpretation of the regression results is based on the variance of the natural logarithm of the weekly rent paid by tourists.

Our analysis reveals that the quality of the natural landscape without doubt influences the variation in rents at the resorts. If we thus take into consideration the two extremes from our evaluation of the aesthetic quality of natural landscapes, that of Champéry makes it possible, *ceteris paribus*, to increase the rent for an apartment by more than 30% compared with the same apartment, i.e. an apartment whose average characteristics were identical, in Haute-Nendaz.

In this same order of ideas, we can assert that a relative increase in the aesthetic quality of the landscape of 10 points (on the MACBETH scale [0-100]) can lead to a positive variation in the rent of over 3%. The opposite of the operation is also valid, i.e. for a relative decrease in quality of 10 points.

We cannot, however, estimate what the effect of a relative increase in the quality of Champéry's natural landscape would be, or the effect of a relative reduction in the aesthetic quality of the natural landscape of Haute-Nendaz. In fact, we can only compare the six resorts used in the sample with each another, since the values obtained are relative. Obtaining a more "absolute" value can however be envisaged if the actors are capable of comparing real goods (photos) with abstract elements (the concept of a "beautiful" landscape) (Tangerini *et al.* 2004).

As could have been expected, the number of rooms is the most important characteristic when defining the rent. An additional room thus leads to an increase in rent of approximately 24%. Interpreting the results of the regression also permits us to assert that the older a building becomes, the more the rent drops. For example, the rent for an apartment in a building constructed in 1992 is on average 3% lower than that for an apartment in a building from 2002. The fact that an apartment has a fireplace makes it possible to increase the rent by approximately 10%. In the same way, an increase of 10 m^2 in the window surface leads to a positive variation in the weekly rent of 5%. This result can also be interpreted in terms of luminosity or even of access to the landscape. It is, in fact, easy to imagine that an apartment whose window surfaces were doubled would make it possible to benefit from more natural daylight, or to derive greater pleasure from the external environment of the building. This could thus be a new indicator that would make it possible to take the view or the access to the landscape into account. Apart from the structural characteristics of the building and of the apartment, our results reveal that the relative length of the ski runs also leads to a positive variation on rents levied in the six resorts of our sample. This signifies that tourists are willing to pay more for longer ski runs. We can draw the same conclusion concerning the infrastructures made available to tourists by the resorts. Those within this group of actors are, in fact, willing to pay a positive and significant sum in order for the resort in which they have chosen to stay to place a larger number of restaurants, bars, or sports shops at their disposal. The distance from the resort's main infrastructures has also affected the variation in rents positively. The fact that the sign of this coefficient is positive permits us to assume that persons who come and stay in a resort have a positive willingness to pay in order to be away from the ropeways, the centre of the resort and the grocery shops. This can be explained by a need for tranquillity, notably during particularly busy periods for the resort (for example during the year-end holidays)

5. CONCLUSION

The objective of this article was to evaluate, by means of the hedonic price method, the implicit price of a relative improvement or degradation of the landscape quality. The results of the estimation of the hedonic function show that a relative improvement or deterioration of the aesthetic quality of the landscape of 10 points (on the MACBETH scale [0-100]) leads to a variation in the rent of over 3%.

To obtain this result, multi-criteria decision analysis techniques permitted us to produce a variable that measured the natural landscapes of six alpine resorts in the Canton of Valais in a cardinal form. The experiment thus shows that it is possible to obtain environmental data that can be directly used in a hedonic analysis.

To date, the hedonic price method has only been used for evaluating environmental characteristics whose quality could be measured with the assistance of instrumental measurement scales. Here, it is used to measure the implicit price of an amenity for which no measurement scale exists. Our study thus reveals that combining multi-criteria techniques and the hedonic price method broadens the field of application. In this sense, it revalorises the hedonic method versus competing methods such as contingent valuation, which has hitherto benefited from a virtual monopoly in the area.

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Appendix

Matrix of simple regression coefficients (OLS)

	LNRENT	AGE	FIREPLACE	WINDOW	GARDEN	WASHING	ROOM	SKI	INFRA	DISTANCES	QUAL_NL
LNRENT	1.0000	-0.1677	0.4244	0.3888	0.1363	0.1564	0.7864	0.2624	0.4369	0.2716	0.2722
AGE		1.0000	-0.0753	0.0288	-0.0016	-0.0038	-0.0149	0.0110	-0.1172	-0.2682	0.02722
FIREPLACE			1.0000	0.2491	0.0221	0.0276	0.4011	0.0997	0.2290	0.0226	-0.0097
WINDOW				1.0000	0.0717	0.1118	0.4015	0.0934	0.1015	0.0660	-0.0097
GARDEN					1.0000	0.1190	0.0640	0.0643	0.0670	0.0882	0.0071
WASHING						1.0000	0.1513	0.0012	-0.0321	-0.0011	-0.0351
ROOM							1.0000	0.0502	0.1757	0.0747	0.1915
SKI								1.0000	0.4358	0.2850	-0.4325
INFRA									1.0000	0.1303	0.0597
DISTANCES										1.0000	0.2007
QUAL_NL											1.0000

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Table II
10 independent variables explain the variance of the natural logarithm of the rent paid by tourists to a degree of accuracy of 80%

Independent variables [a]	OLS[b] (λ_1=0)	MLE[b] (λ_1= -0.07)
Constant	5.7391** (101.726)	5.7372** (96.022)
Structural characteristics of the building		
Age of the building, numerical variable expressing the number of years since its construction [AGE]	-0.0027** (-3.923)	-0.0027** (-3.789)
Structural characteristics of the apartment		
Fireplace, dichotomic variable with value 1 if the apartment has a fireplace (otherwise 0) [FIREPLACE]	0.1025** (4.321)	0.1026** (4.332)
Windows, numeric variable expressing the total surface of the apartment's window, in square metres [WINDOW]	0.0055** (2.784)	0.0055** (2.711)
Garden, dichotomic variable with value of 1 if the apartment has a garden (otherwise 0) [GARDEN]	0.0680** (2.229)	0.0681* (2.174)
Washing machine, dichotomic variable with value of 1 if the apartment has a washing machine (otherwise 0) [WASHING MACHINE]	0.1247* (3.037)	0.1248* (2.576)
Number of rooms in the apartment, numerical variable indicating the number of rooms [ROOM]	0.2408** (18.975)	0.2410** (21.835)
Local characteristics		
Relative length of the ski runs, numerical value expressing the relation between the length of the runs (in km) and the number of ropeways [SKI]	0.0973** (6.479)	0.0974** (6.760)
Infrastructures, weighted index of the various infrastructures available at the resorts (grocery shops, bars, no. of tourist beds, discotheques, restaurants, sports shops, real estate agents) [INFRA]	0.0079** (6.234)	0.0079** (5.935)
Neighbourhood characteristics		
Distances, numerical variable expressing the sum of the distances to the resort's main infrastructures (ropeways, grocery shop and centre of the resort) [DISTANCE]	0.0244** (2.608)	0.0244* (2.149)
Environmental characteristics		
Natural landscape quality, numerical variable reflecting the aesthetic quality of the dominant natural landscape for each resort on a scale of 0 to 100 [QUAL_NL]	0.3116** (7.097)	0.3118** (7.675)
N	402	402
R^2	0.797	0.797
R^2 corrected	0.791	0.791
F	153.14	153.12

a. The dependent variable is the gross weekly rent (including charges), transformed by the value of the coefficient λ_1.

b. The values of $\hat{t}$ are shown between parentheses under the estimated parameters. Coefficients with double asterisk are significant to 99%; those with a single asterisk to 95% (bilateral test).