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ESTIMATING THE IMPACT OF URBAN GREEN SPACE ON PROPERTY VALUE

An Application of the Hedonic Price Model

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Abstract

This paper attempts to quantify the impact of urban green spaces, such as parks and gardens, on the transaction price in real estate markets, through households' residential choice, by using the hedonic price analysis of the relationship between property prices and their proximity to green spaces. The economic value of green space is measured through the willingness of households to pay for a property with higher price situated near to a defined green space. The results show that the property price has an inverse relation with the distance to the nearest green space, which indicates urban green spaces provide a positive impact on the transaction price in real estate markets.

Keywords: urban green spaces, the property price, proximity to green space, hedonic price model

Introduction

This research is part of a research project: the project SERVEUR. The project SERVEUR is a research project funded by the central region. The object is to identify ecosystem services provided by urban green spaces in order to measure the positive impact on local inhabitants. Therefore, this project only interests in urban green spaces. The study covers six cities in the central region in France: Orléans, Tours, Châteauroux, Bourges, Chartres and Blois.

Urban green spaces, such as parks and forests, are an important component of urban area's uses. They provide physical and social development for a city. Parks and natural areas can be used for recreation; wetlands and forests supply storm-water drainage and wildlife habitat; farms and forests provide aesthetic benefits to surrounding residents. And in rapidly growing urban and suburban areas, any preserved land can offer relief from congestion and other negative effects of development.

Since the development of cities puts increasingly pressure on green spaces, there have been more and more concerns over the preservation of urban green spaces in recent years. Urban green spaces create environmental, social and economic values for local inhabitants. However, they are non-market products so that it's impossible to directly place a monetary value on them. Hence, the provision of urban green spaces is often subject to market failures (Choumert, 2010). As a result, the values of urban green spaces are usually misjudged or even ignored in urban planning and decision making.

It is one thing to recognize that green space provides these benefits but quite another to measure their actual economic value. Therefore, the determination of the economic values created by green spaces need to be observed via their influence on other market products.

As Nanette, Jeffery and Laurie (2002) represented, the effect that environmental amenities, such as forested areas and green space, contribute to the value of real estate is often estimated using the hedonic pricing approach, a method that was based on the straightforward premise that the value of a good depends on the stream of benefits derived from that good.

Recently, hedonic price model has been widely used to estimate the value of environmental benefits from costs and prices of related market transactions. This model considers a differentiated product as a set of attributes. The hedonic price is one that decomposes the price of this product into separate components that determine the price. That is to say, this model measures the price of each attribute of a differentiated product. This method has the advantage of being on actual transaction data, choice and purchase price.

On the other hand, housing is a differentiated good, which has multi-dimensions. In general, the price of a house is related to the characteristics of the house and property itself, the characteristics of the neighborhood and community, and environmental characteristics. If non-environmental factors are controlled for, then any remaining differences in price can be attributed to environmental factors. Hence, one way to measure the economic value of urban green space is to study the effect that environmental amenities contribute to the value of real estate, examining how much people are willing to pay for such benefits in their housing.

This approach takes house prices as an indicator of how attractive of green space to local inhabitants and examine to what extent house prices are affected by green spaces in the central region. The environmental characteristic of concern is the proximity to green space, of which the data is obtained from QGIS maps. Data on housing prices and characteristics are available from the French notarial office and the INSEE (the French National Institute for Statistic and Economics Studies). The data are analyzed using regression analysis, which relates the price of the property to its characteristics, the environmental amenity and the characteristics of consumers and suppliers. Thus, the effects of different characteristics on price can be estimated.

This paper is organized as follows: section 2 represents some related papers to show the previous work on this topic. Section 3 outlines the basic model specification. Section 4 includes the data description and a statistical summary. Section 5 presents the empirical results and detailed interpretations of the results. Finally, section 6 draws some conclusions from the analysis.

Literature Review

Green spaces provide many environment and social benefits, which are well documented in the literature. For example, Per Bolund and Sven Hunhammar (1999) found parks indirectly improved individuals' quality of life through the numerous environmental benefits provided to an area including reduced noise pollution and improved air quality. In opinion of Mansfield (2002) increasing the forest cover in a city can reduce summertime's heat and wintertime's cold. Planting trees located around residences can reduce both cooling and heating costs by decreasing summer heat and winter cold. Saving of 1.9% to 2.5% on cooling costs for each per tree have been estimated for each residence so this fact provides a strong financial incentive to choose house's location around areas with dense trees covering.

However, most of the values attached to the green spaces, such as those derived from pleasant landscape, clear air, peace and quiet, recreation, aesthetics, are not directly traded in private markets. The contribution of green spaces is usually difficult to assess and quantify.

Economists have used a variety of techniques for valuing non-market environmental benefits. As Suparmoko M. (2008) represented, economic values of urban green spaces can be measured by means of mathematical model. More than 30 studies have shown that parks have a positive impact on nearby residential property values. Other things being equal, most people are willing to pay more for a home close to a nice park. Economists call this phenomenon "hedonic value." (Hedonic value also comes into play with other amenities such as schools, libraries, police stations, and transit stops.). (Harnik P. and Welle B., 2009)

The term "hedonic" is derived from Latin "hedonikos", meaning satisfaction. This concept is used in economics to imply for enjoyment, satisfaction, pleasure or utility achieved with consumption of goods or services (Kaul S., 2006).

The hedonic method can be traced back to Court (1939) and received considerable application beginning in the 1960s. However, it is not until 1974 that a theoretical model was developed by Rosen. It defines product prices as a function of various characteristics of products. Hedonic price was the implicit price of attributes 'revealed to economic agents from observed prices of differentiated products and the specific amounts of characteristics associated with them' (Rosen, 1974). Rosen's model has been proven to be extremely useful in many years.

Application of the hedonic technique to valuation of environmental amenities has a long history. Freeman (1993) presents a useful overview of environmental benefit studies using the hedonic technique, along with a clear description of the theory underlying the approach. Recently, hedonic pricing model has been widely applied on examining the economic value of urban green spaces.

The most common application of this model is the property price. It relies on the fact that properties are not homogenous and house prices can be affected by many factors, for instance, number of rooms or access to amenities. The price of a house depends upon the availability and level of a wide range of attributes, such as structural characteristics, neighborhood characteristics, and amenity characteristics. Among them, one important factor is environment, for example, view or access to a wooded park or watercourse (Palmquist, 1991).

Theoretically, property valuation methods is a good way to quantify the value of green spaces. The price of a house reflects the people's willingness to pay for the accessibility to forests and the enjoyment deriving from it. In addition, HPM has been used for estimating the contribution of individual trees to property values (Morales, 1980; Morales et al., 1983; More et al., 1988). Anderson and Cordell (1985) found that a 3 to 5% increase in the sales prices of-single-family houses in Athens, Georgia, was associated with the presence of trees in their landscaping.

The hedonic price approach has long been used to quantify the impact of green space on residential housing value (Bolitzer and Netusil, 2000; Doss and Taff, 1996; Lutzenhiser and Netusil, 2001). The first environmental study, Ridker and Henning's analysis of the effects of air pollution on house prices, dates back to 1967. Many studies examine the influence of the size of the nearest green space area on housing prices (Morancho, 2003). Others include the total quantity of surrounding green space areas (Acharya & Bennett, 2001) or the visibility of green space (Morancho, 2003; Luttik, 2000).

The most common approach has been to include distance from property to the amenity as an explanatory variable in the model (Nelson, Genereux, and Generoux 1992; Thayer, Albers, and Rahmatian 1992; Lansford and Jones 1995; McConnell and Walls, 2005).

A common finding in these studies is that green spaces of these types have positive impacts on residential property values up to a distance of one-quarter to one-half mile. As much as 3% of the value of properties could be attributed to park proximity. On the other hand, many of the available studies have proved the impact of green space on the real estate price, but the other factors such as size and age of the real estate, accordingly, have a far greater influence on the price function.

According to Bateman (1993), the hedonic model depends on several assumptions: ‘the willingness to pay is an appropriate measure of benefits; the entire study area is treated as one competitive market with perfect information regarding real estate prices and environmental characteristics; the housing market is in equilibrium market, individuals continually reevaluate their location so that their purchased house constitutes their utility maximizing choice of property given their income constraint.”

As Anderson L. and Cordell H. (2005) represented, hedonic pricing model assumes that differentiated products can be viewed as bundles of characteristics, and that consumers who buy a particular product are really buying the particular bundle of characteristics that meets their needs. These studies rely on extensive data on the characteristics of homes sold, such as specific distance from a defined green space. The prices people are willing to pay for particular characteristics, such as green space can be inferred from the comparisons of the prices that they are willing to buy for different bundles.

Many hedonic analysis are often based on substantially small sample size. Pearson et al.’s (2002) study on the impact of an Australian National Park on surrounding land values was based on 641 prices for a single year 1999. In 2007, a study of urban green space in Jinan City in China used a sample 124 property prices for the year of 2004 (Kong et al., 2007). More recently, Yusuf and Resosudarmo (2009) studied the impact of air pollution on property prices in Jakarta, Indonesia, based on a sample of 470 observations for 1998. Because of lack of data or small sample size, researchers need more accurate data.

The growing availability of Geographic Information Systems (GIS) based data provides new opportunities to incorporate more accurate data on environmental qualities to a larger amount in studies using the hedonic price model. Din, Hoesli and Bender (2001) argued that GIS have made possible the development of databases that can be used to better measure environmental characteristics. Their environmental parameters refer to the quality of the neighborhood and the quality of the location within a neighborhood. Another benefit of applying GIS in analysis is demonstrated by Clapp (1997), he argues that GIS is a powerful tool for supporting research because of its capability of storing and manipulating large data sets on spatial relationships.

This paper takes advantage of this opportunity and examines the economic value of urban green spaces in house prices applying a hedonic price model and using QGIS-based (Quantum GIS)[1] distances information for parks and gardens in six cities of the central region in France.

The distance from green space to the properties is indeed important but there are other factors as well that can affect households' decision about whether to buy the property. For example, because of the limit of budget support, consumers' decisions are actually drawn from a closed range of choice; characteristics of consumers decides the level of their maximizing utility derived from different bundles of attributes; the socioeconomic characteristics of suppliers differentiate their total cost of selling properties and also the benefits they request from properties.

This paper presents the results of an empirical study conducted in six cities of the central region in France. The purpose of this study is to estimate the monetary value of urban green spaces reflected in real estate prices, combining the characteristics of the attributes of properties, consumers' characteristics and suppliers' characteristics.

Hedonic Model

Hedonic analysis is the study of the relationship between the price of a product and the characteristics of that product. Households buy and consume residential real estate for the utility drawn from properties. Each house or apartment has certain attribute that allow people to obtain utility from residing in it. These include the land, the number and size of rooms, and the existence other amenities, for instance, a garage, air conditioning, source of heat, etc. Furthermore, because the property is immobile, the location concerns consumers deeply.

[1] QGIS is a cross-platform free and open-source desktop GIS application that provides data viewing, editing, and analysis capabilities.

The idea behind the hedonic model is that residential housing is a differentiated product, which consist of a variety of characteristics; any particular property can be described by the characteristics of its structure, location and environs. The price of housing is determined by the particular combination of characteristics it displays.

Rosen (1974) provided a widely used model to study the contributions of various characteristics to the price of composite good. Hedonic model defines any house as a vector of structural and accessible characteristics,

$$z = (z_1, z_2 \ldots z_k)$$

where $z = (z_1, z_2 \ldots z_k)$ stands for a vector of the characteristics of the property.

When households chose a particular property in a particular market, it means they chose a particular set of the characteristics. Hedonic model helps derive the values of each characteristic, which means, when buying a house, the price paid is considered as the sum of the prices for each attribute. It can be expressed as

$$P = P(z)$$

Where P is the price of property, and it equals to the sum of the vector of values. The partial derivatives of the price, $\partial P/\partial z_i$, is called marginal value of characteristics'. It defines how much the consumer has to pay for, if they want an additional unit of a certain characteristic.

The easiest way to think about the hedonic function is to follow the lead of Haas or Andrew Court, and for the time being assume that the way you combine the characteristics is by making P(z) a linear function:

$$P = \beta_0 + \beta_1 z_1 + \beta_2 z_2 + \cdots + \beta_k z_k$$

Where z_1 through z_k stands for the attributes levels for k selected attributes, and β_0 through β_k are the weights associated with the particular attribute. Suppose that the first characteristics, z_1, is the number of rooms. The coefficient of this attribute, β_1, implies that if the number of rooms increases one, the housing price rises by β_1 euro. The implicit price of the attribute z_1 in the language of calculus is

$$\partial P/\partial z_1 = \beta_1$$

Which means the change in the housing price due to a change in z_1 is constant and equal to β_1.

The consumers' decision

Besides choosing a particular set of characteristics of the property, households also have needs for all the other goods, x, so that the utility that can be obtained from his budget is maximized, which can be expressed as

$$\text{Max U } (z_1, z_2 \ldots\ z_k, x; d) \qquad (1)$$

$$Y = P\ (z) + x \qquad (2)$$

Where U $(z_1, z_2 \ldots\ z_k, x)$ is the utility of consumers, d is the characteristics of households, Y is the consumer's income, x is a composite commodity whose price is unity.

Because households' budget is limited by their income, equation (2) can also be expressed as

$$P\ (z) = Y – x \qquad (3)$$

Which means the total amount a household spend on a property with characteristics z depends on the amount of money spent on other goods. The less a household pay for other goods, the more he can pay for housing attributes.

Households choose levels of z and x to maximize U (z, x; d). This consumer choice problem can be solved by using equations (1) and (2) to set up the Lafrangian Function:

$$L = U\ (z_1, z_2 \ldots\ z_k, x) + \lambda\ [Y – x - P\ (z)]$$

Maximizing this equation with respect to x, z and λ:

$$\partial L/\partial z_i = U_{z_i} - \lambda U_x = 0 \qquad (4)$$

$$\partial L/\partial x = U_x - \lambda = 0 \qquad (5)$$

$$\partial L/\partial z_i = y - x - P\ (z) = 0 \qquad (6)$$

Where U_{z_i} can be interpreted as the extra utility that comes from one extra unit of characteristics z_i. U_x is the extra utility that comes from one extra unit of money for the other goods.

Equation (4), (5) and (6) represent the conditions that define the household's optimal choice of resident. That is to say, given the constraint of their budget, the flow of utility that the household enjoys will be maximized by choosing a property whose characteristics is satisfy the condition laid out in these three equations.

Therefore the first order condition requires that $\partial P/\partial z_i = p_i = U_{z_i}/U_x$, under usual properties of u.

Rosen defined the bid-rent function, $\theta(z_i, y, d, u)$, as the amount of money a household is will to pay for alternative values of z at a given level utility. Therefore,

$$u = u(y - \theta, z, d)$$

where d represents a parameter of households' tastes.

Then the additional expenditure a household is will to pay for another unit of z_i is equal to $\theta_i = U_{z_i}/U_x$. θ schedules which are lower correspond to higher utility levels, but the price levels corresponding to these higher utility levels are too low to be accepted by the market. Therefore, the maximized utility with minimum price the household must pay is at the point where the demand function is tangent to the curve of price function:

$$\theta(z^*, u^*, d) = P(z^*)$$

$$\text{and } \theta_i(z^*, u^*, d) = p_i(z^*)$$

There is one factor that need to be considered, which is lending interest rate. It can also affect households' decision of purchasing houses. The relationship between is simple. Lending rate staying in a high level means a high level of interest on money borrowed, which raises households' cost. In this case, consumer may consider to delay their plan of purchasing house, or to choose any other property with lower prices. If lending interest rate remains in low level, then the possibility for consumers to purchase a property is higher.

Now, the determinations of the demand for property market is clear, which include housing characteristics, households' characteristics such as income, lending interest rate and the most important, the price of property in the market. Therefore, the demand equation is estimated in the form of

$$D_t = \text{G}\ (P_d,\ \text{r},\ I_\text{t},\ \sum_{i=t+1}^{t+n} I_{t+i},\ \alpha_i,\ z_i)$$

Where t indexes each time period, P_d stands for housing price, r stands for lending interest rate, $I_\text{t}$is consumers' income, , $\sum_{i=t+1}^{t+n} I_{t+i}$ is the income in the future, z_i is structural housing characteristics and α_i is the characteristics of locality, such as distance to green space.

The bid-rent function can be expressed as

$$\theta\ (z_1, z_2 \ldots\ z_k,\ \alpha_i, d_i,\ \text{r})$$

Where d_i represents the socioeconomic characteristics of households, the regression coefficients of this vector describe how demand functions for housing attributes differ between consumer types. This equation can be read as the demand price of a property is determined by housing characteristics of all kinds, lending interest rate and consumers' socioeconomic characteristics.

<u>The suppliers' decision</u>

So far the property market from the demand side has been examined, which is the determination of consumers' decision to purchase a property. It is also necessary to examine the supply side of the property market, to make sure how suppliers decide the price of attributes and the type of properties to supply.

The cost to the supplier of supplying a property with characteristics z, can be expressed as C (z; μ), where μ stands for factors prices.

The maximized profit of supplier is

$$\text{Max}\ \pi = \text{P(z)} - \text{C (z; }\mu)$$

The offer function, ∅ (z; π, μ) is defined as the market price that would be required in order to realize the profit π for different levels of z. Then the optimal condition for suppliers is

$$\emptyset\ (z^*, \pi^*, \mu) = \text{P}\ (z^*)$$

$$\text{and } \emptyset_i(z^*, \pi^*, \mu) = p_i(z^*)$$

However, in the property market, there are two types of supplier, one is the real estate agency; another is household suppliers. The former is more professional with continuous activities; the latter is more private, more like a one-time action. The way of obtain the properties and their propose of use is different, which leads to different kinds of cost.

As a non-professional supplier, to resell the property, household need to consider the price paid for the property when first purchased. Assuming a household purchased a property at the period of t_0 with the initial purchase price of the property, p_0, and sell it at the period of t, then during t-t_0 period of time, the household has already paid $p_0 \frac{(t-t_0)}{n}$ to the former owner. After selling the house, the household still needs to pay $p_0 - p_0 \frac{(t-t_0)}{n}$ for the property. During this process, it generates a cost related to interest on money borrowed, c (z; t-t_0 , i, p_0), where i represents lending interest rate.

The cost of household suppliers the sum of all three parts, which equals to

$$p_0 + c\ (z;\ t\text{-}t_0\ , r, p_0)$$

In this case, household suppliers would offer a selling price, which is higher than the total cost, to maximize their profit.

As a result, the equation of maximization the profit of household suppliers is,

$$\text{Max } \pi_{it} = P(z) - [p_0 + c\ (z;\ t\text{-}t_0\ , r, p_0)]$$

Which can also be expressed as

$$\text{Max } \pi_{it} = P(z) - C\ (z;\ r, p_0)$$

As to professional suppliers, the production quantity and type of products differ from supplier to supplier. During a recession that depressed the housing market and resulted in a relatively low price for housing attributes, suppliers will consider to reduce the production of properties; during a property market boom when the price of housing attributes is relatively high, suppliers will increase the quantity of production. According to market research, real estate agency need to know well consumers' tastes of house attributes to produce or to purchase properties.

Generally, real estate agent obtain their product via two methods. They either construct new properties, or purchase from other house owners, which generate the construction cost or the cost of the money that they pay for the properties. Here, the construction cost is considered as a type of initial price. Therefore, p_0 here stands for both construction cost and initial price. Another part of the cost is related to interest on money borrowed. Therefore, the cost of real estate agency of supplying a property with characteristics z is given by the cost function:

$$c\ (z_1, z_2 \ldots\ z_k, p_0, \text{c (r)})$$

This cost function is the result of minimization problem in which the suppliers attempts to find the cheapest cost means by which to produce a property with characteristics z.

The maximization of the profit that real estate agency derives from selling a property with characteristics z will be determined by the price the suppliers offer for such a property in the market:

$$\text{Max } \pi = P(z) - C\ (z_1, z_2 \ldots\ z_k, p_0, r)$$

Therefore, the equation standing for the profit of individual suppliers and real estate agent can be expressed in the same form. The determination of the supply for property market is clear, which includes housing attributes, z_i, the construction cost and the initial purchase price of the property, p_0, and lending interest rate. Regarding different suppliers have different cost and offer properties with different bundles of attributes, the characteristics of suppliers may also be a factor that can influent the housing price. The socioeconomic characteristics of suppliers, s_j, is added in to the offer function. Hence the offer function of suppliers should be ,

$$\emptyset\ (z_1, z_2 \ldots\ z_k, s_j, p_0, r)$$

Equilibrium

So far the consumers' decision and the suppliers' decision in the property market have been examined independently. Households define their optimal residential location by choosing a property with a set of attributes that can maximize their profits. Simultaneously, suppliers offer commodities with a set of attributes, the price of which can maximize their profits and still be compatible with market prices.

In the situation of market equilibrium, the bid curve of households and the offer curve of suppliers are tangent to the same point along the hedonic price function. At this point, the price that households are willing to pay for a given set of attributes to maximize their utilities is equal to the price that suppliers offer to maximize their profits.

Therefore, the final equation of this model is

$$P_{l,t} = \mathrm{F}\ (z_1, z_2 \ldots\ z_k, , \alpha_i, d_i, s_j, p_0,\ \mathrm{r},)$$

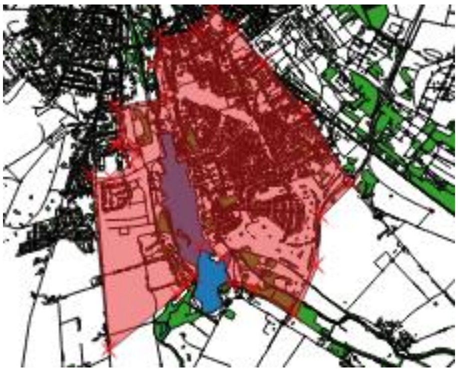
Which can be read as the price of a property in location l at period t determined by the housing attributes and external housing characteristics, a set of vector of the characteristics of consumers and suppliers, the initial price of the house and lending interest rate.

This research is to reveal the impact of green space on real estate price. According to the deduction above, the estimation process proceeds in three stages. The first stage in estimation the model is to determine the marginal prices associated with the proximity to green space without the other factors. The second stage is to examine the impact on the price of properties drawn from each chosen set of characteristics, including a set of housing attributes, a set of the socioeconomic characteristics of households and that of suppliers. In the final stage, cross-section data on observed transactions are used in estimation regression relationship between marginal prices and all the factors being examined in the first two stage.

Data

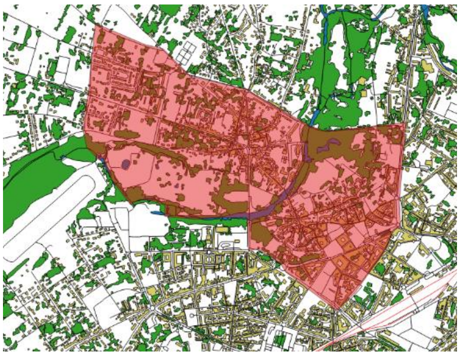
The French notarial office provides a database called PERVAL. PERVAL is a public limited company 100% owned by the French notarial office. The objective is to create a notarized real estate reference database of France. PERVAL data is not completely available to the public, but enough of it is available for a thorough analysis of real estate transactions. The information is identified with the coordinates (X, Y) of the geographic address of each property. The data is available with reference to the community division in IRIS, including 2000 inhabitants in a given geographical area from 2003 to 2013.

The database is taken from the French notarial office and the INSEE (the French National Institute for Statistic and Economics Studies), which has information on the properties (apartments or houses) and the six nearest green spaces (parks and/or gardens) in six cities in the *Centre* region of France. Each of these six cities has been identified in IRIS, and contains a buffer zone of 500 meters around the urban green spaces. These six green spaces and the buffer zones are the areas marked in red in figure 1:

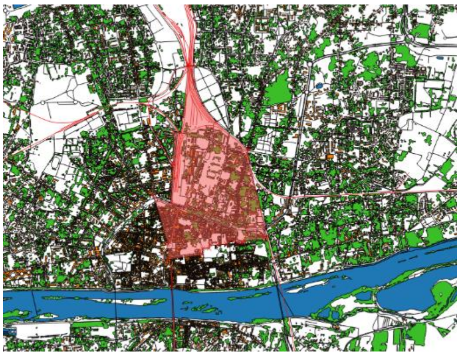


Jardin de Lazenay in Bourges

Parc Central in Chartres

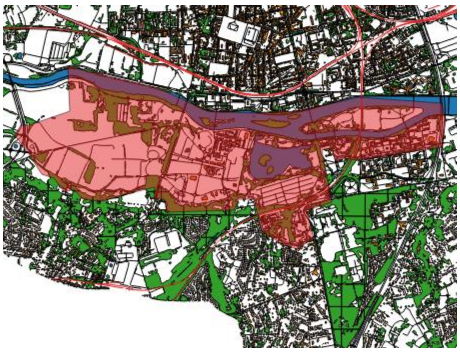


Prairie Saint-Gildas in Châteauroux



Jardins Familiaux de la Bergeonnerie in Tours

Parc de l'Arrou in Blois



Parc Pasteur in Orléans

The goal is to study the impact of green space on property price. In this study, the distance from every property to every green space has been measured by Quam Geographical Information System (Q-GIS), then the smallest value for each distance measured is kept in the database. For example, the distance from House A in Tours to

Park B in Tours is X1. House A's distance to Park C in Blois is X2. If X1 is bigger than X2, then X1 is removed, leaving X2 in the database.

Table 1 Description of variables and summary statistics

Variable	Mean	Std. Dev.	defination
lprix_m2	7.282218	.4229643	the logarithm of the price of the property per square meter in euro
lndistance	6.380082	.7134758	the logarithm of the distance from properties to the nearest green space
int_rate	3.455998	1.243701	the average rate of interest charged on loans by commercial banks
year	2008.88	2.962051	dummy variables defined according to the year to which each observation belongs
18	.4386339	.4963524	dummy variable equal to 1 if city is Bourges
28	.2134472	.4098501	dummy variable equal to 1 if city is Chartres
36	.13127	.3377856	dummy variable equal to 1 if city is Châteauroux
37	.0106724	.1027818	dummy variable equal to 1 if city is Tours
41	.1141942	.3181319	dummy variable equal to 1 if city is Blois
45	.0917823	.2887954	dummy variable equal to 1 if city is Orléans
characteristics of suppliers (dummy variables)			
d_en	.0469584	.2116062	business, real estate agent
d_pa	.86873	.3377856	individue
d_qual_atr	.0597652	.2371146	government institutions
d_hin	.1571906	.3640819	high income group, e.g supervisor or chief executive officier
d_min	.1270903	.333167	middle income group, e.g dealer, professeur
d_lin	.5373467	.4987423	low income group, e.g employee, worker
characteristics of consumers (dummy variables)			
d_en_a	.054429	.2269229	business, real estate agency
d_pa_a	.9082177	.2887954	individue
d_qual_atr_a	.0138741	.1169995	government institutions
d_hin_a	.1571906	.3640819	high income group, e.g supervisor or chief executive officier
d_min_a	.1270903	.333167	middle income group, e.g dealer, professeur
d_lin_a	.5373467	.4987423	low income group, e.g employee, worker
characteristics of properties			
nbr_pieces	5.20064	1.828843	number of rooms
nbr_parkings	1.096939	3.543986	number of garages
nbr_niveau	1.852721	.7563051	number of storeies
lmnt_mutprec_euro	11.30029	.9193878	the logarithms of the price paid for the property when first purchased or constructed
age	10.22965	10.68563	the age of properties

Table 1 presents the description of variables and summary statistics. The first variable is the dependent variable. The second is the distance from properties to the nearest green space. The shapes of green spaces are different, some of them are rectangle (Figure 1). Therefore, the distance in this research is not the distance from properties to the center of the green spaces but to the closest edge of a given green space.

The distance variable is intended to capture the effect of the proximity to amenities on housing prices. Previous studies proved the distance to forests can affect the residential choice. Applying hedonic pricing method, Tyrvainen and Miettinen (2000) found that house prices decrease with the distance between the house and a forest in Finland. Negative distance effect was expected for the amenities since shorter distance means more convenience.

In fact, the distance variable is not a perfect measurement of this effect. It lacks the information of the distance to the nearest medical centers, schools, railroads, and so on. Therefore, the effect of these factors cannot be excluded. Limited by the database, this paper will focus on the proximity to green spaces.

Suppliers with different socioeconomic characteristics may offer different housing price levels and different costs. For instance, the cost of a private supplier depends mainly on the initial price paid for the property, but the cost of real estate agents not only depends on the initial price, more often than not it also depends on construction costs. In this paper, construction costs are considered as initial price for real estate agents in the database.

The socioeconomic characteristics of consumers has an important influence on the residential location choice. The propensity of different consumers to consume is not equal. People with higher incomes have less limitations when purchasing property.

To examine the effects of green spaces on housing price, variables relating to structural characteristics were included in the regressions, such as the number of rooms, number of garages, age of the property and price paid for the property when first purchased or constructed. This type of information is necessary to explain differences in price attributable to the structural characteristics, as opposed to those which are the result of amenities and socio-economic characteristics of consumers and suppliers.

Estimation results

To reveal the impact of urban green spaces on the property transaction market, the regression analysis is used as a statistical tool. The housing price is regressed against sets of explanatory variables. The results of regression analysis are used to derive a hedonic price function that indicates how much the housing price will change for a small change in each characteristic, holding all the other characteristics constant. The hedonic price function can be used to determine how much more must be paid for a property with an extra unit of particular characteristics.

In this paper, seven model are established based on the deduction in section 3. Model 1 is a simple model in which only lending interest rate, the log of distance and year dummy variables are included as explanatory variables. To estimate the impact of socioeconomic characteristics of suppliers and consumers, a set of socioeconomic characteristics of suppliers listed in table 1 is introduced in model 2 and model 3 incorporates a set of socioeconomic characteristics of consumers into model 1. Model 4 contains both the characteristics of suppliers and that of consumers. The comparison between model 4 and model 1 reveals the influence of supplier and consumer on the property price without the property attributes. To examine the influence of the property characteristics, a set of house attributes are introduced in model 5. Model 6 repeats the analysis of model 5 but excludes the variable referring to the age of property. Model 7 including all the explanatory variables used in model 4 and model 6.

Figure 2 distribution of logarithms of property price by city

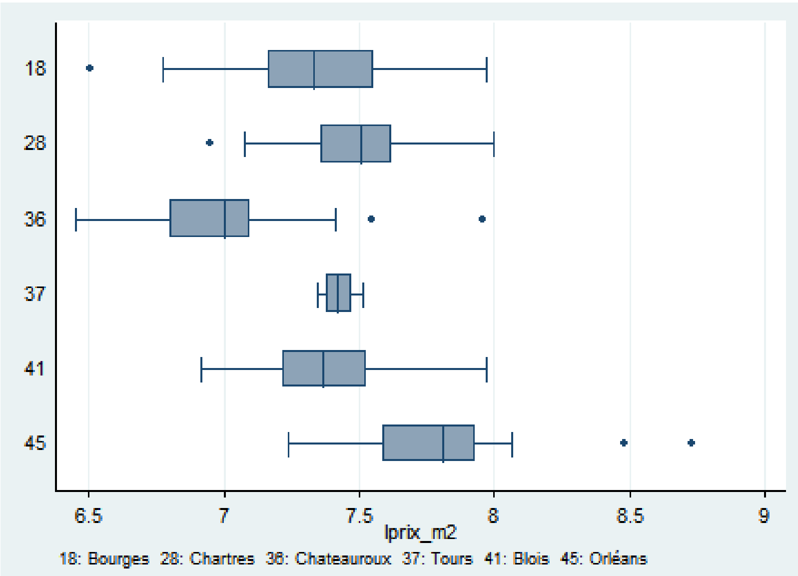


Figure 2 describes the distribution of transaction price per square meter logarithms in the property market in six different cities for the year 2008. The median value of the price in Orléans is higher than the others, which equals to 0.89 (log7.8). The price level of a quarter of all the properties sold in Orléans was less than 0.88(log7.6), which was already higher than that of 75% of properties sold in the other five cities. 25% of the properties in Orléans were sold at the log price between 0.9 (log7.9) and 0.91(log8.1). Meaning that the housing price level in Orléans was the highest among the six cites. The price level of properties between Bourgers and Blois is quiet similar. The properties in Tours and in Chartres are a bit more expensive. The median value of the price in Châteauroux was the lowest, which was only 0.85 (log7). It was much cheaper than the housing price in the other five cities. The lowest housing price in Orléans was still higher than that of over 75% of properties in Châteauroux. The housing price level in Tours was the most interesting, the range of which varied from about 0.86 (log7.3) to 0.88 (log 7.52). One deduction drawn from figure 1 is that the effect of green space on housing price in Tours is quiet small.

As mentioned before, the distance value kept in the database is the smallest value. Therefore, it's possible that the property and the nearest green space to it do not belong to the same city. Hence, given the fact that the series of dummy variables of a given city may reduce the variability of data, this series is excluded from all the regressions.

Table 2 presents the ordinary least squares regressions (OLS) estimates for six specified hedonic price models in which the dependent variable is the natural logarithm of the transaction price in the property market, and the explanatory variables include a range of attributes of house and a set of socioeconomic characteristics of suppliers and consumers respectively. The data is taken from the French notarial office database and the INSEE database, as explained in section 3. The table reports coefficients and t statistic values.

Table 2 regression results

	(1) lprix_m2	(2) lprix_m2	(3) lprix_m2	(4) lprix_m2	(5) lprix_m2	(6) lprix_m2	(7) lprix_m2
int_rate	0.0236 (0.82)	0.0275 (0.95)	0.0281 (0.97)	0.0285 (0.98)	0.0294 (0.79)	0.0307 (0.77)	0.0272 (0.65)
lndistance	- 0.0353**	-0.0266*	-0.0217	-0.0237	-0.0197	- 0.0493**	-0.0434*

	(-2.65)	(-1.96)	(-1.60)	(-1.75)	(-1.23)	(-2.98)	(-2.54)
2003.year	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)
2004.year	0.152**	0.134**	0.133**	0.133*	0.176	0.152	0.141
	(2.91)	(2.60)	(2.58)	(2.58)	(1.71)	(1.38)	(1.30)
2005.year	0.370***	0.354***	0.359***	0.353***	0.289**	0.340**	0.327**
	(6.81)	(6.62)	(6.72)	(6.59)	(2.83)	(3.11)	(3.04)
2006.year	0.379***	0.378***	0.377***	0.376***	0.269*	0.305**	0.309**
	(6.22)	(6.29)	(6.26)	(6.25)	(2.57)	(2.73)	(2.79)
2007.year	0.434***	0.411***	0.406***	0.405***	0.380**	0.411**	0.404**
	(5.06)	(4.82)	(4.77)	(4.75)	(2.98)	(3.02)	(2.92)
2008.year	0.463***	0.457***	0.458***	0.456***	0.396**	0.450**	0.454**
	(5.27)	(5.21)	(5.21)	(5.20)	(2.91)	(3.10)	(3.06)
2009.year	0.412***	0.420***	0.419***	0.417***	0.331**	0.423***	0.423***
	(8.80)	(9.11)	(9.10)	(9.03)	(3.30)	(3.95)	(3.99)
2010.year	0.502***	0.491***	0.496***	0.495***	0.397***	0.460***	0.435***
	(10.01)	(9.88)	(9.95)	(9.92)	(3.89)	(4.21)	(4.00)
2011.year	0.456***	0.483***	0.480***	0.486***	0.412***	0.496***	0.496***
	(9.86)	(10.54)	(10.46)	(10.59)	(4.20)	(4.73)	(4.77)
2012.year	0.570***	0.561***	0.572***	0.574***	0.486***	0.597***	0.632***
	(11.03)	(10.32)	(10.48)	(10.52)	(4.70)	(5.44)	(5.59)
2013.year	0.437***	0.438***	0.440***	0.441***	0.353**	0.421***	0.393***
	(7.71)	(7.68)	(7.71)	(7.73)	(3.25)	(3.66)	(3.40)
d_en		-0.193**		0.100			0.0257
		(-2.59)		(1.67)			(0.09)
d_pa		-0.160*		0.107*			-0.154
		(-2.45)		(2.02)			(-0.61)
d_qual_atr		-0.287***					
		(-4.11)					
d_hin		0.190***					
		(4.24)					
d_min		0.0793					
		(1.72)					

d_lin		-0.0156					
		(-0.39)					
d_en_a			-0.269***	-0.344***			-0.157
			(-3.65)	(-4.23)			(-0.55)
d_pa_a			-0.182**	-0.254***			-0.0605
			(-2.90)	(-3.59)			(-0.21)
d_qual_atr_a			-0.297**	-0.375***			-0.374
			(-2.91)	(-3.48)			(-1.19)
d_hin_a			0.236***	0.197***			0.160**
			(7.03)	(4.41)			(3.11)
d_min_a			0.127***	0.0872			0.0907
			(3.61)	(1.90)			(1.71)
d_lin_a			0.0362	-0.00337			0.0605
			(1.35)	(-0.08)			(1.31)
nbr_pieces					-0.0159*	0.0115	0.00689
					(-2.16)	(1.56)	(0.89)
nbr_parkings					0.00295	-0.000815	-0.000801
					(1.25)	(-0.33)	(-0.32)
nbr_niveau					-0.00533	-0.0155	-0.0158
					(-0.34)	(-0.94)	(-0.91)
lmnt_mutprec_euro					0.273***	0.134***	0.128***
					(16.65)	(10.58)	(9.58)
age					0.0154***		
					(10.69)		
_cons	7.016***	7.080***	7.022***	7.040***	3.837***	5.575***	5.786***
	(52.59)	(49.17)	(48.53)	(48.61)	(14.45)	(23.18)	(18.94)
adj. R^2	0.113	0.149	0.148	0.149	0.306	0.198	0.217

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The coefficients present in table 2 report the change in the log prices corresponding to a unit change in explanatory variables. The coefficients of explanatory variables present the implicit price of each attribute. Note that interpretation of the results requires that both the magnitude of the coefficient, and the precision with which it is measured need to be taken into account. A coefficient can be large in magnitude implying potentially large price effects, but be imprecisely measured, and hence statistically insignificantly different from zero. In such cases, there must remain some uncertainty about whether or not the corresponding characteristic is economically important.

The coefficient of the logarithm of distance variables in model 1 reveals that the distance variable is highly significant at the 1% level, it represents quiet large implied economic effects. There are an inverse relation between the distance to the nearest green space and the housing price, meaning the further away an apartment or house is situated to the green space, the lower the price of the property. For example, if the distance value increases by 1%, the property price per square meter decreases by 3.53%.

Comparing the coefficient of the variable lndistance in model 1 with that in the other models, both the significance and the coefficient magnitude are unstable. However, all the coefficients of lndistance remains negative, which reveals the face that the distance from property to the nearest green space has a negative impact on the real estate price.

The coefficient of year dummy variables stands for the time trend for the property price. The 2003 housing price levels are taken as a reference group. Then dummy variables from 2004.year to 2013.year are generated, which represent the comparison of housing price level in each year (from 2004 to 2013) with that of 2003. For example the 2004 housing price level increased by 15.2% on the basis of the 2003 housing price level. All the coefficients of year dummy variables are large and extremely significant. From 2004 to 2008, the property price per square meter increased year by year. However, in 2009, the negative impact of the global financial crisis lead to a fall in housing prices.

The coefficient of lending interest rate is similarly large but not significant. A 1% increase in lending rate is associated with a 2.39% increase in the property price per square meter. This figure can be calculated by applying the transformation exp(0.0236) -1. The low significance of the coefficient of lending rate proves its positive impact on the housing price, but the other factors, such as lndistance and year dummy variables have a greater impact on the real estate price.

A set of socioeconomic characteristics of suppliers is introduced as control variables in model 2. Model 3 incorporates a set of socioeconomic characteristics of consumers as control variables. The value of adjusted R-square in these two models has increased about 3% compared with the value of adjusted R-square in model 1. Almost all the control variables in model 2 and model 3 are statistically significant, meaning that the socioeconomic characteristics of suppliers and consumers are important factors that can affect the transaction price in real estate markets.

The significance and coefficient magnitude of lndistance decreases both in model 2 and in model 3, but the sign of this variable is still negative, which shows an inverse relationship between the distance to green space and the property price per square meter.

There is a high correlation among the income group of suppliers and consumers. As a result, the group of variables of suppliers' income is removed from model 4, so as the variable d_qual_atr. (Table 3)

Comparing the regression result of model 4 with the result of model 3, the value of adjusted R-square increases by 1%. That is to say, the added variables d_en and d_pa are meaningful predictors of the price of property per square meter.

Most control variables in model 3 are highly significant. In model 4, the coefficient magnitude of socioeconomic characteristics has changed a bit, but the statistical significance is almost the same. In model 4, all the coefficient of the variables referring to the socioeconomic characteristics of consumers, except for the middle and low income groups, are surprisingly significant at the 0.1% level. However, the significance of the supplier group decreased, only the coefficient of the individual supplier variable is significant at the 5% level. This reveals that in the real estate market, households' social character and their income can have a greater effect on the property price than that of suppliers.

Model 5 introduces a set of housing attributes. Among these variables, the coefficients of the number of rooms, the initial price of properties and the age of properties are statistically significant.

Supposing two properties with the same characteristics, except one was bought in 1980, another in 2000. The price paid for the former property when first purchased should be lower than the price paid for the latter. That means the older the property is, the lower the price will be. However the coefficient of the variable referring to the age of properties in this model is positive, which fails to confirm the initial expectation, that the age of properties would have a negative impact on the housing price. The reason is the high correlation between the age of properties and the price paid for the property when first purchased. The Pearson correlation coefficient of these two variables is -0.63. For this reason, the age variable is removed in the final model.

To see how the model applying a set of house attributes is changed when the variable referring to the age of properties is excluded, model 6 repeats the analysis of model 5 without the age variable. The result is not the same. The coefficient magnitude and statistical significance are surprisingly different from those derived in model 5 with the age variable.

The variable referring to the distance to the nearest green space is highly significant in the 1% level. Households are willing to pay more for a residence near to a green space than for the properties with the same characteristics but further away from the green space. For a residence situated one meter closer to a defined green space, households would pay a price 4.9% higher.

The comparison of the value of adjusted R-square (0.198) in model 6 with that in model 2 and in model 3 reveals the housing attributes have a far greater impact on the real estate price than the impact of suppliers and consumers.

According to the final hedonic price function deducted in section 2, the attributes of properties and the socioeconomic characteristics of suppliers and consumers are incorporated in model 7. The variability of the housing prices measured by the adjusted R-square is accounted for differently in the estimated models. The first four models and also model 6 explain less than 20% of the variation in housing prices, model 7 accounts for 22%. Model 6 accounts for 31% of the price variance, however, this model contains the age variable which is excluded because of its high correlation with the variable referring to the initial property price. Therefore, model 7 provides the best fit out of all the models.

The coefficient of lending interest rate (0.0272) is greater than that in the other models. The sign of the coefficient of lending rate reveals that the higher lending rate increases, the more expensive the real estate will be. A one unit increase in lending rate is associated with 3.1% increase in the housing price. However, this variable is statistically insignificant, and there is some uncertainty about the price effects.

There is an inverse relation between the property transaction price and the distance to the nearest green space, meaning that with one unit further away from the green pace, the price of property will be 4.3% lower. This result is consistent with previous hedonic studies. Crompton (2001) found that holding other characteristics constant, the properties close to naturalistic parks and open spaces generally were 10 – 20% more expensive than other comparable properties without such amenities. Morancho (2003) found that for every 100m further away from a green space there is a drop of approximately 18000 euros in the total housing price in Castellon, Spain. Dehring and Dunse (2006) presented that with each meter closer to a city park the property price increased by 0.02% in Aberdeen, Scotland.

The series of year dummy variables stays highly significant in all the six models. The coefficient magnitude is smaller than that in model 1, but the trend is quiet similar. The property price level in 2003 is taken as a reference group. The property price has been continuously rising from the 2004 to 2008, and in 2009, the price level became unstable because of the global financial crisis.

The signs of the estimated coefficients for the low, middle, and high income consumer groups are all positive. Considering the fact that many households in this database are living in poverty, it is interesting to note that only the coefficient of the high income group is statistically significant. High income families are much more sensitive to the price of property than the other two income groups. This is reasonable, high income means less limitation in budget. Therefore, households with more possessions are willing to pay more for extra attributes to keep a better quality of life.

The number of rooms has a positive relation with the housing price. Holding all the other characteristic constant, households are willing to pay o.7% more for a property with one more room than for other comparable properties. There is an interesting phenomenon in the real estate market. It's not the properties with more rooms that are more popular. In fact, most of families are more willing to choose a residence with 3 to 4 rooms.

However, the sign of the variable for the number of rooms is positive. This is reasonable. The subject consumer of residences with 3 to 4 rooms are households with low incomes or part of the middle income level households. Properties near a green space are usually more expensive than comparable properties situated further away. Over 59% of the properties in the database have 5 to 8 rooms, which is different from the general situation. As a result, the sign of this variable is positive.

Regarding the partial significance of each variable in model 7, the Student's t-statistic reveals the price paid for the property when first purchased as the variable with the greatest explanatory power. The price paid for the property when first purchased has a positive influence on the property price. According to the hedonic price function, for an individual supplier, a high initial price p_0 means an increase in the cost related to interest on money borrowed, p_0 + C (z; t-t_0 , r, p_0); for a real estate agent, a high initial price means a high price paid for the property when first purchased, or a high construction cost for the property, c (z_1, z_2 ... z_k, p_0, c (r)). Either way, this will increase the suppliers' cost. Since the selling price must be higher than the cost to insure suppliers' profits, the property with a higher initial price will be sold at a higher price than comparable properties with the same characteristics but with a lower initial price.

Conclusion

This paper first demonstrates the importance of incorporating the socioeconomic characteristics of consumers and suppliers and the attributes of house in hedonic price model when assessing the impact of green space on property price. As shown in the result section, the attributes of house have a far greater impact on the housing price than the socioeconomic characteristics of households and suppliers. The comparison between the effect of households and the effect of suppliers reveals that households' characteristics are more significant than that of suppliers.

Then, all these relevant variables are synthesized in the hedonic price model. The analysis shows significant price effects of distance, consumers' characteristics and initial price of properties. However, the influence of initial price of properties on prices is significantly higher than the influence of proximity to green space on housing price and the influence of household income level. The socioeconomic characteristics of suppliers may impact the housing price, but the influence is not strong.

According to the analysis, the proximity to green space, such as parks and gardens, positively impact the transaction price in real estate market. Holding all the other characteristics constant, households are willing to pay for the property situated near to a defined green space with a price of 4.3% higher than for a comparable property. People with different income levels have different impact on transaction price in real estate market. The analysis result shows households with high income level are more sensitive to property price than households with middle and low income level. Regarding the partial significance of each variable in model 7, the Student's t-statistic reveals the price paid for the property when first purchased as the variable with the greatest explanatory power and provides a positive influence on the property price.

This research estimates residential property value premium from proximity to green space. The research on this topic will be important in policy debates over the public versus private value of green space in the future. With the application of the hedonic price method, the economic values for ecosystem or environmental services has been demonstrated. However, there are a number of limitations in design and data availability.

The property price is relevant to property characteristics, neighborhood characteristics such as property taxes and crime rat, accessibility characteristics such as distance to work or shopping center, environmental characteristics such as air quality. The data applied in this research doesn't contain any information concerning neighborhood characteristics nor accessibility characteristics. It is important to include all relevant factors in regression models for control variable based research. Data limitations prevents the model from improving explanatory power. In addition, many of the variables are likely to be correlated, so that their values change in similar ways. This can lead to understating the significance of some variables in the analysis. This estimation of the impact of urban green space on real estate price may be biased by data limitation problem. Future research should incorporate more precise data on urban green space in order to provide more specific information on the economic value of urban green space.

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Table 3 Pearson’s correlations coefficient

	lmnt_m~o	**age**	**d_pa**	**d_en**	**d_qual~r**	**d_hin**	**d_min**
lmnt_mutpr~o	1.0000						
age	-0.6301	1.0000					
d_pa	-0.0028	0.0256	1.0000				
d_en	-0.0180	-0.0162	-0.8289	1.0000			
d_qual_atr	.	.	.	.	.		
d_hin	0.1970	-0.1221	0.0767	-0.0636	.	1.0000	
d_min	0.1184	-0.0900	0.0288	-0.0527	.	-0.1977	1.0000
d_lin	-0.2627	0.1766	0.1375	-0.1546	.	-0.5801	-0.4807
d_pa_a	0.1260	-0.1051	0.3708	-0.2393	.	0.1023	0.0128
d_en_a	-0.1068	0.1172	-0.2784	0.2842	.	-0.0775	-0.0052
d_qual_atr_a	-0.0789	0.0169	0.0180	-0.0149	.	-0.0560	-0.0464
d_hin_a	0.1970	-0.1221	0.0767	-0.0636	.	1.0000	-0.1977
d_min_a	0.1184	-0.0900	0.0288	-0.0527	.	-0.1977	1.0000
d_lin_a	-0.2627	0.1766	0.1375	-0.1546	.	-0.5801	-0.4807

	d_lin	**d_pa_a**	**d_en_a**	**d_qual~a**	**d_hin_a**	**d_min_a**	**d_lin_a**
d_lin	1.0000						
d_pa_a	-0.0229	1.0000					
d_en_a	0.0073	-0.8575	1.0000				
d_qual_atr_a	0.0633	-0.4052	-0.0278	1.0000			
d_hin_a	-0.5801	0.1023	-0.0775	-0.0560	1.0000		
d_min_a	-0.4807	0.0128	-0.0052	-0.0464	-0.1977	1.0000	
d_lin_a	1.0000	-0.0229	0.0073	0.0633	-0.5801	-0.4807	1.0000