HEDONIC VALUATION OF MARGINAL WILLINGNESS TO PAY FOR AIR QUALITY IMPROVEMENT

Endah Saptutyningsih
Universitas Muhammadiyah Yogyakarta
end_naufal@yahoo.com

Agus Tri Basuki
Universitas Muhammadiyah Yogyakarta

Abstract

This study aims to identify the highest air pollution areas and to estimate household marginal willingness to pay for air quality improvement. The result of Kriging technique indicates that six sub districts in Yogyakarta City and one sub district in Gunungkidul have highest concentration of particle pollution (PM10). The result of hedonic price method conclude that by adopting a two-stage estimation procedure an 1% increase in the level of PM10 reduced property prices in the study area by 0.32%. Marginal implicit price for reducing PM10 is Rp 957,900.00. The households are willing to pay an additional amount of 1.34 percent for a reduction in PM10 by 1%.

Keywords: Air pollution, marginal willingness to pay, hedonic price, implicit price
JEL classificationn umbers: D12, Q53

Abstrak

Penelitian ini bertujuan mengidentifikasi daerah polusi udara tertinggi dan untuk memperkirakan kesediaan marginal rumah tangga untuk membayar untuk perbaikan kualitas udara. Dengan menggunakan teknik Kriging, hasil penelitian menunjukkan bahwa enam kecamatan di Kota Yogyakarta dan satu kecamatan di Gunungkidul memiliki konsentrasi tertinggi partikel polusi (PM10). Sementara itu, dengan metode harga hedonik yang mengadopsi prosedur dua tahap, paper ini menyimpulkan bahwa setiap peningkatan PM10 sebesar 1% akan menurunkan harga properti di daerah penelitian sebesar 0.32 persen. Harga implisit marjinal untuk mengurangi PM10 adalah Rp 957,900. Rumah tangga bersedia membayar tambahan 1,34 persen untuk pengurangan PM10 sebesar 1%.

Kata kunci: Polusi udara, keinginan membayar marjinal, harga hedonik, SIG, harga implisit
JEL classificationn umbers: D12, Q53

INTRODUCTION

The increase in per capita income, which has been evidenced in Indonesia in the last few decades, is one of the achievements of Indonesia as a society. This has, as a result, increased the demand for various goods and services, including motor vehicles as means of transportation.

The demand for motor vehicle has been so massive that the urban air pollution caused by it has become serious health problems due to the effects on morbidity and mortality and also the loss of environmental comfort due to visibility reduction. Therefore, loss assessment caused by air pollution is important in assessing the costs to overcome the pollution.

Various types of transportation equipments, especially motor vehicle, every day thronged the streets in cities as centres of economic activities (central business district). This phenomenon also occurred in Yogyakarta Special Territory (YST) where there are many centres of commerce and education that support the local economy. The pollution problems arise due to the increasing number of motor vehicles which is much more than that can be supported by the highway capacity. This has caused congestion, noise and air pollution.

The number of vehicles in the YST has been increasing in the last couple of decades. From 2000 to 2010, the number of motor vehicles has increased, on average, by 9.02 percent per year. It is therefore necessary to map the region for identifying the areas that need to be prioritized for reducing levels of air pollution.

The largest number of vehicles in 2010 was in Sleman District, namely 493,800 units, followed by the city of Yogyakarta as many as 367,957 units. Motor cycles dominate the streets of the five districts/cities in YST. Motorcycles comprise 87.75% of all vehicles in YST. Sleman District has the highest number of vehicles in YST, with motor cycle as much as 87.4% of all vehicle types. In addition, motorcycle is 83.9% of all types of vehicles in the city of Yogyakarta.

Residential property prices have increasingly been influenced by the quality of air and its deterioration. In most of industrial cities in the world, consumers express their strong preferences for environmental amenities such as improved air quality and are even willing to pay for such improvements. Consumer's willingness to pay (WTP) in turn has been influenced by structural characteristics like size of plot, number of rooms, garage space, central heating; public and socioeconomic characteristics like social security, quality of schools, racial composition, rate of employment; and local amenities like environmental quality, access to services, communication (Baby, 2003). Although these factors influence the choices of consumers, the primary concern of this inquiry is to unearth how the quality of air influences property values.

The Hedonic Pricing Method is a revealed preference method of valuation. The surrogate market is used in the hedonic price method of environmental valuation for placing a value on environmental quality (Gundimeda and Kathuria, 2004). Economic theory argues that in certain circumstances, it is possible to separate the effects of various attributes of a good in ways by which they influence individual's utility. For many environmental goods, it is often possible for individuals to choose levels of consumption through their choices. For instance, in a decision to buy a home, there is an implicit market for environmental quality. The demand for non market environmental goods such as air quality influences observed prices and consumption of other market goods. The most commonly applied model to quantify this relationship is the hedonic price model of environmental valuation.

Some studies used hedonic price to analyze the property values. There is a positive relationship between marginal WTP and the income and education (Murty et al., 2003). Moaz (2005) found that pollution levels reduce property values.The average MWTP for any decrease in the concentration of TSP is USD 60. Other studies concluded that households would be paid for each one unit reduction in PM10 concentrations had a median of USD 149 to USD185 (Bayer et al., 2006).

Table 1: Number of Vehicles in Yogyakarta Special Territory, 2010

Regencies	Type				
	Car Passengers	Car Freight	Bus	Motorcycle	Total
1. Kulonprogo	4,134	3,122	533	89,626	97,415
2. Bantul	12,311	9,720	8,112	286,023	316,166
3. Gunungkidul	5,153	4,864	902	103,883	114,800
4. Sleman	42,102	11,771	8,347	431,580	493,800
5. Yogyakarta	36,551	14,706	7,944	308,756	367,957
Total	100,251	44,183	25,837	1,219,867	1,390,138

Source: Kantor Ditlantas Polda Provinsi D.I. Yogyakarta

Measuring the exposure to air pollution requires simplifications and assumptions. The size of ambient pollution is taken in a small number of stations and rarely recorded continuously and even more fickle urban population. Therefore, the assumption must be made to estimate personal exposure. There is a variety of pollutants from time to time and space because of such factors as the source of meteorology, topography and emission. Gauges are changed from time to time depending on its cities, and have little reliability. Therefore it is necessary to assume the data to a single point representing a wide geographical area.

More recently, an understanding of the complex urban air quality has been supported by applying urban air shed model. This model calculates the spatial and temporal variations and differences in the reactivity of air pollutants that can provide detailed spatial picture of pollutant levels. When combined with GIS techniques, this model can improve the measurement of exposure in relation to health (Hoek et al., 2001).

The development of spatial data management within the framework of geographic information systems (GIS) has created a new era of environmental modelling. More powerful computers have made the air quality model run at the global and local spatial scale as possible. In order to understand the function of more complex models, modelling system should be composed of other subsystems (point and area sources of pollution, the description of the spatial height of the area, meteorological data and air quality monitoring network).

More recently, the use of GIS has become essential in providing the boundary with air quality models. Many models have been combined with GIS to simulate various environmental processes. Data are stored and visualized in a GIS environment, and descriptive and exploratory techniques may raise questions and suggest theories about phenomena of interest. These theories may be subjected to traditional statistical testing using spatial statistical techniques. Spatial analysis is an especially dynamic multidimensional area not only because of ongoing methodological and theoretical advances but also because of the extent to which the field responds to developments in technology which can provide spatial information (O'Connor et al., 2005) and emergence of new research challenges such as those associated with concerns over environmental, socio-economic, and global change (Verburg et al., 2004; Chu et al., 2009).

By GIS, Cowell and Zeng (2003) found that integrated uncertainty theories with GIS for modelling areas vulnerable to climate change.

Based on the above background, this study will identify areas with the highest air pollution in YST by using Geographic Information System (GIS) approach. It is expected to estimate the benefits to local households to reduce air pollution in the district/city in YST. Total benefits consisting of health benefits, and the benefit of the environmental ease of reducing urban air pollution can be estimated using the model of hedonic property value model. Table 2 presents some summary of related research studies will be conducted.

The purpose of this study is: a) to identify the highest level of air pollution (especially PM10) in YST; b) to estimate household marginal willingness to pay for air quality improvement in the area

METHODS

Hedonic price technique is a method for estimating the welfare effects of environmental assets and services by estimating the influences of environmental attributes on property value. The hedonic price theory assumes that as environmental quality changes, property prices would also change, indicating a scope for estimating an implicit demand function for the environmental goods by observing the property price variations. Therefore, hedonic prices are defined as the implicit prices of the attributes and are revealed to economic agents from observed prices of differentiated products and the specific amounts of characteristics associated with them.

Following the general principles of consumer's behavioural theories, decisions in property markets are governed by demand supply interactions. The basic hedonic property model can be explained as follows Let the price of i^{th} residential location (PPRICE) be:

$$PPRICE_i = PPRICE\ (S_i, N_i, E_i) \quad (1)$$

Where S_i is structural characteristics, N_i is neighbourhood characteristics, and E_i is environmental characteristics.

Consider the utility function of the individual who occupies house *i* as

$$U = u\ (X, S_i, N_i, E_i) \quad (2)$$

where *X* represents composite private good that is taken as a numeraire. Assume that preferences are weakly separable in housing and its characteristics. The individual maximizes (2) subject to the budget constraint,

$$M = X + PPRICE \quad (3)$$

the first order condition for choice of environmental amenity *qj* is given as,

$$\frac{\partial u / \partial qi}{\partial u / \partial x} = \frac{\partial PPRICEi}{\partial qj} \quad (4)$$

The partial derivative of (1) with respect to one of the environmental quality characteristics *qj*, (air quality), give the implicit marginal price of that characteristics.

In the second stage, MWTP for environmental quality is expressed as a function of *qj*, given S_i, N_i, E_i* and W_i, where E_i* is the vector of other environmental characteristics and W_i is socioeconomic characteristics.

$$b_{ij} = b_{ij}\ (q_j, E_i^*, S_i, N_i, W_i) \quad (5)$$

Equation (5) gives the individual's MWTP for the improvement in environmental quality *qj*.

Model Estimation

The estimation of the Hedonic Model is undertaken in two stages. In the first stage, the hedonic property price function is estimated and the implicit prices are computed for all the observations. In the second stage, implicit demand function or the marginal willingness to pay function is derived from the hedonic price function for given sets of environmental characteristics. The procedure is explained as follows.

The hedonic price function relates price of residential property to the structural, neighbourhood and environmental characteristics of the property (Murty and Kumar, 2002)[1] and is estimated using a simple least square regression model. Following this general specification and refining it by dropping insignificant variables, the hedonic price function is estimated as follows.

$$ln\ PPRICE = a_0 + a_1\ ln\ LANDSIZE + a_2\ ln\ BUILDSIZE + a_3\ ln\ DISHPITAL + a_4\ ln\ DISSPMARKET + a_5\ ln\ DISREST + a_6\ ln\ DISMSTREET + a_7\ GARDENDUM + a_8\ ln\ PM10 + e \quad (6)$$

where *ln PPRICE*is natural log of property price, *ln LANDSIZE is* natural log of plot area, *ln BUILDSIZE is* natural log of building area, *ln DISHPITAL is* natural log of

[1] The model is specified as follows:
$LnPh_i = \beta_0 + \Sigma\beta_j S_{ji} + \Sigma\beta_k Q_{ki} + \Sigma\beta_l N_{li} + \varepsilon_I$,
where,
i is 1,2,…,n
S_i is structural characteristics
N_i is neighborhood characteristics
Q_i is environmental characteristics
From the above hedonic price function, implicit price(s) of environmental characteristic(s) is calculated. First partial derivative of the hedonic price function with respect to environment quality provides the implicit price.

distance from hospital, *ln DISSPMARKET is* natural log of distance from supermarket, *ln DISREST is* natural log of distance from restaurant, *ln DISMSTREET is* natural log of distance from mainstreet, *ln PM10 is* natural log of PM10, and *GARDENDUM* is dummy variable for there is or no garden near house.

The partial derivative of this function with respect to air quality gives its implicit marginal price. This price is the additional amount which the household would be willing to pay for choosing a house with reduced amounts of air pollution, other things remains the same. The marginal implicit price is estimated as follows:

$$implicitpricePM10 = PPRICE.\left(\frac{1}{PM10}\right) a8 \quad (7)$$

Estimated implicit prices for different sites correspond to the individual willingness to pay (WTP) for a marginal unit of environmental good purchased. The individual chooses the level of characteristic at which their Marginal Willingness To Pay (MWTP) for that characteristic is equal to its implicit marginal price. The inverse demand function is then obtained by regressing implicit price as a function of air quality, PM10, and other socio economic features of individuals along with a demand shift variable, such as income. The regression equation for inverse demand function in general is:

$$lnIMPPRICE = b_0 + b_1 Y + \Sigma b_2 sosec + \Sigma b_3 struc + \Sigma b_4 neigh + \Sigma b_5 env + u \quad (8)$$

where *Y* is the annual income of the household, *sosec* is the social economic characteristics, *struc* is the structural characteristics, *neigh* is neighbourhood characteristics, and *env* is environmental characteristics.

However, if some or many of structural characteristics are not significant, these factors could be neglected while specifying the relation. Therefore, after omitting the insignificant variables through a trial-and-error method, the implicit price function considered for final estimation is:

$$lnIMPPRICE = b_0 + b_1 INCOMEDUM + b_2 \ln LANDSIZE + b_3 \ln BUILDSIZE + b_4 \ln DISHPITAL + b_5 DISSPMARKET + b_6 \ln DISREST + b_7 \ln DISMSTREET + b_8 GARDENDUM + b_9 lnPM10 + \varepsilon \quad (9)$$

where *ln IMPPRICE* is natural log of implicit price; *INCOMEDUM* is level of income.

RESULTS DISCUSSION

The results of mapping with GIS methods conclude that the area which have the highest concentration of PM10 in the city of Yogyakarta are Mantrijeron, Kraton, Gondomanan, Ngampilan, Gedongtengen, and Danurejan sub-districts. In addition, some subdistricts such as Wirobrajan, Mergangsan, Pakualaman, Jetis and Gondokusuman also have relative high concentrations of PM10. In Gunung Kidul districts, Karangmojo, there are also relatively high PM10 concentrations in some areas.

In order to estimate a hedonic price function, it is necessary to gather data on all characteristics that are relevant to the sale prices of the house. The explained variable, price of house, is considered as a function of environmental, structural, and neighbourhood variables and these data sets relate to the residential areas of mapping results by the above GIS. Data from 250 households are collected using a structured questionnaire.

Table 2 shows that the average house price is 300 million rupiahs. The area of house is one of the important variables affecting house prices. The average area of land is 206.5 square meters. The average area of building is 124.28 square meters. Another factor which influences residential property price is the number of rooms that a house has. The average number of rooms observed for houses in the study area is four.

Table 2: Description and Statistic Summary of Variables

Variable	Description	Mean	Stand.Deviation
PPRICE	Sales price of house(Rupiahs)	3E+008	243,617,628.2
LANDSIZE	Plot area (m^2)	206.05	198.288
BUILDSIZE	Building area (m^2)	124.28	111.246
NUMROOM	Number of rooms (units)	4.00	4.614
WSTRUCTDUM	Dummy structure of wall	1.15	0.497
DISSCHOOL	Distance from school (m)	512.94	555.328
DISHPITAL	Distance from hospital (m)	956.26	802.810
DISSPMARKET	Distance from supermarket (m)	990.68	867.411
DISREST	Distance from restaurant (m)	642.64	785.568
DISCITY	Distance from city (m)	2,062.04	1,592.980
DISMSTREET	Distance from main street (m)	192.01	165.511
GARDENDUM	Dummy for close to garden or not	1.79	0.407
INCOMEDUM	Dummy for level of income	1.88	0.509
FAMEMBER	Number of family members (people)	3.92	1.356
PM10	Concentration of PM10 (ppm)	1,223.12	39.612

Among the neighbourhood variables, six major ones namely distance from school, distance from hospital, distance from supermarket, distance from restaurant, distance from the city, distance from main street, are also considered for this analysis. The distance calculated is that from the residence of the household to the nearest location related. The average distance from school is 512.94 meters. The distance from the nearest hospital is 956.26 meters on average. The average distance from main-street is 192 meters. One of the ‘socioeconomic variables’ is the number of family member. The average number of family member is four people. In the hedonic price model that we adopt in this study, the concentration of PM10 is taken as a measure of air quality. The data used comes from ambient air quality monitoring of Badan Lingkungan Hidup of YST. Ambient air quality for the year 2010 is 1,223.12 ppm on average.

In the estimation of hedonic price equation, we assume a negative relationship between environmental characteristic PM10 and the property price, and that the presence of garden near the house is assumed to have a positive influence. All the structural parameters included in the model, like plot area and building area, are expected to have positive relations with the property price. Neighbourhood characteristics like distance from hospital and restaurant are inversely related with property price. It is normally expected that as distance from hospital increases, property price decrease, where as distance from main-street increases property price also increases. Applying these assumptions on the model specified above, the parameters are estimated using the method of ordinary least squares and is given in table 3 below.

The main inferences of this analysis are given as follows. (1) All the neighbourhood and structural characteristics except wall structure, number of rooms, distance from school and distance from city are statistically significant at 5 percent level of significance. (2) The environmental characteristic, PM10, is negatively related to house price and it significant at 1 percent level. The results also confirm that as the level PM10 increases by one percent house price reduces by 0.32 percent on the average. (3) Among the neighbourhood characteristics, the presence of garden positively related to property price. (4) Distance from hospital or restaurant are negatively related to house price, showing that the plots nearer the hospital or restaurant have high property values. (6) Distance from supermarket or main-street are positively related, showing that when distance increases, property price also increases. (7) The plot area and building area are also positively related to property price.

Table 3: Regression Result of Hedonic Price Function

Variable	Full Model	Fit Model
(Constant)	17.181 (17.689)***	17.210 (20.064)***
LnLANDSIZE	0.397 (4.381)***	0.396 (4.432)***
LnBUILDSIZE	0.353 (3.404)***	0.393 (3.915)***
LnNUMROOM	0.116 (1.121)	-
WSTRUCTDUM	-0.081 (-1.012)	-
LnDISSCHOOL	-0.046 (-0.895)	-
LnDISHPITAL	-0.163 (-2.936)***	-0.160 (-3.115)***
LnDISSPMARKET	0.103 (1.918)*	0.103 (1.975)**
LnDISREST	-0.155 (-3.606)***	-0.160 (-3.999)***
LnDISCITY	0.039 (0.680)	-
LnDISMSTREET	0.091 (3.089)***	0.092 (3.153)***
GARDENDUM	0.261 (2.637)***	0.232 (2.377)**
LnPM10	-1.355 (-2.355)**	-0.320 (-2.806)***
No. Observation	250	250
Adjusted R^2	0.606	0.606

The regression results of the hedonic price function shows that all the significant estimated variables follow the expected relationship pattern. Hence the estimated equation could be written as:

$$\textit{ln PPRICE} = 17.210 + 0.396\ \textit{lnLANDSIZE} + 0.393\ \textit{ln BUILDSIZE} - 0.160\ \textit{ln DISHPITAL} + 0.103\ \textit{ln DISSPMARKET} - 0.160\ \textit{ln DISREST} + 0.092\ \textit{ln DISMSTREET} + 0.232\ \textit{GARDENDUM} - 0.320\ \textit{ln PM10} + e$$

The first derivative of the hedonic price function can be interpreted as the implicit marginal price function for the environmental goods. Descriptive statistics of implicit marginal prices for 250 observations is given in the table 4 below.

Table 4: Descriptive Statistics of Implicit Marginal Price

Descriptive Statistics	Implicit Marginal Price (Rupiahs)
Mean	957912.3
Standard error	87071.6
Median	409600
Mode	352000
Standar deviation	1376723
Minimum	19200
Maximum	1E+007

Hence the marginal implicit price for reducing PM10 is calculated as Rp 957.900. This result clearly identifies air quality as an important factor, along with structural and neighbourhood characteristics, in determining demand for property transaction in Yogyakarta Special Territory.

As mentioned earlier, second stage estimation of inverse demand curve is done by regressing the implicit marginal price on the quantity of environmental goods purchased and other socio economic features including income level of the individuals. The results are given in Table 5 below.

The major inferences are as follows. (1) The first derivative of the implicit marginal price function with respect to PM10 is negative (-1.341) signalling decreasing marginal implicit prices for increasing environmental quality. It means that in the study area, a reduction in PM10 by one percent leads to 1.34 percent increase in property values. (2) The coefficient of number of family members, wall structure, distance from school, and distance from city are not significant. (3) All other variables except number of family members, wall structure, distance from school, and distance from city are significant at 5 percent level of significance. It is interesting to note that the distance from the main-street increases by one percent, residential property value enhances by 0,096 percent. (4) Plot area and building area are positively related to residential property values.

So far we have explained the hedonic price function estimation and its implications to residential property values. The results indicate very clearly that the households are willing to pay for improved air quality. It is therefore necessary to estimate the welfare benefits accruing to them through the purchase of property with reduced air quality.

Table 5: Estimation of Inverse Demand Function

Variable	Full Model	Fit Model
(Constant)	16.037 (16.551)***	16.080 (18.840)***
INCOMELEVEL	0.101 (1.204)	0.143 (1.844)*
LnFAMEMBER	0.098 (0.912)	-
LnLANDSIZE	0.393 (4.337)***	0.391 (4.387)***
LnBUILDSIZE	0.358 (3.452)***	0.381 (3.810)***
WALLSTRUCTDUM	-0.080 (-0.996)	-
LnNUMROOM	0.069 (0.650)	-
LnDISSCHOOL	-0.50 (-0.977)	-
LnDISHOSPITAL	-0.168 (-3.025)***	-0.163 (-3.195)***
LnDISSUPERMARKET	0.101 (1.873)*	0.103 (1.981)**
LnDISRESTAURANT	-0.159 (-3.695)***	-0.165 (-4.129)***
LnDISCITY	0.039 (0.689)	-
LnDISMAINSTREET	0.096 (3.199)***	0.100 (3.416)***
GARDENDUM	0.260 (2.590)**	0.221 (2.273)**
LnPM10	-1.341 (-10.932)***	-1.355 (-11.784)***
No. Observation	250	250
Adjusted R^2	0.752	0.754

CONCLUSION

The primary objective of this study was to establish the relationship between air quality and the residential property values in Yogyakarta Special Territory (YST). By mapping the area which has highest concentration of PM10 earlier and estimating the hedonic property value in the area, we can establish the relationship between air quality and the residential property values.

In the constructed model, we incorporated a number of structural, neighbourhood, environmental and socioeconomic variables as determinants of consumer's willingness to pay for reduced air quality. We hypothesized that the major environmental variable PM10 is inversely related to the residential property values. Similarly, the presence of garden, distance from main-street, distance from supermarket, plot area, and building area are positively related to property price while distance from hospital and distance from restaurant are negatively related.

By adopting a two-stage estimation procedure to estimate these relationships, we found that, on the average, an increase in the level of PM10 reduced property prices in the study area by 0.32 percent. We estimated the marginal implicit price for reducing PM10 as Rp 957,900.00. Further estimation revealed that the households are willing to pay an additional amount of 1.34 percent for a reduction in PM10. In short, the analysis revealed a positive response of households in YST, which have highest concentration of PM10, between air quality and property prices.

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