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Do Open Sewers Lead to a Reduction in Housing Prices? Evidence from Rawalpindi, Pakistan

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Abstract

In this study, we use the Hedonic property value method to estimate how a disamenity, bad odor from an open sewer system, affects housing prices in the city of Rawalpindi in Pakistan. We provide estimates of the benefits of converting the open system into a closed sewer system. We find that house rents decrease by approximately 10% if there is an open sewer (nali) by the house. House rents also increase for homes located further away from the main open drain (Nala Lai) – e.g. a house located 400 meters away from the main open drain enjoys a 12 percent increase in rent because of its distance. Sewer smell has a depressing effect on rent in those areas where smell remains constant throughout the day. The results suggest that residents are willing to pay to be away from bad odor emanating from the open sewerage system. City planners need to take this into account and consider installing sewerage pipes in open sewer areas, which would change the nature of Nala Lai from a disamenity to an amenity.

Key Words: *Disamenity values; Open sewer; Hedonic prices; rent; Willingness-to-pay; Pakistan.*

Do Open Sewers Lead to a Reduction in Housing Prices? Evidence from Rawalpindi, Pakistan

1. Introduction

A house can be defined as a set of many goods, including the number of bedrooms, bathrooms, the quality of local services and utilities, the tidiness of the neighborhood, and the quality of the local environment (Kiel, 2006). Differences in the value of houses can be attributed therefore to housing and neighborhood characteristics with different amenity or disamenity values. Of these, location has always been an important determinant of property value. Before modern transportation, most people, in fact, preferred to live close to their places of work. Today, on the other hand, it is the quality of the neighborhood that determines the choice of residence for most people, with amenities such as green fields and fresh air, as opposed to disamenities such as noise, dust, open drains, odor, etc., often influencing housing decisions.

From the viewpoint of environmental policies the measurement of localized amenities and disamenities is important. Since there is no direct market for environmental goods, one way to understand the value of environmental goods is to examine how their presence or absence affects the housing market and housing prices. Thus, there are a number of studies which estimate the implicit price of an environmental attribute through an examination of the relationship between attributes preference and the price of property. The value of an environmental amenity is the additional price at which a property will sell due to the presence of that amenity.

The Hedonic property price approach is popular among economists for the purpose of estimating the value of environmental amenities and disamenities based on housing prices. For instance, Nelson et al. (1992), Reichert (1997), Michaels and Smith (1990) and Cameron et al. (2006), who examined the localized environmental disamenity of a superfund site for perceived risk, found that distance has a significant impact on housing prices. Kolhase (1991), who estimated the impact of a toxic waste site on housing prices, found that the capital value of the house and the distance to the toxic site were positively correlated. Similarly, Sergio et al. (2002) found that apartments located in close proximity to a sewage treatment plant carried relatively low prices in comparison with those located at a greater distance from the plant.

Most Hedonic studies are, however, based in Western countries, with comparatively fewer studies from the Asian region. In the case of Pakistan, no empirical work has been conducted so far to investigate preferences with respect to locational disamenities. The present study attempts to address this knowledge gap by estimating the impact of an open sewer system on housing values, identifying distance to sewers and smell as disamenities. We base the study on survey data from 1000 households in Rawalpindi, Pakistan. The results show that the disamenity of the open sewer system does have a depressing effect on property values in the city, which makes it incumbent upon policy makers to address the problem of open sewers on both environmental and economic grounds.

2. Background

In Rawalpindi, Pakistan, the historic Nala Lai[1] (a tributary and sewerage stream) winds through the city for a length of 15 km before flowing into the River Soan on the southeastern side of the city. Several side drains that carry rain water from the city are also connected to the Nala Lai. Over time, many natural drains for storm water have also turned into sewers due to the absence of a sewage treatment plant in Rawalpindi (ADB, 2003). The Nala Lai is now a fully open sewer that Rawalpindi relies on to get its waste out.

[1] Nala Lai is the Urdu word for a tributary stream carrying rain water and household-industrial sewerage.

While the city has a closed sewer system, it services only 30 percent of the city area. In the remaining 70 percent, the sewerage system remains open with drains of different widths and depths.[2] Since the drainage system is not well developed, rain water mixes with sewerage waste and remains pooled in the streets for long periods of time. Moreover, not only do heavy rains cause extensive local flooding, low-lying areas remain flooded for a long time. Since, in many places, sanitation lines (carrying drinking water) cross sewage lines, broken lines lead to seepages, thus contaminating drinking water. The lack of a proper sewer network for sewage disposal and for sewage treatment has thus worsened the living conditions in the city, especially for poor people living in low-lying areas.

In this study, we estimate the demand for housing in Rawalpindi City and evaluate the impact of the open sewer system on house rent. Since the city offers two different types of locations for its residents, i.e., near open sewers and near closed sewer systems,[3] we use the variation in housing prices in relation to the bad odor emanating from the open sewer system to estimate the depressing impact of smell disamenities on the rental prices. The results give us a measure of the benefits that would occur if the sewer system was closed.

We use the Hedonic pricing method to estimate the value of the sewerage disamenity in Rawalpindi. Two main approaches have contributed greatly towards the theoretical work on Hedonic prices: utility theory and revealed preference theory (Lancaster 1966; Rosen 1974). Both approaches aim to impute the prices of attributes based on the relationship between the observed prices of differentiated products and the number of attributes associated with these products.

The Hedonic pricing method is based on the fact that a property has both fixed and relative locational attributes. Fixed attributes are usually in relation to the whole urban area and measure of accessibility (Follain & Jimenez, 1985; Orford, 1988). Relative location attributes are identified through surrogate measures such as class and racial composition, aesthetic attributes, pollution levels and proximity to local amenities (Dubin 1998). Traveling time, cost of travel, convenience, and availability of different transport modes are ways to measure accessibility (So et al., 1996).[4]

Relevant for this paper are the many studies that have empirically estimated the effect of distance to an environment amenity/disamenity on property prices (See Table 1). Brown and Pollakowski (1977) was an early study, which estimated the value of living near a lake in Seattle, Washington, and found that the degree of distance from the waterfront significantly reduced a property's selling price. A study by Tse and Love (2000), interestingly, found that a cemetery view has a negative impact on property prices in Hong Kong since residents, mostly ethnic Chinese, avoided dwellings with a cemetery view because of its associations with death.

Given the focus of this paper on disamenities such as open sewers, it is useful to examine the Hedonic property literature on disamenities.[5] Several studies related to disamenities such as a superfund site, toxic waste site or landfill site, use distance from the disamenity as a key variable to understand the effect of these sites on property values. For instance, Kolhase (1991), who estimated the impact of a toxic waste site on housing prices, found that the capital value of the house and distance to the toxic site were positively correlated. Cameron et al. (2006), who studied the environmental disamenity of a superfund site, found that while the magnitude of distance has an effect on housing prices, it may also depend upon the direction in which distance was measured.

While most of the Hedonic studies use a single disamenity along with housing, neighborhood and environmental variables in order to estimate the demand for households, Thayer et al. (1992) used multiple disamenities such as sewage treatment, air quality, waste site and water quality in order to study their negative impact on property values. Cameron (2006), who examines distance from a superfund site, also extended the distance profile from two dimensions to three dimensions in order to explain the impact of directional heterogeneity on housing value. We discuss later our own measure of distance as a proxy for the disamenity we study in Rawalpindi.

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2 The drain with one foot width is called "Nali" while the drain with 4 to 6 foot width is called "Nala." The drain with 100 to 300 foot width is called "Nala Lai."

3 While one third of the city area is developed and has a proper sewage system, two thirds of the city has no proper sewage system.

4 Although location is often measured in terms of accessibility to the Central Business District, accessibility, in whatever form it is measured, has some influence on housing prices. (McMillan et al., 1992; Ridker & Henning 1968).

5 An interesting aspect of property values is that they are, as in the case of other markets, dependent on information. Gayer et al. (1999), for instance, found that households overestimate the risk of hazard of waste sites on human health, which has a severe impact on property values. However, according to Kinnard & Geckler (1991), residents' perception of the risk became more rational once information on EPA remedies was available. Thus, they demonstrated that distance does not affect prices in places where remedies are quick and effective either before or after the listing of the site as a hazard waste site.

3. Methods

The Hedonic Price Model determines how the attributes of various dwellings affect value. The model is based on the assumption that amenities have a positive impact on the value of property while disamenities affect prices negatively. Assuming that each individual's utility is a function of a composite good (X), housing characteristics S (where $S = S_1, S_2, S_3 ... S_n$), neighborhood characteristics N (where $N = N_1, N_2, N_3 ... N_n$) and environmental variables Q, (where $Q = Q_1, Q_2, Q_3 ... Q_n$), the utility function of jth household is given by:

$$U^j = u(X, Q_i, S_i, N_i) \quad (1)$$

while the rental price R of the jth residential unit (apartment or house) is,

$$R^j = R(S_i, N_i, Q_i) \quad (2)$$

and the budget constraint is

$$M^j - R^j - X^j = 0 \quad (3)$$

where M is the income of the jth household.

The consumer will maximize his utility, U_j (1), by choosing attributes of the environmental good Q_i, housing characteristics S_i, and the composite good X, subject to the budget constraint (3). The first order conditions with respect to environmental good Q_i gives the implicit price for that attribute,

$$\frac{\partial R}{\partial Q_i} = \frac{\partial U / \partial Q_i}{\partial U / \partial X} \quad (4)$$

Equation 4 shows that the marginal rate of substitution between any environmental characteristic, Q_i, and the composite good, X, is equal to the rate at which consumers can trade Q_i for X in the market. The ratio of the implicit price for Q_i and the price of the composite good, which equals one, reflects the change in the rental value (R) per unit change in the environmental characteristic. In this paper, we estimate equation (4) to assess the negative values created because of the housing disamenity, bad odor.

Many Hedonic studies discuss the importance of the functional form of the Hedonic functions. Rosen (1974), for instance, argues that a linear function implies that consumers can unbundle the house's characteristics without a cost. Generally, Hedonic studies use linear, log linear and log-log functional forms. The linear functional form is used to find the constant partial effects between housing characteristics and selling price whereas the log linear model gives the non-linear price effect (Allen 1997). In this study, we use linear and log linear functional forms to explain the impact of the open sewage system on house rent. Drawing upon the existing literature, the study also uses a number of housing, neighborhood and environmental variables as explanatory variables (Kolhase, 1991). We identify the variables used in different studies in Table 1.

The linear and log-linear Hedonic price equations that are estimated are given by:

$$Y = \alpha_1 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \delta_i Z_i + u \quad (5)$$

$$h\, y = \alpha_1 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \delta_i Z_i + u \quad (6)$$

Y in both equations (5) and (6) represents the rental price of the jth house. While X_1 to X_9 are different explanatory (housing characteristics) variables that can affect the rent, Z_i represents the disamenity of smell that affects Y. We use five indicators to measure disamenity Z_i. These include two dummy variables that account for perceived smell intensity, the presence of open sewers, and distance and distance squared from the main open sewer. We estimate the Hedonic rental price equations (5 and 6) using each of these different disamenity measures.

We discuss the variables used in estimating the Hedonic price equation below.

House Rent (Y): House rent is the dependent variable. Since few well-maintained records of the purchase and sale of houses were available in the study area, we use self-reported rental values as proxy to estimate the Hedonic property price function. We collected information on the monthly rent of the house from each household while imputing the rent for the ground-floor portion of the house irrespective of whether the occupant was a tenant or the owner. The accuracy of our imputed rent estimates were confirmed through discussions with property dealers and tenants with similar houses on the same street.

A number of variables can explain differences in house rent. The explanatory variables used as indicators of housing characteristics were:

Plot Size (X_1): Plot size is measured in square yards. We estimate plot size as the total of both the open (un-built) as well as covered areas of the ground portion of the house.

Bedroom (X_2): This variable refers to the number of bedrooms in the house. In houses with more than two floors, we took care to compute only the bedrooms on the ground-floor of the house.

Drawing Room (X_3): The drawing room of the house is a dummy variable. If there is an area in the house that the household uses for guests and visitors only, and not for sleeping purposes on a regular basis, we treat this room as a drawing room.

Bathroom (X_4): The bathroom is a discrete variable that refers to the number of bathrooms in the ground floor portion of the house.

Television Lounge (X_5): TV lounge is a dummy variable and it is consider as a place where household members sit or watch TV.

Garage (X_6): The availability of a garage in the house is identified as a dummy variable. We consider space for at least one car as a garage.

Lawn (X_7): The availability of a lawn in front or at the back of the house is a dummy variable. For the outdoor space to qualify as a lawn, it has to comfortably accommodate at least four chairs.

Distance to Park (X_8): Distance is measured as the distance to the nearest public park in kilometers.

Distance to Hospital (X_9): Distance is measured as distance to the nearest public hospital in kilometers.

We used five different variables to explain the smell disamenity. These were:

Odor occasional (Z_1): Dummy variable reflecting the intensity of the smell, which equals 1 if there is an odor on occasion in the vicinity of the house, 0 otherwise.

Odor Always (Z_2): Dummy variable for a continuous smell that remains in the air on most days. It equals 1 if there is a smell throughout the day and 0 otherwise. The expected signs of Z_1 and Z_2 are negative.

Open Sewer (Z_3): Dummy variable for any type of open sewer (nali) either in front or back of the house. We expect the coefficient of this dummy variable to be negative.

Sewer Distance (Z_4): We measure the distance in meters between each house and the nearest Nala Lai. We calculated this distance using GPS coordinates. As the distance from the Nala Lai increases, we expect the smell to decrease and the rental values to increase.

Sewer Distance Square (Z_5): We measure this as the square of the distance (in meters) to the nearest Nala Lai. We expect the sign of distance square in the regression analysis to be negative. Thus, we expect rental values to increase at a decreasing rate as the distance between the house and the Nala Lai increases. We also use the distance square function to find the maximum distance from the sewer system at which the smell dissolves in the air and the rental value is not affected due to the presence of an open sewer.

4. Data

According to the Asian Development Bank (ADB)[6], the ratio of open sewer area to the closed sewer area in Rawalpindi is 70:30 respectively. Thus, our aim was to identify and collect data from a total sample of 1000

[6] ADB report 370003.

households with 30 percent of the sample drawn from closed sewer areas and 70 percent drawn from open sewer areas. The area of Rawalpindi city (excluding the cantonment area) is approximately 8 square kilometers. Using a Google map, we therefore first divided the city of Rawalpindi into 64 blocks (grids), each being 0.5 square kilometers in area. This helped us to identify sample blocks for household selection.

To select our sample households, we treated the distance to the main sewer (Nala Lai) as a proxy for odor. Thus, we first selected the northern-most block next to the main open sewer (Nala Lai) and then selected subsequent blocks by skipping one block in each direction, i.e., from north to south and east to west. By doing this, out of a total of 64 blocks, we were able to identify 24 sample housing blocks at varying distances from the open and closed sewers in Rawalpindi, with 16 housing blocks located in the open sewer areas and 8 located in the closed sewer areas.

We also wanted to ensure variation in housing characteristics in our sample. Thus, before choosing our housing sample, we created a sub-strata based on housing size or the covered area (square yard) of the house. We identified three sizes of housing by this method: 1) less than 90 square yards; 2) between 90 to 210 square yards; and 3) more than 210 square yards. The proportion of houses chosen in each stratum was based on the latest census report,[7] which indicated that 26 percent of houses in the area had less than 90 square yards while 58 percent had between 90 to 210 square yards, and 16 percent had more than 210 square yards.

We also selected the houses based on two additional conditions: 1) variation in type of ownership (with sixty percent of households being owner-occupied and forty percent being tenant-occupied) and 2) use of ground-floor space, that is, households being selected only if the ground floor of the house served as living space. Thus, in each block, the sample of houses selected fulfilled three strata: housing size, prescribed owner-tenant ratio, and use of ground floor of house as dwelling space. The method led to the selection of 40 to 50 houses from each block for the survey. This method yielded a stratified sample of 701 households from open sewer areas and 299 households from closed sewer areas as our final sample.

We conducted the survey of the sample households during the months of August-October 2007. Our questionnaire, which had nine sections, gathered information on the socio-economic background of the household, the house characteristics, neighborhood values, amenities and disamenities, etc. We also measured the GPS coordinates of each house using the E-TEC receiver.

Since housing comes in different forms–apartments, stand-alone houses, etc.—the study did not use the rental value of the entire building. Instead, in order to ensure homogeneity, we used rental information on the ground floor only of the house since it is common practice in Rawalpindi for people to sublet different floors to more than one tenant. Another significant reason for considering the rent of the ground-floor only of the house is that it is usually the only section of the house that includes a garage and lawn facilities.

We collected information on the demographic characteristics of the selected households such as family size, age, education level of household head and spouse, and the occupation of the household head through the survey. We computed the income of the household through the household wealth index.

5. Results and Discussion

5.1 Summary Statistics

The Rawalpindi Housing Census (1998) reported the owner-tenant ratio in the city to be 58:42. The owner-tenant ratio in our dataset is close to this figure at 62:38 percent. Table 2 presents the summary statistics from our data which we discuss below.

The mean age of a house in our data set is 13 years in the open sewerage areas. The minimum age of a house in the open sewerage areas is one year with the maximum age recorded being 82 years, indicating that open sewer areas are to be found in the older parts of the city. The minimum age of houses for the closed sewerage areas is also one year but the maximum age is 66 years. Interestingly, the mean age of houses in closed sewer areas is higher at 15 years. We also found houses in the closed sewer areas to be more developed than those in the open

7 Rawalpindi Housing Census Report, 1998.

sewerage area with thirty percent of households having tiled bathrooms relative to 16 percent of houses in the open sewer areas. Furthermore, while only 38 percent of kitchen cupboards were made of wood in the areas with open sewers, this number rises to 55 percent in areas with closed sewers. The mean plot size is lower in the open sewer areas compared to the closed sewer areas.

Although the variation in the number of bedrooms, drawing rooms, television lounge and bathrooms is the same in both areas, houses in the closed sewer areas have more structural characteristics in the form of a garage and lawn as well as more neighborhood facilities. The mean distance to public amenities such as public hospitals and park is also greater in the case of the open sewerage areas relative to the closed areas. The minimum distance to a public hospital, for instance, is 0.148km and 0.207km for closed and open sewerage areas respectively. Similarly, the mean distance to a park in the closed sewerage area is 2.5km compared to 3km for the open sewerage area. The mean rent in the open and closed sewer areas is PKR 4,575 and PKR 6,592 respectively.

We also found the quality of the fresh air in the morning to be better in the closed sewer areas than in the open sewer areas with less of an odor in the case of the former. The data also suggests that the evening air is fresher than morning air in the open sewer areas. Residents of the sample households informed the enumerators or researchers that the intensity of the smell is higher in the summer season, especially on rainy days. This could be due to the monsoon season which, in the case of the city of Rawalpindi, occurs during the months of July and August, with temperatures during these months amongst the highest in Pakistan.

Since the sewer channels are scattered across the city like a spider-web, in order to measure sewer distance, we calculated the closest point from the main Nala Lai to the house (in any direction) using GPS coordinates. We found the maximum distance from a house to the nearest Nala Lai to be 1,573 meters in the case of the open sewer areas and 1,565 meters in the case of the closed sewer areas. We also estimated the average distance from a house to the nearest Nala Lai in the open and closed sewer areas to be 250 meters and 374 meters respectively.

5.2 Regression Analysis

Tables 3.1, 3.2 and 3.3 present the regression estimates of the Hedonic property function for open sewer, closed sewer areas and the pooled data respectively. Each Table has results for linear and log linear functional forms. For the open and closed sewer area estimates in Tables 3.1 and 3.2, we used three different indicators of the environmental disamenity: odor occasionally, odor always and sewer distance. Thus, both Tables have three models each with three different disamenity indicators while each model is estimated with linear and log-linear specifications. When we pool the data in Table 3.3, we add an additional disamenity indicator by including a dummy variable for the open and closed sewer areas. Since, as shown in Tables 3.1, 3.2 and 3.3, the signs of the coefficients are the same for both the linear and log-liner models, we mostly discuss the results from the log-linear models below.

The Hedonic regressions in Tables 3.1, 3.2 and 3.3 show that the values and expected sign of structural and neighborhood attributes in open, closed and pooled data are very similar in all model specifications. The variables for housing characteristics have the expected sign and are generally consistent with the findings of a vast body of Hedonic literature. For example, the presence of a drawing room increases house rent by approximately 27 percent in open sewer areas (see Table 3.1) and 30 percent in closed areas (see Table 3.2). However, the increase in rent due to the presence of a drawing room is 28 percent in the case of pooled data also (see Table 3.3). When it comes to the availability of a garage, the increase in rent is 12 percent for the open sewer area and 19 percent for the closed sewer areas (see Tables 3.1 and 3.2). It is 14 percent for the pooled data (see Table 3.3).

The distance between a neighborhood amenity such as a hospital and park and house has a negative impact on house rent, with the rent decreasing as distance to these amenities increases. One reason for this is that there are only two public parks and three public hospitals in the area. The distance to the public park and the hospital from the house decreases the rent of the house in open sewer areas by 0.6 percent and 0.5 percent respectively per one kilometer increase in distance (see Table 3.1). Interestingly, in the case of closed sewer areas (see Table 3.2), the decrease in house rental is greater with distance to public amenities, with house rent decreasing by 12.78 percent and 11.83 percent respectively per one kilometer increase in distance to a public park or hospital.

5.3 The Effects of the Smell Disamenity on Rental Prices

We discuss here the effects of the different indicators of the smell disamenity on rental prices. The results reported are from the log-linear specification of the Hedonic price function.

In Model 1, we measure the environmental variable by the dummy variable, “odor occasional”, which is equal to one if an occasional sewerage smell is to be found in the vicinity of the house. But the results in Tables 3.1, 3.2 and 3.3 (model 1) show that while the dummy “odor occasional” has a significant impact on house rent in the open sewer areas it carries a positive sign, which is not easy to explain, though one conjecture being that occasional odor is taken as an inevitable part of city life that causes little or no inconvenience to house owners or renters. The sign, however, is insignificant in closed areas and in the case of pooled data.

Model 2 also looks at the effect of odor by using the dummy variable “if odor always exists in the vicinity of house”, the sign for which is negative and significant in open, closed and pooled data models (see Tables 3.1. 3.2 and 3.3 (Model 2)), thus confirming the Hedonic hypothesis. When odor is persistent throughout the day, it decreases rent in the open and pooled data models by approximately 8 percent (see Tables 3.1 and 3.3) and in closed sewer areas by 7 percent (see Table 3.2), which confirms the significant depressing effect of odor on rent, with the impact assuming more or less the same rate in both the open and closed sewer areas.

In Model 3, where distance to the main sewer (Nala Lai) is treated as the measure of the locational disamenity, the results (reported in Tables 3.1, and 3.3 (Model 3)) suggest that the effect on rent of distance to the main sewer system is positive while the effect of distance square is negative. Thus, the increase in distance to the Nala Lai from the house increases the house rent at a declining rate. However, it does not yield significant coefficients in the log-linear model

In the pooled data estimation (Table 3.3), we used an additional dummy variable to indicate the presence of any type of open sewer (nali) in the front or back of the house. We use this dummy to split the study area between the open and closed sewer areas (see Models 1-4). In most specifications, the existence of an open sewer decreases house rent by about 10 percent.

6. Distance Damage Function for Nala Lai

Several researchers have used the concept of distance rings to estimate the value of damages within a specified area. The use of distance rings or ranges allows researchers to identify the number and value of the properties within each ring and estimate value changes as distance from the disamenity increases. Smollen et al. (1992), for instance, uses distance rings to examine the effect of distance from a toxic chemical waste landfill on property prices. He identifies rings of 0-2.6 miles, 2.61-5.75 miles and greater than 5.75 miles. The reason for different distance ranges within each ring is to obtain an equal sample size. Reichert (1997), on the other hand, used four distance rings to examine the impact of distance from a landfill with ring 1 including properties which are between 0-2250 feet distance from the landfill, ring 2 including properties between 2251-4500 feet distance from the landfill, ring 3 including properties between 4501-6750 feet distance from the landfill and ring 4 to include the remaining properties. In his 1991 study, Kohlhase used one mile distance rings for an area that was seven miles in extent around the superfund site of Houston, Texas, in order to examine property values.

Following these studies, we too use different distance rings to estimate the gain in house rent as houses come to be located further away from the main sewer, Nala Lai. Each ring is drawn at a constant scale of 200 meters from the Nala Lai. Thus, we use distance ring 1 at a range of 200 meters from the Nala Lai, distance ring 2 at 200 to 400 meters from the Nala Lai, distance ring 3 at 400 to 600 meters from the Nala Lai and distance ring 4 at more than 600 meters from the Nala Lai.

We use a log linear model to find the percentage impact on house rent as distance from the Nala Lai increases. The control variables remain the same as in equation (5 and 6) but we use distance ring dummy variables for our disamenity variables. We estimate the following model using our pooled data sample:

$$ln\ y = \alpha_1 + \beta_1 (plotsize) + \beta_2 (bed) + \beta_3 (drawingroom) + \beta_4 (bath) + \beta_5 (TVlounge) + \beta_6 (Garge) + \beta_7 (Park) + \beta_8 (Hospital) + \beta_9 (ring_i) + u \quad (7)$$

where *ring i = 1, 2, 3, 4*

Distance ring 1= 1 if a house is within a distance of 100 meters from the open sewerage, 0 otherwise;
Distance ring 2 = 1 if a house is between 200 to 400 meters from the open sewerage, 0 otherwise;
Distance ring 3 = 1 if a house is between 400 to 600 meters from the open sewerage, 0 otherwise;
Distance ring 4 = 1 if a house is more than 600 meters from the open sewerage, 0 otherwise.

We report in Table 3.4 the regression results for the distance damage impact for the four distance rings where the base dummy is distance ring 1. As can be seen in Table 3.4, the variables related to the structure of the house and neighborhoods are significant, with the house rent increasing by 9.6 percent if the house is 200-400 meters away from the open sewer. In brief, the household is willing to pay 9.6 percent more in rent for the privilege of not having the open sewerage in sight and for the lessened impact of the odor from the open sewerage that comes with distance. House rent increases by 12 percent if the house is 400 meters away from the open sewer. However, we observed the coefficient on the dummy variable related to houses in distance ring 4, i.e., for houses that are located more than 600 meters from the open sewer, to have a negative sign though this is insignificant.

7. Conclusions and Policy Recommendations

The results of the study suggest that rent for houses in the open sewer areas is lower than that for houses in the closed sewer area, which support our hypothesis that odor and house location affect housing values with open sewers decreasing house rent by about 10 percent. The analysis also found that when sewer odor was in the air throughout the day, it decreased rent by between 7 percent and 8 percent. Thus, it is clear that the odor from sewers significantly depress rent in Rawalpindi.

Our results also indicate that households are willing to pay a higher rent to live further away from the main drain, Nala Lai. Nala Lai became the deposit point of household sewer in the early eighties when the then existent sewer system failed to cater to the growing population of the city. The malfunctioning of sewer treatment plants also worsened the sewerage situation. Therefore, a properly functioning sewerage treatment plant and the installation of sewerage pipes in the open sewer area would change the nature of Nala Lai from a disamenity to an amenity. If Nala Lai is used only as a rain drain and to carry household sewerage after treatment then the negative impact of Nala Lai could decrease significantly.

There are several limitations of this study that need to be acknowledged. Odor is just one aspect of the open sewer system. The study has not been able to incorporate the role of wind speed and wind direction in assessing the negative impact of odor on house rent. We expect to address this aspect of the problem in the future. The study is also limited by the lack of market data on housing sales prices. The hedonic price function is based on self-reported rental values, while similar studies are generally done with house sale values. It is possible that our sample households, who are owners of properties, were not able to provide accurate rental values.

While further research with more precise data is needed to both test and consolidate the findings of the present study, those in charge of policy-making and implementation in Rawalpindi can use the results of the present study. This extent of disamenity generated by open sewers, as identified in this study, can be used to motivate investment projects to close sewers. The value of the disamenity generated by open sewers in Rawalpindi would be useful in estimating the net benefits of any investment projects related to drainage and sewerage systems in Pakistan.

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Table 1: Summary of Hedonic Model (Distance) Literature Review

Author	Location	Environmental Variables	Sample Size	Functional Form	Results
Kiel & McClain (1995)	North Andover, Massachusetts	• Distance from incinerator in feet; • Distance from house to interstate entrance ramp in feet.	2593 single family home sales	Natural log of price and distance from house to interstate (distance in quadratic form)	• Distance is insignificant for pre-rumor and rumor stage. • Distance is significant when incinerator construction is started by EPA. • The distance impact remains significant 7 years after construction.
Nelson et al. (1992)	Ramsey, Minnesota	• Distance from landfill site; • Dummy for tree cover.	708	Linear form	• Impact of landfill is significant within 2 mile radius. • The house value decreased by 12 percent (at landfill site boundary) to 6 percent (2 miles to landfill boundary).
Thayer et al. (1991)	Baltimore	• Access to beach; • Seasonal ozone concentration; • Sulfur dioxide concentration; • Nitrogen dioxide; • Particulate matter; • Distance from landfill; • Distance from hazardous waste site.	2323 (1985-86)	Linear and semi-log	• Access to beach increases the house value, which is equal to one bathroom in value. • 6 percent improvement in air quality has contributed to an increase in value equal to central air conditioning. • The distance gradient of one mile, 1.5 to 4 miles, and greater than 5 miles is the significant shift factor. • The hazard waste site has two times the negative impact than non-hazard waste site. • The benefit of removal of waste site is limited to local group within one-mile radius.
Reichert (1997)	Uniontown, Ohio	• Season (quarters); • Distance from land fill and year of sale.	1977 to 1994	Log linear	• The average one mile damage impact of landfill has 12.5 percent. • The damage to 75 year old houses in ring 1 was 14.66 percent, for ring 2 6.40 percent and for ring 3 5.4 percent.
Smolen et al. (1992)	Toledo, Ohio	• Distance to landfill	1312, 1237	Linear	• Distance is insignificant for the control area (more than seven miles). • Distance rings of 2.6 miles and 2.6 to 5.75 miles show the same negative impact on house value.
Kolhase (1991)	Houston	Distance to toxic site Seasons dummy	1976-85 sales data	Log linear	• The distance and distance square to toxic waste site is insignificant in 1976 as site is not listed in EPA. • The distance becomes significant in 1980 up to 2.7 miles as EPA listed the site. • Housing prices increase at decreasing rate up to 6.2 miles.
Cameron (2006)	Woburn, MA	Distance to landfill Direction of wind	5498 (1988-96)	Log	• Directional diffusion impact on property value is non-circular. • Directional heterogeneity gives significant distance impact. • The average distance elasticity effect by controlling direction is also positive and significant.

Table 2: Descriptive Statistics

	Pooled Model (1000 Obs)				Open Sewer Model (701 Obs)				Closed Sewer Model (299 Obs)			
Variable	**Mean**	**Std. Dev.**	**Min**	**Max**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Mean**	**Std. Dev.**	**Min**	**Max**
Owner to Tenant Ratio	0.63	0.48	0	1	0.64	0.479	0	1	0.622	0.48	0	1
Age of House (years)	13.29	14.29	1	82	12.68	13.96	1	82	14.74	14.96	1	66
Rent per Month (PKR)	5,177.6	2,853.9	500	27,000	4,574.5	2,268.8	500	20,000	6,591.6	3,514.4	1,000	27,000
Plot Size (square yard)	146.5	71.9	30.0	600.0	139.7	66.2	30.0	600.0	162.4	81.7	45.0	600.0
No of Bedrooms	2.1	0.9	1.0	8.0	2.0	0.9	1.0	8.0	2.2	0.8	1.0	8.0
Drawing Room (dummy)	0.7	0.4	0.0	1.0	0.7	0.5	0.0	1.0	0.8	0.4	0.0	1.0
Bathroom	0.4	0.5	0.0	1.0	0.3	0.5	0.0	1.0	0.5	0.5	0.0	1.0
TV Lounge (dummy)	1.3	0.6	0.0	4.0	1.2	0.5	0.0	4.0	1.4	0.6	1.0	4.0
Garage (dummy)	0.3	0.5	0.0	1.0	0.2	0.4	0.0	1.0	0.5	0.5	0.0	1.0
Lawn (dummy)	0.0	0.2	0.0	1.0	0.0	0.2	0.0	1.0	0.1	0.2	0.0	1.0
Distance to Hospital (km)	1.457	0.605	0.148	3.106	1.547	0.595	0.20754	3.10	1.25	0.576	.148	3.09
Distance to Public Park (km)	2.84	.992	0.362	4.892	2.994	0.987	0.36194	4.89	2.473	0.906	0.487	4.462
Open Sewerage nali (dummy)	0.7	0.5	0.0	1.0	0.9	0.2	0.0	1.0	0.0	0.1	0.0	1.0
Odor Occasional (dummy)	0.4	0.5	0.0	1.0	0.4	0.5	0.0	1.0	0.3	0.5	0.0	1.0
Odor Always (dummy)	0.4	0.5	0.0	1.0	0.4	0.5	0.0	1.0	0.3	0.4	0.0	1.0
Sewer Distance (meter)	287.3	405.2	0.6	1,573.7	250.1	369.9	0.6	1,573.7	374.3	467.1	0.6	1,565.6
Sewer Distance Square (meter)	2.5E+05	6.3E+05	3.8E-01	2.5E+06	2.0E+05	5.6E+05	3.8E-01	2.5E+06	3.6E+05	7.5E+05	3.8E-01	2.5E+06

Table 3.1: Estimates of the Hedonic Regression with Data from Open Sewer Areas

	Model 1		Model 2		Model 3	
	Linear	**Log-linear**	**Linear**	**Log-linear**	**Linear**	**Log-linear**
Plot Size	14.41*** (14.25)	0.00245*** (10.84)	14.42*** (14.31)	0.0024*** (10.92	13.88*** (13.83)	0.002356*** (10.44)
No. of Bedrooms	571.08*** (7.08)	0.154*** (9.6)	566.24*** (7.9)	0.1533*** (9.6)	607.41*** (8.53)	0.1611*** (10.06)
Drawing Room	870.92*** (7.08)	0.272*** (9.9)	875.20*** (7.14)	0.2727*** (9.9)	848.02*** (6.94)	0.2686*** (9.77)
Bathroom	186.05** (1.57)	0.0185 (0.7)	165.14 (1.39)	0.0129 (0.49)	245.67*** (2.1)	0.02924 (1.11)
TV Lounge	464.13*** (3.96)	0.1076*** (4.1)	425.41*** (3.63)	0.0990*** (3.78)	446.72*** (3.84)	0.1054*** (4.03)
Garage	796.29*** (5.24)	0.1261*** (3.71)	746.93*** (4.93)	0.1157*** (3.42)	789.15*** (5.24)	0.1233*** (3.64)
Lawn	1,438.94*** (4.2)	0.06801 (0.89)	1,462.55*** (4.3)	0.0718 (0.95)	1,423.24*** (4.21)	0.06623 (0.87)
Distance to Hospital	-276.73 (3.0)	-0.06722 (-3.26)	-280.79 (-3.05)	-0.06853 (-3.4)	-110.38 (-1.04)	-0.0341 (1.44)
Distance to Public Park	-246.89 (-4.38)	-0.0569 (-4.52)	-250.22 (-4.45)	-0.05766 (-4.6)	-267.19 (-4.1)	-0.06526 (-4.46)
Odor Occasional	295.35*** (2.68)	0.05755*** (2.33)				
Odor Always			-372.43*** (-3.36)	-0.0841*** (-3.4)		
Sewer Distance					2.08*** (4.2)	0.00030*** (2.71)
Sewer Distance Square					-0.001532*** (-4.51)	-2.43E-07*** (-3.18)
Constant	1,283.34*** (4.16)	7.64*** (110.77)	1,611.27*** (5.07)	7.71*** (108.76)	930.49*** (2.83)	7.60*** (102.66)
Number of obs	697	697	697	697	697	697
F(10, 686)	115.74	93.9	116.100	95.34	108.24	86.32
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000
R-squared	0.627	0.5778	0.630	0.5816	0.634	0.5809
Adj R-squared	0.622	0.5717	0.624	0.5755	0.628	0.5742

* (**) &(***) denotes significance at 10 (5) & (1) percent levels
t values are in braces

Table 3.2: Estimates of the Hedonic Regression with Data from Closed Sewer Areas

	Model 1		Model 2		Model 3	
	Linear	**Log Linear**	**Linear**	**Log Linear**	**Linear**	**Log Linear**
Plot Size	16.74***	0.0018***	16.89***	0.0019***	16.61***	0.0018***
	(8.01)	(6.97)	(8.16)	(7.09)	(8.04)	(6.97)
No. of Bedrooms	474.56***	0.0838***	474.35***	0.0838***	404.81***	0.0762***
	(2.75)	(3.76)	(2.77)	(3.78)	(2.34)	(3.41)
Drawing Room	1185.15***	0.3039***	1084.05***	0.2929***	1189.82***	0.2993***
	(3.31)	(6.56)	(3.02)	(6.3)	(3.3)	(6.47)
Bathroom	550.04***	0.0778	496.24**	0.0722***	540.83***	0.0774***
	(2.06)	(2.25)	(1.86)	(2.09)	(2.04)	(2.26)
TV Lounge	855.12***	0.0922***	831.16***	0.0901***	863.47***	0.0956***
	(3.74)	(3.12)	(63.68	(3.08)	(3.82)	(3.27)
Garage	894.51***	0.1960***	845.53***	0.1904***	1011.75***	0.2109***
	(2.97)	(5.04)	(2.83)	(4.9)	(3.37)	(5.45)
Lawn	522.14	0.0558	445.82	0.0472	287.87***	0.0246
	(0.91)	(0.76)	(0.78)	(0.64)	(0.5)	(0.33
Distance to Hospital	-616.68***	-0.1183***	-551.64***	-0.1107***	-688.91***	-0.1232***
	(-2.56)	(-3.81)	(-2.3)	(-3.56)	(-2.87)	(-3.98)
Distance to Public Park	-933.37***	-0.1278***	-954.89***	-0.1300***	-655.50***	-0.0980***
	(-6.19)	(-6.56)	(-6.37)	(-6.7)	(-3.43)	(-3.98)
Odor Occasional	180.81	0.0117				
	(0.66)	(0.33)				
Odor Always			-677.92***	-0.0716**		
			(-2.28)	(-1.86)		
Sewer Distance					-0.02566	-0.0001064
					(-0.88)	(-0.72)
Sewer Distance Square					.000060	1.36E-07
					(0.88)	(1.530)
Constant	2907.94***	8.12***	3265.43	8.15***	2279.80***	8.06***
	(4.32)	(93.46)	(4.96)	(95.74)	(2.99)	(81.89)
Number of obs	298	298	298	298	298	298
F(10, 287)	47.45	62.27	48.741	63.33	44.73	58.66
Prob > F	0	0	0	0	0	0
R-squared	0.6231	0.6845	0.6293	0.6882	0.6324	0.6929
Adj R-squared	0.61	0.6735	0.6164	0.6773	0.6183	0.6811

* (**) &(***) denotes significance at 10 (5) & (1) percent levels
t values are in braces

Table 3.3: Estimates of the Hedonic Regression with Pooled Data (Open and Closed Sewer Area)

	Model 1		Model 2		Model 3		Model 4	
	Linear	Log Linear	Linear	Log Linear	Linear	Log Linear	Linear	Log Linear
Plot Size	15.42***	0.0022***	15.44***	0.0022***	15.30***	0.0021***	15.24***	0.0021***
	(15.81)	(12.72)	(15.93)	(12.83)	(15.79)	(12.56)	(15.64)	(12.54)
No of Bedrooms	522.28***	0.1363***	515.63***	0.1350***	516.70***	0.1375**	531.42***	0.1380***
	(7.19)	(10.48)	(7.1)	(10.43)	(7.11)	(10.51)	(7.30)	(10.60)
Drawing Room	917.48***	0.2783***	904.10***	0.2757***	950.77***	0.2826***	936.72***	0.2818***
	(6.95)	(11.77)	(6.87)	(11.72)	(7.23)	(11.94)	(7.09)	(11.91)
Bathroom	535.88***	0.1075***	493.26***	0.0996***	513.25***	0.1054***	532.95***	0.1070***
	(4.54)	(5.09	(4.18)	(4.72)	(4.36)	(4.97)	(4.51)	(5.05)
TV Lounge	484.11***	0.0490***	453.56***	0.0432***	495.61***	0.0510**	494.21***	0.0508***
	(4.36)	(2.47)	(4.09)	(2.18)	(4.48)	(2.57)	(4.45)	(2.55)
Garage	823.53***	0.1489***	783.47***	0.1414***	855.67***	0.1496***	815.95***	0.1475***
	(5.74)	(5.8)	(5.48)	(5.53)	(5.96)	(5.79)	(5.67)	(5.73)
Lawn	1081.11***	0.0583	1072.51***	0.0566	1055.17***	0.0613	1114.98***	0.0645
	(3.57)	(1.08)	(3.56)	(1.05)	(3.5)	(1.13)	(3.68)	(1.19)
Distance to Hospital	-494.93***	-0.0866***	-494.92***	-0.0866***	-566.33***	-0.0895***	-92.82***	-0.08623***
	(-5.3)	(-5.18)	(-5.32)	(-5.21)	(-5.79)	(-5.09)	(-5.26)	(-5.14)
Distance to Public Park	-439.04***	-0.0782***	-443.61***	-0.0791***	-309.40***	-0.0700***	-442..21***	-0.0788***
	(-7.6)	(-7.57)	(-7.71)	(-7.69)	(-4.45)	(-5.6)	(-7.64)	(-7.61)
Open Sewer (nail)	-632.18***	-0.1073**	-587.22***	-.0990***	-575.28***	-.1015***	-617.51***	-0.1046***
	(-4.82)	(-4.57)	(-4.5)	(-4.24)	(-4.39)	(-4.31)	(-4.71)	(-4.45)
Odor Occasional	266.12	0.0485						
	(2.34)	(2.38)						
Odor Always			-446.58***	-0.0832***				
			(-3.83)	(-3.99)				
Sewer Distance					1.1023***	0.0001264		
					(2.23)	(1.42)		
Sewer Distance Square					-.0003541	-5.95E-08		
					(-1.12)	(-1.05)		
Constant	2376.06***	7.87***	2699.98***	7.93***	1927***	7.84***	2449.97***	7.88***
	(7.87)	(145.61)	(8.83)	(144.89)	(5.76)	(130.12)	(8.14)	(146.32)
Number of obs	995	995	995	995	995	995	995	995
F(10, 984)	161.57	159.14	163.91	161.71	149.71	145.05	165	163
Prob > F	0	0	0	0	0	0	0	0
R-squared	0.6439	0.6404	0.6472	0.441	0.6466	0.6393	0.6419	0.6383
Adj R-squared	0.6399	0.6364	0.6432	0.6401	0.6423	0.6349	0.6383	0.6346q

* (**) &(***) denotes significance at 10, 5 & 1 percent levels.
t values are in braces

Table 3.4: Estimation of Hedonic Price Function Using Distance Rings as Independent Variables in Open and Closed Sewerage Areas (Dependent Variable = Log of House Rent)

Variables	Coefficient
Plot Size	0.002***
	(0.000)
No. of Bedrooms	0.140***
	(0.013)
Drawing Room Dummy	0.276***
	(0.024)
No. of Bathrooms	0.109***
	(0.021)
Television Lounge Dummy	0.047**
	(0.020)
Garage Dummy	0.151***
	(0.025)
Distance to Park (km)	-0.082***
	(0.012)
Distance to Hospital (km)	-0.086***
	(0.017)
Open and Closed Sewerage Dummy	-0.101***
	(0.023)
Distance Ring Dummy for 200 to 400 Meters	0.096***
	(0.025)
Distance Ring Dummy for 400 to 600 Meters	0.122**
	(0.055)
Distance Ring Dummy for more than 600 Meters	-0.007
	(0.035)
Constant	7.873***
	(0.058)
R2	0.645
No. of obs	995

* (**) &(***) denotes significance at 10, 5 & 1 percent levels.
t values are in braces

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