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Moderating effect of forest cover on the effect of proximity to chemical facilities on property values

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ABSTRACT

Numerous studies on housing markets indicate that neighborhood amenities such as trees and open space increase property values while the presence of hazardous facilities, pollution and flooding risks decreases housing prices. However, previous studies have focused on the direct impacts of neighborhood characteristics on housing prices using the Hedonic Price Model (HPM). Potential interactive relationships among neighborhood characteristics have not been clearly tested. This study examines direct impacts of urban forest on property values and indirect impact on the relationship between Toxics Release Inventory (TRI) chemical facilities and tax base property values in Tarrant County, Texas. Distance to hazardous chemical sites and the amount of foliage coverage within neighborhoods are measured using Geographic Information Systems (GIS) and regressed to tax base property values. To test the indirect impact of trees coverage on the relationship between TRI sites and property values, the moderation model is examined with more foliage coverage (MF) parcels and less foliage coverage (LF) parcels. The empirical result of this study confirms the findings of previous studies suggesting negative influences of hazardous facilities, and positive effects from trees on housing prices. Furthermore, this study uncovers that amount of tree coverage within a neighborhood have an indirect impact on housing values. Specifically, trees in neighborhood environments significantly reduce the negative influence of distance to TRI hazardous chemical facilities. Negative influences of TRI hazardous chemical facilities appear not to be significant in many-treed neighborhoods while hazardous chemical facilities show negative influences on housing values in neighborhoods less-covered by trees.

1. Introduction

Ecologists and environmental psychologists have noticed positive relationships between various forms of vegetation cover and psychological and social responses among urban dwellers. For example, in neighborhood environments, the presence of vegetated areas increases environmental satisfaction among residents (Kaplan, 2001; Lee, 2002), as well as social interactions (Kweon et al., 1998). Vegetation can also provide softening, space-enhancing, and screening effects at eye level (Cooper Marcus and Sarkissian, 1986). Vegetation also fosters public health and reduces levels of inner-city violence and crime by helping to relieve mental fatigue (Kuo and Sullivan, 2001). Similarly, vegetation in a hospital patient's environment speeds recovery from surgery and aids in stress reduction (Ulrich, 1984; Ulrich et al., 1991).

The economic effects of vegetation in urban settings have also been investigated. Urban economists have found that vegetation by itself or associated with other natural elements affects housing prices and property values (Bolitzer and Netusil, 2000; Luttik, 2000; Tyrväinen, 1997, 2001). Most studies report that vegetation provides aesthetic amenities to houses and neighborhoods and increases housing prices and property values in the local market.

Negative effects on property values come from factors such as environmental pollution and risks. For example, Hageman (1981) identified negative effects of nuclear power plants on housing prices. Folland and Hough (1991) also found these negative effects and extended them to show that even the prices of agricultural lands were significantly diminished by the presence of a nuclear reactor. Housing and land values are consistently and significantly related to environmental factors such as flooding risk (Dei-Tutu, 2002), water quality (Leggett and Bockstael, 2000; Michael et al.,

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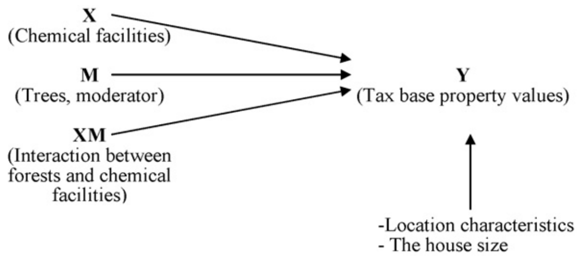

Fig. 1. Framework of the moderation model of the effect of forests on the relationship between tax base property values and distance to chemical facilities.

1996), air quality (Leggett and Bockstael, 2000), nuclear repositories or power plants (Metz and Clark, 1997; Nelson, 1981; Slovic et al., 1991), airport noise (Nelson, 1979), and proximity to toxic waste sites (Boyle and Kiel, 2001; Kohlhase, 1991).

We examined the relationship between chemical facilities and tax base property values. Theoretically, chemical facilities can negatively affect property values in a number of ways such as by potential risk, pollution, and negative visual perceptions. More importantly, we examined how vegetation cover moderates the relationship between chemical facilities and tax base property values. Because visual perception is a critical factor in a person's interaction with the surrounding environment, we hypothesized that vegetation cover can moderate the negative effects of chemical facilities on tax base property values by acting as a visual screen or barrier.

2. Materials and methods

2.1. Moderation model

To test the moderation effect, we used the moderation model of Baron and Kenny (1986). Moderation can be understood as a variable that changes the direction or strength of the relationship between dependent and independent variables. In statistical terms, moderation can be considered an interaction between an independent variable and a factor (moderator) and its relationship to a dependent variable. Baron and Kenny (1986) provided some examples of moderation frameworks. If a moderator is dichotomous and the independent variables are continuous, testing can reveal the difference between two correlation coefficients or the slopes of two regression coefficients. Regardless of the types of variables, a moderation model can be constructed using a dependent variable, independent variable(s), moderator, and the interaction between the moderator and independent variable(s) (Fig. 1). In the moderation model framework, testing for interaction (such as by the interaction term *XM* comprising variable *X* and moderator *M*) can detect a moderator effect. In this way, the moderator effect can be tested by comparing a with-interaction model and a without-interaction model (Cohen and Cohen, 1983).

The hypothesized moderation model in Eq. (1) states that the nearness of a property to a chemical facility listed in the Toxics Release Inventory (TRI) will negatively affect tax base property values; however, foliage coverage can positively contribute to tax base property values and will moderate the negative effects of the TRI chemical facilities. In other words, the relationship between TRI chemical facilities and tax base property values is a function of the foliage coverage in residential areas. Fig. 1 and Eq. (1) also include housing and location characteristics that are commonly reported as significant variables in housing-market studies (Kestens et al., 2004; Tyrväinen, 1997). Before the conceptual moderation model was finalized, all available independent variables were pre-tested in the regression model, and some were dropped because of low *t*-values ($p < 0.05$) and possible internal correlations with other variables.

$$y_v = \alpha + \beta_1 X_c + \beta_2 X_f + \beta_3 X_c X_f + \beta_4 X_h + \beta_5 X_l + \varepsilon \tag{1}$$

where y_v is the tax base property value, X_c the distance of a property to chemical facilities, X_f the foliage coverage within the neighborhood, $X_c X_f$ the product of the distance of a property to TRI chemical facilities and foliage coverage, X_h the house size, X_l the location characteristics, α the constant and β_1, β_2, β_3, β_4, and β_5 are the coefficients; and ε is the error.

From Eq. (1), if a moderator (i.e., foliage coverage within a neighborhood) is dichotomized at a certain point and given values of more foliage coverage (MF, $X_f = 1$) and less foliage coverage (LF, $X_f = 0$), Eq. (1) can be broken into two separate equations. In areas with less foliage coverage (LF), the equation consists of only the constant, distance to TRI chemical facilities and the housing and location terms because the foliage term (X_f) and interaction terms ($X_c X_f$) drop out of the equation when $X_f = 0$ (Eq. (2)). The foliage term becomes a constant in areas with more foliage coverage (MF) because $X_f = 1$ in Eq. (3). The moderation effect can be tested by examining whether or not the slope of X_c in the LF model and the slope of X'_c in the MF model are significantly different. More specifically, a moderation effect of vegetation cover is indicated if β_1 in Eq. (2) is significantly different from β'_1 in Eq. (3); *t*-statistics can be used to test the significance difference in the two slopes (Cohen and Cohen, 1983, p. 56) while holding the housing and location terms at mean values. From the hypothesis, β'_1 (i.e., $\beta_1 + \beta_3$) is expected to be significantly smaller then β_1 because of the moderation effect of vegetation cover when housing and location characteristics are controlled in the models.

$$Y_{LF} = \alpha + \beta_1 X_c + \beta_2 X_h + \beta_3 X_l + \varepsilon, \text{ when } X_f = 0 \tag{2}$$

$$Y_{MF} = (\alpha + \beta_2) + (\beta_1 + \beta_3) X'_c + \beta 4 X'_h + \beta_5 X'_l + \varepsilon', \text{ when } X_f = 1, \text{ and } = \alpha' + \beta'_1 X'_c + \beta'_2 X_h + \beta'_3 X_l + \varepsilon \tag{3}$$

where $\alpha' = (\alpha + \beta_2)$ and $\beta'_1 = (\beta_1 + \beta_3)$

2.2. Site and data

The study site, Tarrant County, is an urban county located in the northern part of Texas. Fort Worth serves as the county seat to a county population of approximately 1.4 million residents spread among 36 cities. With neighboring Dallas County, Tarrant County is one of the fastest-growing urban counties in Texas and in the US (US Census, 2000). This study was based on tax base market values of single-family houses in Tarrant County. The Texas Property Tax Code mandates that appraisal districts in the county annually appraise property values as of 1 January. The code also clearly states that each property shall be appraised based on individual characteristics that affect the property's market value. Therefore, the tax base market values of property in Tarrant County take into account the market value, as well as individual characteristics of a property.

The Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 and the Pollution Prevention Act of 1990 that expanded on the EPCRA require businesses and federal facilities to report the locations and quantities of chemicals stored on-site to state and local governments to assist in response in the event of chemical spills or other emergencies. EPCRA Section 313 requires the U.S. Environmental Protection Agency (EPA) and individual states to annually collect data on releases and transfers of certain toxic chemicals from industrial facilities and to make these data available to the public in the Toxics Release Inventory (TRI). The TRI includes approximately 650 different chemical types (U.S. EPA, 2005; for more details of TRI chemicals, see Table II, EPCRA Section