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The impact of detention basin design on residential property value: Case studies using GIS in the hedonic price modeling

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ABSTRACT

This study examined the impact of two different detention basin designs on residential property value. The hedonic price model was applied to analyze two College Station, TX, subdivisions. One subdivision had only uniuse flood control detention basins (UDBs) and the other included a multi-use detention basin (MDB) integrating a detention pond with a recreational neighborhood park. Geographic information system (GIS) was used for analysis. Spatial autocorrelation and spatial regression were analyzed. The results indicate that the network distance from the UDBs did not have a significant effect on residential property value. Yet, the properties with a view of the UDBs were significantly lowered in property value. In contrast, the network distance from the MDB where a neighborhood park was merged had a significant impact on residential property value within the 274-m (900-ft) impact area, consistent with expectations. The study also found that environmental amenities such as recreational facilities improved the hedonic price model for the impact area of the MDB, whereas the effect of spatial and locational features was not significant due to its spatial location. The findings of this study imply that thoughtful integration between recreation facilities and detention basins could significantly alter public's perception of detention basins from stormwater collection eyesores to neighborhood parks. The challenge is whether municipal governments are willing to adopt a policy that encourages developments with MDBs as these municipalities will typically become responsible for maintaining them after construction.

1. Introduction

Detention basins are typically used as uniuse detention basins (UDBs) solely for flood control. In subdivisions, UDBs are mostly small in size and maintained by homeowner associations. According to Debo and Ruby (1982), UDBs have unfavorable influences on public's perception and quality of life in communities by raising issues such as maintenance problems, health and safety issues, and aesthetic and visual disamenity. In contrast, multi-use detention basins (MDBs) provide multi-functional benefits, in which recreational facilities and MDBs are integrated together along with the intended stormwater control. MDBs are typically larger because of the inclusion of recreational facilities, and they are mainly maintained by municipal governments.

The public's negative perceptions toward UDBs (Debo and Ruby, 1982) are reflected in locational decisions and property values. In response, residents are inclined to perceive safety, visual, and recreational benefits as being more preferred than the UDBs' basic purpose of controlling flood waters. Furthermore, most people pay attention to safety and health issues when searching for a new home. As a response to these public's perceptions, multi-use detention basins that integrate stormwater management functions into neighborhood parks have been developed and constructed.

The purpose of this study was to investigate the influence of different types of detention basin designs on residential property value. Previous studies associated with costs, benefits and public's perception of detention basins were reviewed. Several hedonic price models for two communities located in College Station, TX, with different detention basins were established for the investigation and the final hedonic price models were explained in terms of their impacts on residential property value. Finally, policy implications and recommendations were summarized.

2. Previous studies

Many studies have found that detention basins provide some benefits to communities. Braden and Johnston (2004) conducted a study on the economic benefits of stormwater management and argued that there are numerous advantages including lower drainage system cost, better water quality, less erosion and sedi-

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mentation, and increased ground water recharge. Detention basins also positively affect hydrology by reducing potential flood risk, runoff quantity, and peak discharge rate increased by land development and urbanization. Aquatic habitats can also be preserved by detention basins that alleviate channel erosion (EPA, 1999). Moreover, water quality can be improved to a certain degree by filtering out certain types of pollutants prior to their introduction into receiving streams and rivers (EPA, 1999; Winer, 2000).

Some studies have focused on public's perception and the impact of stormwater detention basins. Debo and Ruby (1982) explored mainly the negative impacts of detention basins within Georgia metropolitan regions and found that almost half of the residents did not know about the existence of nearby detention basins. Only 12% of residents answered that detention basins had an effect on their perception of detention basins. Furthermore, their study found that small basins generally did not function as designed, and even created some problems with regard to maintenance, health and safety, and effectiveness in flood control.

Watt et al. (1997) mentioned in their case study that the property owners' perception of the basin's amenities could be inconsistent with its purposes. They also found that visual and recreational amenities have been sometimes selected as more important than its main flood control function. It is required, they asserted, to understand the different public's perceptions, to identify the conflicts, and to educate the public on the full range of benefits that these detention basins provide.

Meanwhile, a study on the use of basins and attitudes about their role in locational decisions found that properties adjacent to a wet pond were perceived as the most valuable assets; those close to a dry basin, however, were regarded less valuable (Emmerling-DiNovo, 1995). The study claimed that attention to design, plant material, and continuous maintenance would offer a positive impact.

Expo Park located in Aurora, Colorado is another example that provides evidence to support a MDB. In particular, the Expo Park project showed that a MDB can serve as a valuable asset that improves water quality, provides multi-use areas, controls flood, reduces maintenance, and enhances aesthetics through innovative design and cooperation (Hamilton et al., 2001).

In summary, UDBs are regarded as negative facilities in communities because the residents commonly perceive them as objects generating maintenance, health, and safety problems. UDBs' main flood control purpose is conflicted with other amenities and is recognized as less important due to these negative perceptions. Numerous studies have shown that detention basins can have a negative impact on property values. However, economic, environmental, and aesthetic values can be enhanced when careful attention is paid to design, maintenance, and specific concerns of multiple uses (Ferguson, 1991; Emmerling-DiNovo, 1995; Hamilton et al., 2001).

3. Analytical framework

3.1. Empirical model and method

Residential properties are not homogeneous all over a community. They are composed of different characteristics. When people purchase homes, they purchase dwelling units as well as other characteristics including both locational and environmental amenities and disamenities at the same time (Kong et al., 2007). Therefore, it makes sense that the price of a residential property includes the value of various characteristics in addition to housing structure attributes. In this sense, housing price can be described as a function of the heterogeneous dimensions of a residential property. In other words, the price of a residential property is determined by a group of several different factors. They generally consist of the housing structure, spatial and locational features, and neighborhood environmental attributes (Geoghegan, 2002; Irwin, 2002; Kong et al., 2007). The functional form of the empirical model can be expressed as follows:

$$\mathrm{HP} = f(x_1, x_2, x_3, \ldots, x_k),$$

where HP is the sale price of the residential properties in a community and $x_1, x_2, x_3, \ldots, x_k$, are heterogeneous characteristics of the residential properties. The heterogeneous characteristics can also be divided into several groups. The model can then be expressed as a deterministic form as follows:

$$\mathrm{HP} = \alpha + \beta_1 S + \beta_2 L + \beta_3 E + \varepsilon,$$

where HP is an $(n \times 1)$ vector of housing prices; S is an $(n \times i)$ matrix of housing structure attributes; L is an $(n \times j)$ matrix of spatial and locational features; E is an $(n \times k)$ matrix of neighborhood environmental attributes. In particular, detention basin-related variables are included in neighborhood environmental attributes, E. α is a constant, and $\beta_1, \beta_2, \beta_3$ are the estimated parameter vectors, and ε is an $(n \times 1)$ vector of error terms normally distributed with a zero mean and constant variance.

Analytical framework and estimation method of spatial econometrics were employed to analyze potential spatial dependence (or spatial autocorrelation) in the hedonic model estimation process. Spatial autocorrelation implies that housing values can be grouped with a spatial pattern (positive spatial autocorrelation), or housing locations can be encompassed with different property values (negative spatial autocorrelation). Two different modeling types were applied for hedonic model estimation in this study: a spatial lag model and a spatial error model (Anselin and Bera, 1998; Anselin et al., 2004).

The spatial lag model or mixed regressive, spatial autoregressive (SAR) model can be specified as

$$y = \rho W y + X\beta + \varepsilon, \quad \text{or}$$

$$y = (I - \rho W)^{-1} X\beta + (I - \rho W)^{-1}\varepsilon,$$

where y is an $(n \times 1)$ vector of housing price variable; Wy is the spatially lagged housing price variable for an $(n \times n)$ spatial weight matrix W; X is an $(n \times m)$ matrix of all explanatory variables including housing structure characteristics, spatial and locational features and neighborhood environmental attributes; ε is an $(n \times 1)$ vector of error terms; β is an $(m \times 1)$ vector of regression coefficients; ρ is the spatial autoregressive parameter.

It is necessary to note that the coefficients estimated with the ordinary least squares (OLS) method in a regression analysis can be biased when a spatial lag variable is not taken into account in the model specification. Statistical significance of the spatial autoregressive parameter (ρ) implies the existence of spatial autocorrelation in the data. The spatial lag term, on the other hand, can be included to handle spatial autocorrelation caused by spatial mismatch (Anselin, 1988; Anselin and Bera, 1998).

Another method to address spatial autocorrelation is to define a spatial process for the error terms. The SAR error model can be expressed as

$$y = X\beta + \varepsilon; \quad \text{where} \quad \varepsilon = \lambda W\varepsilon + u = (I - \lambda W)^{-1}u, \quad \text{or}$$

$$y = X\beta + (I - \lambda W)^{-1}u = \lambda W y + X\beta - \lambda W X\beta + u$$

where y is an $(n \times 1)$ vector of housing price variable; X is an $(n \times m)$ matrix of all explanatory variables; ε is an $(n \times 1)$ vector of error

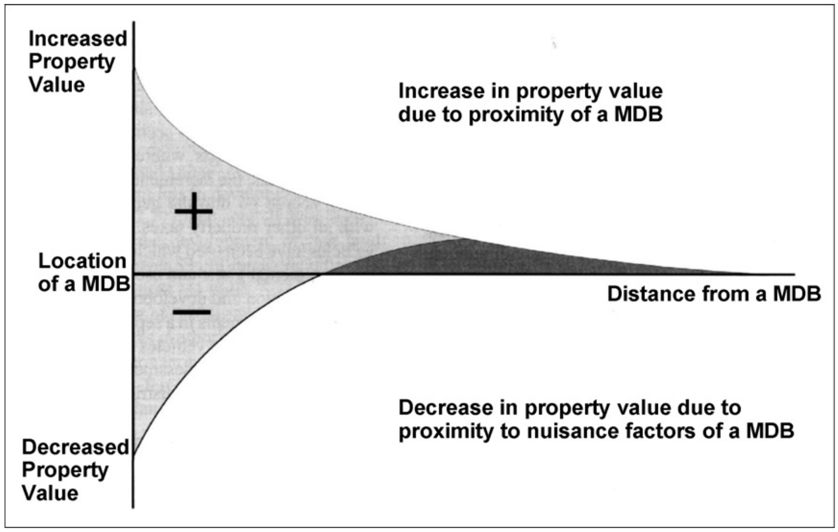

Fig. 1. The impact of a MDB on property value [modified from original source of Crompton (2000, p. 15)].

terms; β is an $(m \times 1)$ vector of regression coefficients; λ is the spatial autoregressive coefficient for the error lag $W\varepsilon$; u is an $(n \times 1)$ vector of error terms with a constant variance.

It should be stated that the estimated parameters with the OLS method are unbiased but inefficient when the spatial error terms are not well considered in the model specification process. The spatial autoregressive coefficient (λ) can be treated as a nuisance factor because spatial autocorrelation lies in either measurement errors or ignored variables in a model specification (Anselin, 1988; Anselin and Bera, 1998).

In addition, this study employed the hierarchical regression analysis method, which effectively tests whether each set of variables can significantly explain the variance of the dependent variable (i.e., price of residential properties) while statistically controlling the set of housing structure variables (Cohen and Cohen, 1983). In this method, independent variables were divided into small groups of similar characteristics: housing structure, spatial and locational features, and neighborhood environmental attributes including detention basin-related variables. Next, a proper sequence of sets of variables called "hierarchy" was decided using the study purpose and objective as a guide. Based on the previous studies and the basic principles of hierarchical order, this study used the empirical model with the hierarchy: (1) housing structure, (2) spatial and locational features, and (3) neighborhood environmental attributes. These three sets of variables were put into the model cumulatively in the hierarchical order.

The R-square (R^2) of the model incrementally increased as additional independent variables were introduced to the model. The increment of R^2 by prior sets was not affected by the subsequent groups of explanatory variables (Cohen and Cohen, 1983). The change in R^2 of the hierarchical regression analysis can be described as follows:

$$R^2_{\mathrm{Y \cdot SLE}} = R^2_{\mathrm{Y \cdot S}} + R^2_{\mathrm{Y \cdot (S \cdot L)}} + R^2_{\mathrm{Y \cdot (S \cdot L \cdot E)}},$$

where $R^2_{\mathrm{Y \cdot SLE}}$ is the coefficient of determination of the full model, $R^2_{\mathrm{Y \cdot S}}$ is the coefficient of determination of the model only including a set of the housing structure variables, $R^2_{\mathrm{Y \cdot (S \cdot L)}}$ is the increment of the coefficient of determination of the model with the addition of spatial and locational feature variables, and $R^2_{\mathrm{Y \cdot (S \cdot L \cdot E)}}$ is the increment of the coefficient of determination of the model with the further addition of neighborhood environmental attribute variables.

Alternative method to test the significance of each hierarchy is the likelihood ratio (LR) test if the maximum likelihood estimation method is used in the model estimation process. LR statistic can be simply expressed as follows:

$$\mathrm{LR} = 2(L_{\mathrm{ur}} - L_{\mathrm{r}})$$

where L_{ur} is the log-likelihood value of the unrestricted model, and L_{r} is the log-likelihood value of the restricted model.

In order to compute LR statistic, other two hierarchies, i.e., spatial and location features and neighborhood environmental attributes, were added to the basic restricted model only containing constant and housing structure variables in the same order as the method using incremental R-square. If the sample size is large enough, LR statistic follows the chi-square (χ^2) distribution with a degree of freedom equal to the number of restrictions in the null hypothesis. The hierarchical analysis was to test the null hypothesis: there is no increment in the variance of the dependent variable explained by additional set of independent variables (Gujarati, 2004).

3.2. An approach to a multi-use detention basin

A detention basin included in a neighborhood park and maintained as an open space is not unusual in the U.S. (EPA, 1999). In fact, many neighborhood parks have their sports fields placed in detention basins. For the purpose of this study, it is necessary to describe the working definition of a MDB, that is, a detention basin that incorporates a recreational neighborhood park used as an open space or sports fields (MDB hereinafter). Based on the definition, a MDB has cooperative multiple purposes including flood control and recreational activities. Because a MDB is a neighborhood park-like facility, the impact of a MDB on housing value can be explained using John Crompton's research on the impacts of parks on residential property value (Crompton, 2000, 2004). As illustrated in Fig. 1, both positive and negative effects, indicated by "+" and "−" signs, respectively, can be generated by a MDB. The positive market values caused by proximity and accessibility to the basin will decrease as the distance from the facility increases. On the other hand, negative impacts mainly due to the nuisance factors such as congestion, noise, vandalism, and poor maintenance will decrease the property value more sharply than the positive influences as the distance becomes greater (Crompton, 2000).

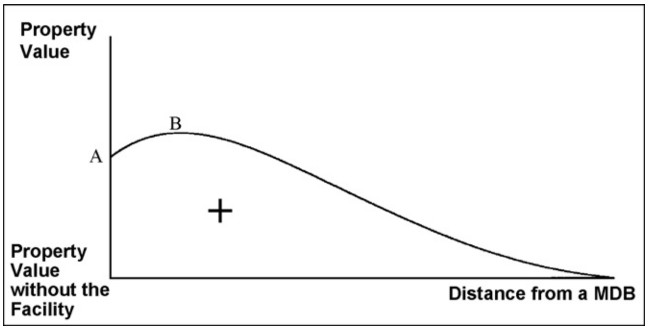

Fig. 2. The net effect of a MDB on property value [modified from original source of Crompton (2000, p. 16)].

As shown in Fig. 2, the net effect of a MDB is expected to be positive as a whole; the magnitude of net positive impact adjacent to the basin (point A) is slightly lower than that of the properties located two blocks away from the facility (point B). This is mainly due to the side effects of a park concluded by Crompton (2000). In the case of a MDB surrounded by streets, the side effects could be buffered by the streets, and, therefore, the conceptual relationship between residential property value and distance from the basin should be inverse. Moreover, this negative relationship is supposed to be significant to a certain extent called the "impact area of a MDB." According to Crompton (2000), the benefit diminishes between 150 and 900 m (500 and 3000 ft) away from the park perimeter in an urban context. Negative effects will be given irrespective of the types of parks if they are not well designed and maintained.

4. Analytical procedures

This study examined the impact of two types of detention basins on property value. Two communities in College Station, TX, with different detention pond designs were analyzed. Data used in the study were obtained from various sources. Housing price data were obtained from the Brazos County Appraisal District (2006), which also included housing structure attributes such as the number of bedrooms and main area (heated area). A geographical information system (GIS) was used for a network analysis to determine spatial and locational features. Specifically, the shortest network distance along roads from each property to each spot of locational importance was measured, in which the shortest network distance was assumed to assimilate pedestrians' walking distance in the communities. Neighborhood environmental attributes were also calculated using GIS.

The shortest network distance from each residential property to each place of interest was computed through several steps. First, complete network data were prepared to represent the network of roads in the subdivision. Next, the center of each house was connected to the road network. Meanwhile, some locational and environmental attributes were determined through site surveys and satellite aerial photos. "Accessible points" were set at the front edges of each community facility such as park, church, school and commercial area, where they were adjacent to roads, which in turn were connected to the road network. The last step was the computation of the shortest distance from houses to the accessible points of each facility. The outcomes were compared with each other to determine the final distance.

In addition, dummy variables were created to indicate whether a house was adjacent to a specific facility such as park, school, church and commercial area. "Yes" or "No" was assigned to the dummy variable to indicate whether adjacency existed.

Table 1
General variables and data sources.

Category	Variables	Data sources
Housing structure (S)	Bedroom, bathroom, built age, heated area	Brazos County Appraisal district
Spatial and locational features (L)	Distance to arterial roads, highway and commercial district. (dummy variables of adjacency to facility)	GIS data
Neighborhood environmental attributes (E)[a]	Distance to schools, church and park (dummy variables of adjacency to facility). Distance to a MDB or UDBs (dummy variable of adjacency to a drainage channel of a MDB and dummy variable of adjacency to a UDB)	GIS and site survey data

[a] Detention basin variables were originally included in neighborhood environmental attributes.

Table 1 shows three sets of variables and data sources in the hedonic price model for this study. The hedonic price model was generated after the variables to be entered into the model were determined and categorized.

Data were processed and analyzed using the Microsoft® Excel, Statistical Package for the Social Sciences (SPSS®) and GeoDa™ (Anselin, 2003, 2004; Anselin et al., 2006). In particular, GeoDa™ was employed to analyze spatial autocorrelation and spatial regression.

4.1. Woodcreek subdivision

Woodcreek subdivision is located in the eastern area of College Station, TX. It is composed of more than 160 residential properties and two small-size UDBs, one located in the north and the other in the east of the subdivision (Figs. 3 and 4). In terms of spatial and locational features, Woodcreek Drive runs through the center of the subdivision and serves as a collector road to State Highway 6. Commercial sites are located in southern and western areas, distant from the subdivision. Neighborhood environmental attributes beyond single family homes are comprised of a small park and a church in the northwest portion of the development.

Three hypotheses were established for Woodcreek subdivision with two UDBs.

First, residential property value does not significantly decrease with increasing distance from the UDBs.

Second, the property value of houses with a view of the UDB is significantly lower than that of other properties in the subdivision.

Third, spatial and locational features and neighborhood environmental attributes contribute significantly to the improvement of the hedonic price model.

The dependent variable was the property value, represented by the value of main (or heated) area. A semi-logarithm linear model was employed as a functional form of the model. Table 2 presents explanatory variables.

4.2. Edelweiss Estates subdivision

The Edelweiss Estates subdivision is located in the southwest of College Station, TX. It is a relatively large area made up of about 600 residential properties and a MDB, i.e., the Edelweiss Park (Figs. 5 and 6). The subdivision encompasses a commercial district to the west and some industrial land uses to the south. The MDB covers an area of 5 ha (12.3 acres). The inventory includes two soccer and baseball fields, open volleyball and basketball courts, a jogging and walking trail, a pavilion, and a parking lot for 10 vehicles.

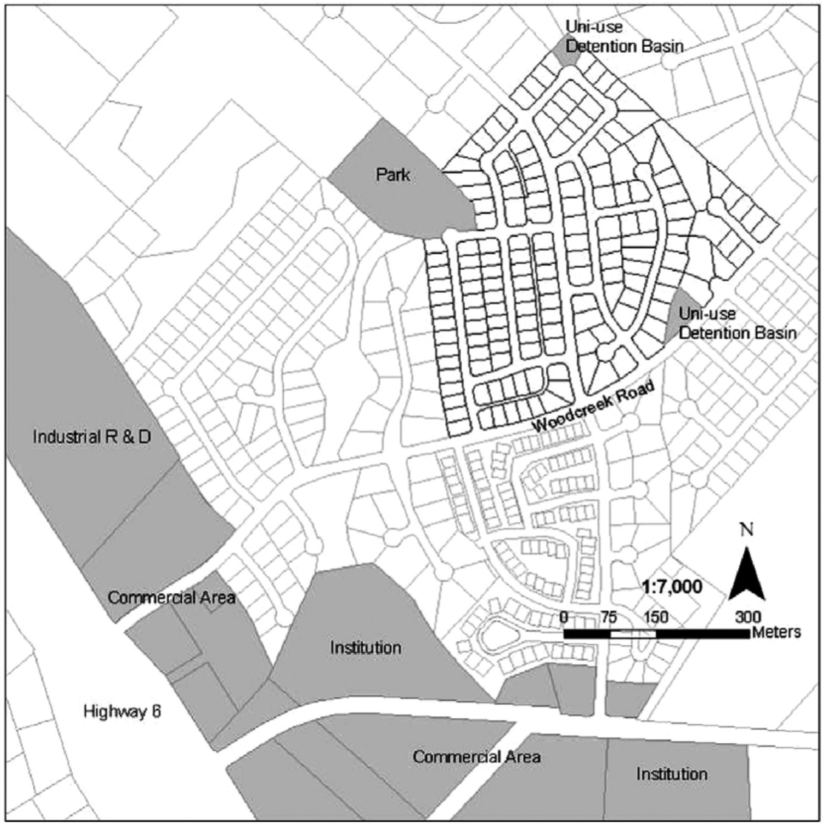

Fig. 3. Study area of the Woodcreek subdivision.

Fig. 4. Photographs of the Woodcreek subdivision. (a) North detention basin; (b) east detention basin.

Two hypotheses were constructed for Edelweiss Estates subdivision.

First, residential property value decreases with increasing distance from the MDB.

Second, spatial and locational features and neighborhood environmental attributes contribute significantly to the improvement of the hedonic price model.

The property value represented by the value of heated area was also used as the dependent variable. A linear model was applied as a functional form of the model. Table 3 presents the explanatory variables that include three groups of variables.

5. Results

5.1. Woodcreek subdivision

The final model, refined by considering factors of correlation, explanatory power and previous studies are presented in Table 4. Only 9 of the 12 original independent variables that constructed the original hedonic price model were kept in the final model. The result shows that the variance of the dependent variable was well explained by the independent variables. Signs of the estimated coefficients were consistent with expectations.

Based on the result, it was found that the distance to UDBs (Dist_UDBs) from each residential property showed a negative sign but was insignificant (p-value = 0.308). This indicates that the distance from each house to UDBs had no significant effect on residential property values in this subdivision, which conforms to the first hypothesis. In addition, residential properties within view of the detention basins were significantly less expensive than others, which agrees with the second hypothesis.

Table 2
Variable selection and definition for Woodcreek subdivision.

Category	Name	Definition	Units	Mean	S.D.
Housing price	Val_Main	Appraised value of heated area	Dollar	141429.50	28360.72
Housing structure (S)	Area_Main	Size of heated area in residential area	m^2	214.72	41.16
	Bedroom	Number of bedrooms	Number	3.83	.48
	Bath	Number of bathrooms	Number	2.39	.50
	Builtyrs	Period between built year and 2006	Year	15.47	6.06
Spatial and locational features (L)	Dist_Road	Shortest distance to Woodcreek Dr.	m	279.63	153.55
	Dum_Road	Properties adjacent to Woodcreek Dr.	Y or N[a]		
	Dist_Hway	Shortest distance to Highway 6	m	1139.86	195.27
	Dist_Comm	Shortest distance to commercial Area	m	879.75	141.60
Neighborhood environmental attributes (E)[b]	Dist_Park	Shortest distance to park	m	363.85	186.79
	Dum_Park	Properties adjacent to park	Y or N[a]		
	Dist_UDBs	Shortest distance to UDBs	m	321.24	132.74
	Dum_UDBs	Properties with a view of UDBs	Y or N[a]		

[a] Y or N denotes “Yes” or “No.”
[b] Detention basin variables were originally included in neighborhood environmental attributes.

Table 3
Variable selection and definition for Edelweiss Estates subdivision.

Category	Name	Definition	Units	Mean	S.D.
Housing price	Val_Main	Appraised value of heated area	Dollar	109594.42	17461.99
Housing structure (S)	Area_Main	Size of heated area in residential area	m^2	165.80	25.86
	Bedroom	Number of bedrooms	Number	3.53	.52
	Builtyrs	Period between built year and 2006	Year	9.43	3.07
Spatial and locational features (L)	Dist_Rock	Shortest distance to Rock Prairie Rd.	m	686.74	291.50
	Dum_Rock	Properties adjacent to Rock Prairie Rd.	Y or N[a]		
	Dist_Grah	Shortest distance to Graham Rd.	m	887.68	206.40
	Dist_FM2154	Shortest distance to FM 2154	m	940.28	254.89
	Dist_Hway	Shortest distance to Highway 6	m	2579.64	249.89
	Dist_Comm	Shortest distance to commercial area	m	1155.70	256.14
	Dum_Comm	Properties within two blocks of commercial area	Y or N[a]		
Neighborhood environmental attributes (E)[b]	Dist_Churc	Shortest distance to church	m	842.81	354.68
	Dum_Churc	Properties adjacent to church	Y or N[a]		
	Dist_Spark	Shortest distance to the middle school and Southwood Park	m	1113.79	352.42
	Dum_Spark	Properties within two blocks from middle school and Southwood Park	Y or N[a]		
	Dist_SScho	Shortest distance to intermediate school	m	1226.49	267.68
	Dist_MDB	Shortest distance to entrances of MDB	m	503.40	196.76
	Dum_WC	Properties adjacent to the drainage channel of the MDB	Y or N[a]		

[a] Y or N denotes “Yes” or “No.”
[b] Detention basin variables were originally included in neighborhood environmental attributes.

Also presented in Table 4, the result of the hierarchy test using likelihood ratio statistics indicates that both spatial and locational features and neighborhood environmental attributes contributed significantly to the improvement of the hedonic price model for Woodcreek subdivision. As explained in Section 3, three hierarchies were included in the model in an orderly manner: (1) housing structure, (2) spatial and locational features, and (3) neighborhood environmental attributes. The first hierarchy test shows that the

Table 4
Result of the final hedonic price model and tests for Woodcreek subdivision.

Category	Independent variable	Coefficients	Individual test		Hierarchy test	
			t-Statistic	p-Value	LR	p-Value
	Constant	11.207	174.558	0.000		
	Lamda (λ)	0.146	1.588	0.112		
Housing structure (S)	Area_Main	3.92E−03	39.305	0.000		
	Builtyrs	−0.014	−12.908	0.000		
Spatial and locational features (L)	Dist_Road	4.61E−05	0.570	0.568	10.699	0.013
	Dum_Road	−0.029	−2.040	0.041		
	Dist_Comm	−4.39E−05	−0.486	0.627		
Neighborhood environmental attributes (E)[a]	Dist_Park	1.36E−04	3.028	0.002	14.987	0.005
	Dum_Park	0.020	1.257	0.209		
	Dist_UDBs	−4.96E−05	−1.019	0.308		
	Dum_UDBs	−0.035	−2.152	0.031		

Dependent variable is the natural log of the property value, ln(Val_Main). $N = 156$, pseudo-$R^2 = 0.963$.
[a] Detention basin variables were originally included in neighborhood environmental attributes.

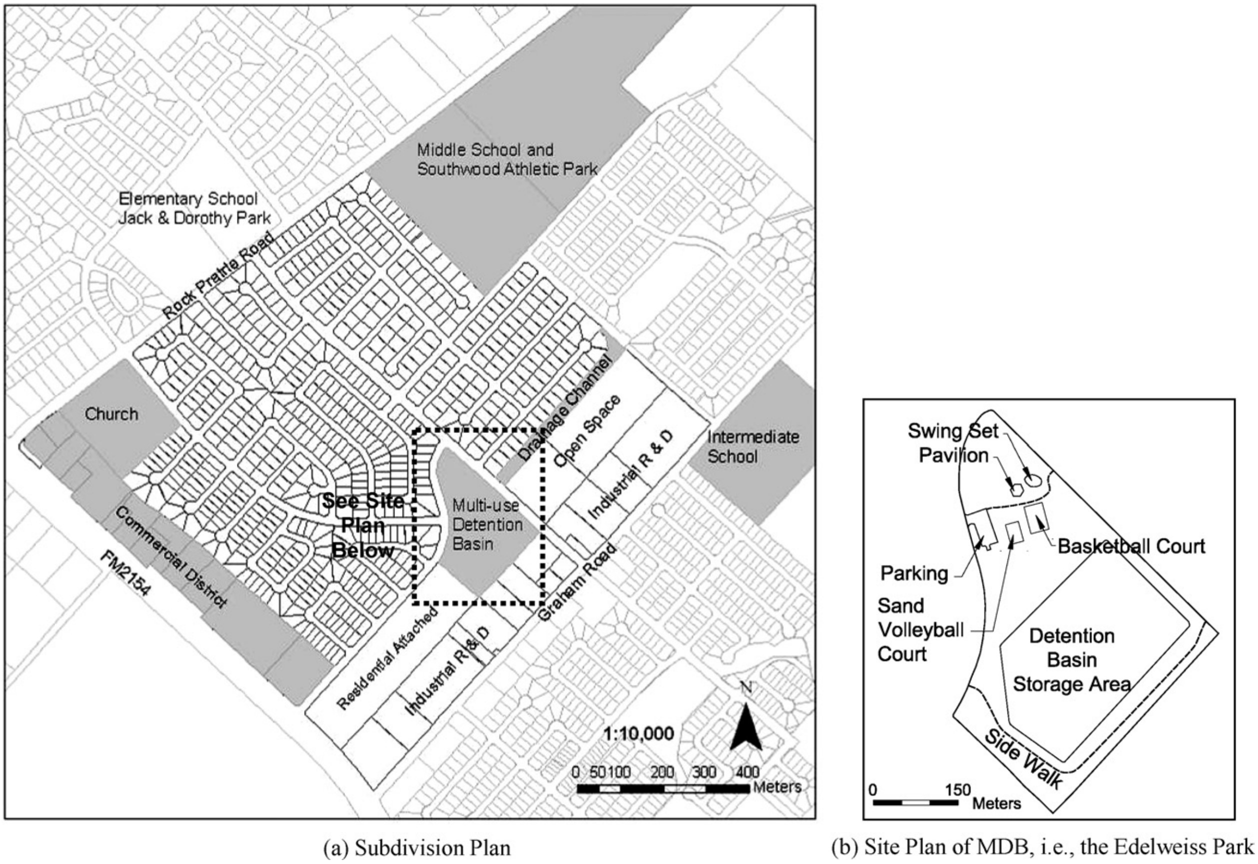

Fig. 5. Study area of the Edelweiss Estates subdivision. (a) Subdivision plan; (b) site plan of MDB, i.e., the Edelweiss park.

group of spatial and locational features significantly improved the model (LR = 10.699 and *p*-value = 0.013). The second hierarchy test also confirms that a set of neighborhood environmental attributes improved the model significantly (LR = 14.987 and *p*-value = 0.005).

5.2. Edelweiss Estates subdivision

Seventeen independent variables of three hierarchies were originally included in the hedonic price model. After the correlation analysis, only 12 independent variables were kept in the model. This is because these variables were generated from a relatively small area of the overall subdivision. Several variables were already highly correlated. As a result, only the most significant variables were kept in the model.

The result of the initial hedonic price model indicates that residential property value significantly decreased with increasing distance from the MDB to each property. Following the finding, the researchers further determined the "impact area" and "outside area" of the MDB with a series of model estimation procedures. The analyses began with examining the relationship between the value of heated area and network distance with a simple scatterplot. Where changes of the relationship were observed on the scatterplot, a series of 15-m (50-ft) increments of network distance were tried to determine the boundary of the impact area based on *p*-values of the network distance variable in the estimated models.

As a result, the 274-m (900-ft) distance was determined as the boundary of the impact area because the effect of the network distance beyond 274 m (900 ft) became insignificant, namely, the *p*-values for both 290-m (950-ft) and 305-m (1000-ft) network distance increased to 0.064 and 0.296, respectively although their coefficients (Dist_MDB) still showed negative signs (see Table 5). It should be noted that Crompton (2000) who had studied the effect of parks on property value also reported a similar impact area distance ranging between 150 and 900 m (500 and 3000 ft).

The model for the impact area is presented in Table 6. Seventy-two residential properties were within the impact area and used to construct the model for the impact area (Fig. 7). It is necessary to note that some houses along the northwest edge of the MDB had backyard fences facing the MDB. Their network distances (aka. walking distances) from the properties to the MDB were greater than 274 m, which was considered as the outside (non-impact) area. The results indicate that the hedonic price model for the

Table 5
Trials for determining the impact area of the Edelweiss Estates subdivision.

	213 m (700 ft)	229 m (750 ft)	244 m (800 ft)	259 m (850 ft)	274 m (900 ft)	290 m (950 ft)	305 m (1000 ft)
No. of properties	34	40	49	58	72	89	97
Coefficient of variable Dist_MDB	−20.548	−12.208	−9.096	−5.608	−16.482	−10.938	−6.417
Standard error	11.019	9.125	7.711	6.558	6.519	5.912	6.144
t-Statistic	−1.865	−1.338	−1.180	−0.855	−2.529	−1.850	−1.045
p-Value	0.072	0.190	0.244	0.393	0.011	0.064	0.296

Table 6
Result of the hedonic price model for the impact area for Edelweiss Estates subdivision.

Category	Independent variable	Coefficients	Individual test		Hierarchy test	
			t-Statistic	*p*-Value	LR	*p*-Value
	Constant	7538.796	1.363	0.173		
	Lamda (λ)	0.554	6.908	0.000		
Housing structure (S)	Area_Main	662.414	42.071	0.000		
	Builtyrs	−167.475	−0.578	0.564		
Neighborhood environmental attributes (E)[a]	Dist_MDB	−16.482	−2.529	0.011	11.593	0.009
	Dist_Spark	−2.784	−1.185	0.236		
	Dum_WC	2488.835	1.627	0.104		

Dependent variable is the property value, Val_Main. $N = 72$, pseudo-$R^2 = 0.987$.
[a] Detention basin variables were originally included in neighborhood environmental attribute category.

impact area was well explained by independent variables (pseudo-$R^2 = 0.987$). The coefficient of the distance to the MDB (Dist_MDB) from each residential property was significant (p-value = 0.011) and the sign was consistent with expectations.

In Table 6, the coefficient for the distance to the MDB (Dist_MDB), −16.482, indicates that the residential property values decreased by $164.82 per 10 m (33 ft) away from the MDB. Distance to the middle school and Southwood Park (Dist_Spark), although insignificant (p-value = 0.236), also had a negative effect on residential property values. Meanwhile, the dummy variable (Dum_WC) representing whether the properties were adjacent to a drainage channel of the MDB was insignificant (p-value = 0.104).

(a) Detention basin used as soccer fields (on background)

(b) Recreational facilities next to the detention basin

(c) Drainage channel next to fenced houses

Fig. 6. Photographs of the Edelweiss Estates subdivision. (a) Detention basin used as soccer fields (on background); (b) recreational facilities next to the detention basin; (c) drainage channel next to fenced houses.

From the result of the hierarchy test, two facts can be recognized. One is that the null hypothesis of the hierarchy test was rejected, which concludes that neighborhood environmental attributes significantly contributed to the improvement of the final model for the impact area (LR = 11.593 and p-value = 0.009). Another is that none of spatial and locational feature variables was included in the model for the impact area (see Table 6). This is possibly due to the spatial location of the MDB and the impact area. As shown in Fig. 7, the impact area is located at the inner part of the subdivision; therefore, it is unlikely that the properties in the impact area were significantly influenced by distant spatial and locational features such as major roads and commercial district.

Another hedonic price model was constructed for the residential properties outside the impact area. This outside area includes 527 residential properties. Similar to the analysis of the impact area, some of the original independent variables were removed after the correlation analysis. The result of the estimated model for the outside area is presented in Table 7. Overall, the variance of the dependent variable was well explained by the independent variables. Also, negative or positive signs of the estimated coefficients corresponded with expectations. Within the housing structure hierarchy, the result indicates that the property value increased with increasing size of heated area (Area_Main). On the other hand, the Builtyrs variable, period between the built year and 2006, showed that the housing price decreased as the houses became older (p-value = 0.081).

In addition, three out of four variables of spatial and locational features were significant. The distance from Rock Prairie and Graham arterial roads (Dist_Rock and Dist_Grah) both had a positive effect on the property value, suggesting that the property value increased as properties became more distant from these collector roads. Dummy variable (Dum_Rock) representing whether properties were adjacent to the Rock Prairie Road showed that those properties were significantly less valuable than others (p-value = 0.007), while Variable Dum_Comm, indicating the properties near the commercial district, was insignificant (p-value = 0.353). In this case, property values were more affected by collector roads than by commercial area.

Meanwhile, three variables of neighborhood environmental attributes representing the housing units located within one or two blocks from the middle school and Southwood Park (Dum_Spark), a church (Dum_Churc), and a drainage channel (Dum_WC) were all dummy variables. As shown in Table 7, lower housing prices for houses adjacent to the middle school and Southwood Park were observed (p-value = 0.076) while higher housing prices were found for properties adjacent to the church (p-value = 0.001).

The result of the hierarchy test in Table 7 supports the second hypothesis, that is, spatial and locational features and neighborhood environmental attributes significantly improve the hedonic price model.

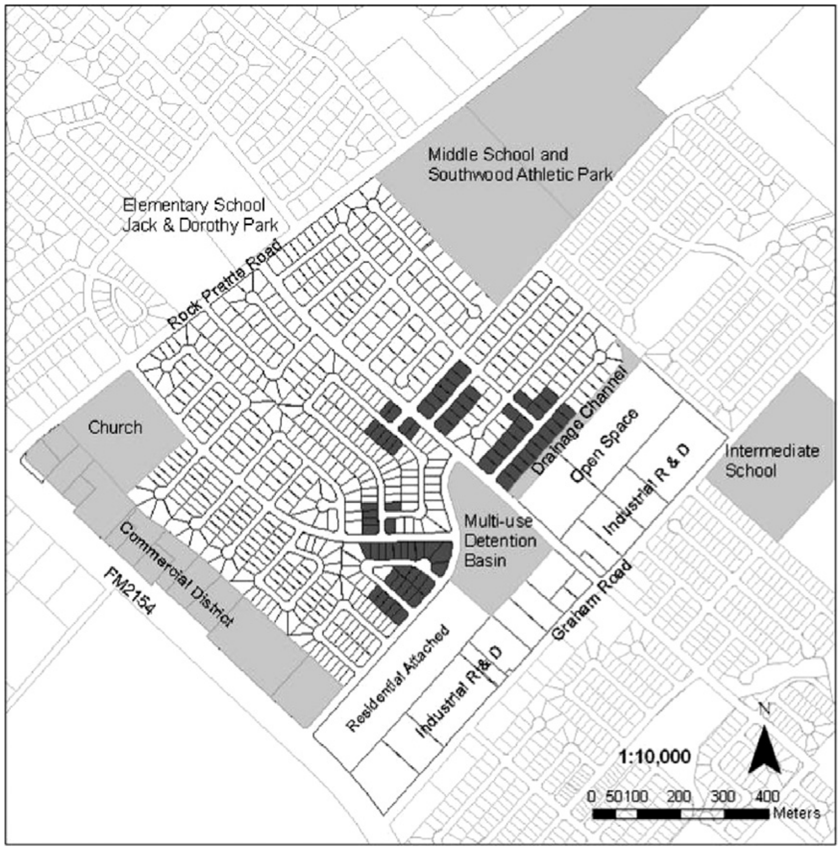

Fig. 7. Impact area of the Edelweiss Estates subdivision. *The impact area is indicated by shaded properties; houses on the northwest corner of the MDB have backyard fences facing the MDB.

Table 7
Result of the hedonic price model outside the impact area for Edelweiss Estates subdivision.

Category	Independent variable	Coefficients	Individual test		Hierarchy test	
			t-Statistic	*p*-Value	LR	*p*-Value
	Constant	−16634.610	−8.772	0.000		
	Rho (ρ)	0.233	15.909	0.000		
Housing structure (*S*)	Area_Main	565.776	65.993	0.000		
	Builtyrs	−90.624	−1.747	0.081		
Spatial and locational features (L)	Dist_Rock	5.830	7.691	0.000	64.220	<0.001
	Dist_Grah	4.169	3.494	0.000		
	Dum_Comm	−491.285	−0.930	0.353		
	Dum_Rock	−1830.654	−2.689	0.007		
Neighborhood environmental attributes (E)[a]	Dum_Spark	−888.368	−1.773	0.076	16.260	0.001
	Dum_Churc	1786.591	3.408	0.001		
	Dum_WC	1143.678	1.044	0.296		

Dependent variable is the property value, Val_Main. $N = 527$, pseudo-$R^2 = 0.972$.
[a] Detention basin variables were originally included in neighborhood environmental attributes.

6. Conclusion and implications

This study examined how detention basins with different design concepts affect residential property value using hedonic price model estimation. Two subdivisions, located in College Station, TX, with different types of detention basins were investigated. Woodcreek subdivision with two uniuse detention basins and Edelweiss Estates subdivision with a multi-use detention basin designed for sports, recreation, and stormwater management were analyzed. Several hypotheses were established in each case to assess the impact of detention basins on property value. In addition, a hierarchical analysis was used to determine whether a set of independent variables significantly improved the hedonic price model. The results can be summarized as follows.

In the Woodcreek subdivision, network distance from the UDBs did not have a significant influence on residential property value. However, a view of the UDBs had a significant impact on the value while controlling the effect of other variables. The price of residential properties with a view of the UDBs was clearly lower than that of others. In addition, the result of the hierarchical analyses indicates that both spatial and locational features and neighborhood environmental attributes including detention basin-related variables improved the hedonic price model significantly.

In contrast, the MDB in Edelweiss Estates subdivision had a significantly positive impact on residential property value within the 274-m (900-ft) impact area. Apparently the park design overcame the negative image of detention basins and made the MDB perceived as a valuable asset in the community. Moreover, another hedonic price model for those properties outside the impact area showed that once the distance from the MDB was greater than 274 m (900 ft), the distance effect became insignificant. It was also found that environmental amenities such as recreational facilities improved the model for the impact area whereas the effect of spatial and locational features was not significant due to its spatial location.

This study has limitations which should be considered in further research of stormwater detention basins. First, the number of study areas is relatively small. With additional communities that have UDBs or MDBs, generalized hedonic price models can be analyzed for UDBs and MDBs, which could increase the statistical power of the findings. In addition, analytical framework of spatial econometrics or statistics needs to be introduced to address potential spatial dependence or spatial autocorrelation in the modeling process. Second, the size between the UDBs and MDB of the study is quite different. An improvement will be to find detention basins that are similar in size. Third, this study only focused on the relationship between residential property value and types of detention basins. However, the internal connection between them is not simple as described in the study. Rather, it is reasonable that different types of detention basins would influence the public's perception, attitude and satisfaction, which in turn affects the property value. In this study, appraised property value was used because sale price data was not available and not all the properties would have sale transactions within a short timeframe suitable for this study. An alternative will be to use a contingent-valuation (willingness to pay) method to collect data. In addition, socioeconomic variables such as household size, income and tenure were not considered. This is because the hedonic price models were estimated for the neighborhood level but not for regional or city-wide level. Nonetheless, socioeconomic variables could be considered.

Several policy implications can be raised from the findings of the study. First, it seems that visual effect, aesthetics, and safety are considered to be the most important concerns in subdivisions with UDBs. Therefore, it is necessary that more attention should be paid to such issues during the site planning and design process. From this sense, examining existing UDBs for their visual effect and maintenance effort could potentially improve those poorly maintained UDBs.

Policies that include MDBs in subdivision design should be encouraged over UDBs. Certainly, policy alone cannot guarantee a successful outcome. Design, implementation, and maintenance are also critical. Thoughtful integration of the recreational function into detention basins could completely alter the public's perception from stormwater collection eyesores to neighborhood parks. A well-planned design process that engages interest groups in the early development stages is a prerequisite to create a successful community design. Lastly, regardless of whether the detention basins are uniuse or multi-use, maintenance is always a critical factor for not only affecting the public's perception but also neighborhood quality of life. One of the challenges ahead becomes whether the city government is willing to adopt a policy that encourages developments with MDBs. This challenge exists because the municipal government typically assumes the responsibility for maintaining parks and therefore, a MDB with a park-like functionality becomes the municipality's responsibility.

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References

Anselin, L., 1988. Spatial Econometrics: Methods and Models. Kluwer Acacemic Publishers, Dordrecht, Netherlands.
Anselin, L., 2003. GeoDa^{TM} 0.9 User's Guide. Spatial Analysis Laboratory (SAL), Department of Agricultural and Consumer Economics, University of Illinois, Urbana-Champaign, IL.
Anselin, L., 2004. GeoDa^{TM} 0.9.5-i Release Notes. Spatial Analysis Laboratory (SAL), Department of Agricultural and Consumer Economics, University of Illinois, Urbana-Champaign, IL.
Anselin, L., Bera, A., 1998. Spatial dependence in linear regression models. In: Ullah, A., Giles, D. (Eds.), Handbook of Applied Economic Statistics. Marcel Dekker, New York, pp. 237–289.
Anselin, L., Bongiovanni, R., Lowenberg-DeBoer, J., 2004. A spatial econometric approach to the economics of site-specific nitrogen management in corn production. Am. J. Agric. Econ. 86, 675–687.
Anselin, L., Syabri, I., Kho, Y., 2006. GeoDa: an introduction to spatial data analysis. Geogr. Anal. 38 (1), 5–22.
Braden, J.B., Johnston, D.M., 2004. Downstream economic benefits from storm-water management. J. Water Resour. Plann. Manage. 130 (6), 498–505.
Brazos County Appraisal District, 2006. Property Assessment and Tax Information. Available at: www.brazoscad.org/Appraisal/PublicAccess (accessed March 26, 2007).
Cohen, J., Cohen, P., 1983. Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences, second edition. Hillsdale, NJ.
Crompton, J.L., 2000. The Impact of Parks and Open Space on Property Values and the Property Tax Base. National Recreation and Park Association, Ashburn, VA.
Crompton, J.L., 2004. The Proximate Principle: The Impact of Parks and Open Space and Water Features on Residential Property Values and the Property Tax Base, second edition. National Recreation and Park Association, Ashburn, VA.
Debo, T.N., Ruby, H., 1982. Detention basins-an urban experience. Public Work 113 (1), 42–43.
Emmerling-DiNovo, C., 1995. Stormwater detention basins and residential locational decisions. Water Resour. Bull. 31 (3), 515–521.
Ferguson, B.K., 1991. Taking advantage of stormwater control basins in urban landscapes. J. Soil Water Conserv. 46 (2), 100–103.
Geoghegan, J., 2002. The value of open spaces in residential land use. Land Use Policy 19, 91–98.
Gujarati, D.N., 2004. Basic Econometrics, fourth edition. McGraw-Hill Publishing, Boston, MA.
Hamilton, K., Hindman, P., Wegener, K., 2001. Water quality and multi-use improvements to a storm runoff detention facility: state dam. In: Proceedings of the World Water and Environmental Resources Congress, Environmental and Water Resources Institute of ASCE, Orlando, FL, p. 215.
Irwin, E.G., 2002. The effects of open space on residential property values. Land Econ. 78 (4), 465–480.
Kong, F., Yin, H., Nakagoshi, N., 2007. Using GIS and landscape metrics in the hedonic price modeling of the amenity value of urban green space: a case study in Jinan City. Chin. Landsc. Urban Plann. 79 (3/4), 240–252.
U.S. Environmental Protection Agency (EPA), 1999. Preliminary Data Summary of Urban Storm Water Best Management Practices. Office of Water, Washington, DC, Available at: www.epa.gov/waterscience/guide/stormwater (accessed March 26, 2007).
Watt, W.E., Marsalek, J., Anderson, B.C., 1997. Stormwater pond perceptions vs. realities: a case study. In: Sustaining Urban Water Resources in the 21st Century. Proceedings of an Engineering Foundation Conference. ASCE, Melmo, Sweden.
Winer, R., 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, second edition. Center for Watershed Protection, Ellicott City, MD.

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