An Option Value Approach to Valuing Preservation Properties

By

Jason A. Winfree
Jill J. McCluskey
Ron C. Mittelhammer

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Abstract: There has been a recent trend towards purchasing land for farmland preservation, wildlife refuges, other conservation, and cultural and historical preservation. There is a great deal of unexplained variation in the dollars paid per acre for these properties. The theoretical basis for this analysis is an option value model with stochastic returns to development. The data used in our analysis is sales transactions data for natural resource conservation and farmland preservation purposes from throughout the United States. We find that land, when it would be best used for development, but is not developed, has a significantly higher price.

*Winfree: Ph.D. candidate, Department of Economics, Washington State University; McCluskey: Assistant Professor, Department of Agricultural Economics, Washington State University; Mittelhammer: Professor, Department of Agricultural Economics and Program in Statistics, Washington State University, Pullman, WA; The authors with to thank without implicating John Kilpartrick, Bill Mundy, Jeff Krautkraemer, and Fred Inaba for helpful discussion. Jason Winfree gratefully acknowledges a fellowship from the Thomas S. Foley Institute for Public Policy and Public Service. We are indebted to Mundy & Associates for providing the data.

Introduction

In recent years, the number of land trusts that purchase land for farmland preservation, wildlife refuges, other conservation, and cultural and historical preservation, has grown across the country. Not only have municipal, state, and federal government agencies been buying land for preservation, but also private groups that wish to conserve the land. The National Land Trust Census estimates that as of December 31, 2000, there were 6,225,225 acres of land that were protected by land trusts by 1263 different groups. In this paper, we analyze sales transaction data for land that was purchased by government agencies, private land trust groups, and individuals for conservation and preservation purposes.

There is a great deal of unexplained variation in the dollars paid per acre for conservation and preservation properties. This creates difficulties for appraisers, buyers, sellers, and policy makers. There are many factors that influence land prices. The current and potential uses of the land greatly affect land prices. When a buyer purchases undeveloped land for conservation and preservation purposes, he or she is not just paying for the current use of land. The buyer must also pay for the option value of development.

The value of land has been estimated many different ways. In this paper, we estimate land values using sales transaction data as a function of the current rents gained from the land along with the rents that could be gained from other uses of the land. When groups buy land for preservation purposes, the option to develop the land effects the price. The option value may be higher for these types of land, since the point of buying them is to keep them from being developed. The land purchase decision may reflect a greater perceived threat of development relative to land not purchased.

Development is generally considered irreversible. Therefore, some risk is involved when landowners decide to develop, since no options are then left to the landowner. So, if the landowner decides to develop, the developed land must have a higher expected value than undeveloped land. Although developing land may yield substantial rewards, often times investors' estimates of return to development are too high. Other sources of uncertainty are potential exogenous shocks caused by the evolution of the surrounding community. The returns to development depend on the surrounding economic environment, which may be very difficult to predict. It is also important to remember that if the landowner owns undeveloped land, he or she knows the current revenue that undeveloped land generates, but does not know the revenue that developed land would yield.

Since a greater percentage of land is developed near populous areas, population is an important factor when considering land development. As cities and their surrounding areas grow, the demand for development grows. On the other hand, undeveloped land generally does not depend upon population. Farmland is generally valued by the crop yield it can produce. Similarly, undeveloped recreational land does not depend as much on population, but may depend upon other characteristics of the property. One could argue that in many recreational areas, it is more enjoyable if the population is sparse.

The remainder of this paper is organized as follows: first previous studies of land development and valuation are briefly reviewed. Next, an option value model is introduced, and the reduced-form equation modeling land values as the discounted stream of returns for undeveloped and developed uses is presented. This is followed by a description of the data and a discussion of the empirical estimation and results. Conclusions are presented in the final section of the paper.

Previous Studies

There are a number of different potential explanations for the variation in prices for undeveloped land. One explanation is that there may be speculation bubbles in the real estate market (Abraham 1996). Other reasons may include inefficiencies or uncertainty of revenues or costs (Gunnelin 2001). Finally, a major impetus for price variation may be the presence of option value associated with development.

Many researchers have analyzed agricultural land valuation by including proxy variables for future development rents, which indirectly suggest an option value. Examples include Chicoine (1981), Elad, Clifton, and Epperson (1994), Hushak and Sadr (1979), Mendelson, Nordhaus, and Shaw (1994), Palmquist and Danielson (1989), Plantinga and Miller (2001), Shi, Phipps, and Colyer (1997), Shonkwiler and Reynolds (1986), and Vitaliano and Hill (1994).

A smaller number of researchers have specifically considered the effect of option values on land development and land prices. These papers include Capozza and Li (2002), Capozza and Sick (1994), Quigg (1993), Tegene, Wiebe, and Kuhn (1999), Titman (1985), and Turvey (2002).

Model of Land Valuation

When modeling the decision to develop land, it is common practice to assume that the returns to undeveloped land are stagnant and the returns to developed land are increasing (Tegene 1999). Therefore, there exists an optimal time for the landowner to develop. However, this optimal time may be later than when the returns for developed and undeveloped land are equal (Tegene 1999). Since development is irreversible, there is an opportunity cost of not being able to go back to undeveloped land. In the current paper, we include variability in the value of undeveloped and developed land (as do Quigg 1993, Plantinga and Miller 2001, Plantinga et al 2002). Therefore, even if in all likelihood the returns may be greater if the landowner develops, it may be profit maximizing to wait. If the land is undeveloped, it not only has the returns from undeveloped land, but also an option value.

For our model, there are only two choices available to the landowner: develop the land or leave it undeveloped. Although there may be a number of alternative uses for the land, we will use development as the only relevant alternative for the landowner. The rent of the undeveloped land is denoted as *U*. Also, we let the net returns accruing to developed land be *D*. If *T* is the time that the landowner decides to convert the land, then the value of the land to the land owner, is,

$$P(T) = \int_0^T U(t)e^{-rt}\,dt + \int_T^\infty D(t)e^{-rt}\,dt \tag{1}$$

Where *r* is the discount rate.

We let both *U* and *D* be Brownian motion processes. Brownian motion processes are used because it seems reasonable to assume that the error in net land revenues, take the form of the normal distribution. We assume that *U* has no drift and specify,

$$dU = s_U e_{Ut}(dt)^{1/2} \tag{2}$$

where *dU* is the change in the rent of undeveloped land, s_U is the standard deviation for undeveloped rents, e_{Ut} is distributed standard normal and is the error term for undeveloped land at time *t*, and *dt* is the change in time from $t = 0$. Note that the expected value of the net returns to undeveloped land is equal to the initial value. Although there can be variation in the undeveloped rents, the expected value is the same for all t. This implies that when the landowner decides to develop the land, the expected rents are equal to the rents that were accrued in the last period. We assume that D is a geometric Brownian motion process with drift so that,

$$D(t) = D_0 e^{X(t) - X_0} . \tag{3}$$

where D_0 is the initial value of the developed land, $X(t)$ is a Brownian motion process with drift, and X_0 is where the Brownian motion process starts. For the rents of developed land, α_d represents the drift. We let $\alpha = \alpha_d + .5\sigma_x^2$ so that,

$$dX = a_d dt + s_X e_{xt} (dt)^{1/2} \tag{4}$$

and

$$dD = aDdt + s_X D e_{xt} (dt)^{1/2}. \tag{5}$$

where dX is the change in the Brownian motion process, s_X is the standard deviation for Brownian motion process, e_{Xt} is distributed standard normal and is the error term for developed land at time t. Notice in equation (5), that the change in D can be represented as a percentage of D. As discussed later in the paper, we assume that the value of developed land is proportional to the surrounding population. It seems reasonable that population changes as a percentage of itself, therefore a geometric Brownian motion process is used to describe developed land.

To ensure the landowner will eventually want to develop the land and also to make sure the problem is bounded, we assume $0 < \alpha < r$. If we denote the initial value of U as U_0, then the expected value of the land can be written as,

$$E\left[\int_0^T U(t)e^{-rt}dt + \int_T^\infty D(t)e^{-rt}dt \middle| T\right] = \frac{U_0}{r}\left(1 - e^{rT}\right) + \frac{D_0}{r-a}e^{-(r-a)T} \quad . \tag{6}$$

In words, the price of the land is equal to the sum of undeveloped and developed returns. We also make the assumption that Cov($\varepsilon_{xt,}$ ε_{Ut}) = 0 for all *t*. That is, the two processes are independent of each other.

Assuming the landowner is maximizing expected profits, the landowner will develop the land when the value of the developed land is equal to a reservation price, *R**, i.e., the landowner's decision problem is a threshold problem. The landowner will develop at the first point in time when *R** is achieved. Since it is unknown when the rents for developed land will reach *R**, *T* is now stochastic. Therefore, given that *D(T)* is a geometric Brownian motion with drift, we can use the distribution of *T* to find the expected time it will take for the developed value of the land to reach *R** (Karlin and Taylor 1975).

$$E\left\langle e^{-rT} \middle| D_0, R^* \right\rangle = \left(\frac{D_0}{R^*}\right)^r \tag{7}$$

where,

$$r = \sqrt{\frac{a^2}{s^4} + \frac{2r}{s^2}} - \frac{a}{s^2} \tag{8}$$

Substituting equation (7) into (6) we get price which is not a function of time, so it can be written as,

$$P = \frac{U_0}{r}\left(1 - \left(\frac{D_0}{R^*}\right)^r\right) + \frac{D_0}{r-a}\left(\frac{D_0}{R^*}\right)^{\frac{r(r-a)}{r}} \tag{9}$$

Assuming that the landowner will maximize the value of the land, by taking the derivative of equation (9) with respect to R^*, holding everything else constant, and setting it equal to zero, they will develop when the following equation holds:

$$R^* = U_0^{\frac{r}{ra}} D_0^{1-\frac{r}{ra}} \tag{10}$$

Therefore, substituting the reservation price back into equation (9), the value of the land equals

$$P = \frac{U_0}{r}\left(1-\left(\frac{D_0}{U_0}\right)^{\frac{r}{a}}\right) + \frac{D_0}{(r-a)}\left(\frac{D_0}{U_0}\right)^{\frac{(r-a)}{a}} \tag{11}$$

In this representation, price is expressed as a function of the initial undeveloped rent, the initial developed rent, the growth rate of the developed rent, and the interest rate. If the land is never developed, the value is simply U_0/r, so if this value is subtracted from equation (11), the value of the option to develop the land is defined as

$$P(T^*) - P(\infty) = \left(\frac{U_0 a}{r(r-a)}\right)\left(\frac{D_0}{U_0}\right)^{r/a} \tag{12}$$

where T^* is the optimal time to develop the land. This value denotes how much landowners should be willing to pay for development rights. Further, the value of being able to use the land while it is undeveloped is

$$P(T^*) - P(0) = \frac{U_0}{r}\left(1-\left(\frac{D_0}{U_0}\right)^{\frac{r}{a}}\right) + \frac{D_0}{(r-a)}\left(\left(\frac{D_0}{U_0}\right)^{\frac{(r-a)}{a}} - 1\right). \tag{13}$$

Data

The data used in our empirical analysis is a sales transaction data set of land that was purchased by government agencies, private land trust groups, and individuals for conservation and preservation purposes. The list of government agencies includes the National Park Service, National Forest Service, Bureau of Land Management. The database includes 77 real estate transactions that occurred throughout the United States. Each parcel of land was being used as agricultural land at the time of the purchase. The data set includes sales price and independent variables, including size in acres, population within a one-hundred mile radius (in millions), whether or not the parcel has a notable wildlife habitat or species, and whether or not there is a river on the land. All of the previously specified data was obtained from a real estate consulting firm.

Yearly agricultural rents, or net cash return per acre, were obtained from the United States Department of Agriculture. Average net cash return per acre was available for every county in the data set. Although data was not available for every year, it was available in 1987, 1992, and 1997. The year that was closest to the time of the transaction was used. Net cash return per acre was calculated by dividing total agricultural net cash return for the county by the number of acres of farmland in the county. All data has been deflated and is in 1997 dollars. In some cases there are missing data. The overall sample means were used in place of this missing data. Variable descriptions and summary statistics are presented in Table 1.

Empirical Specification

In Equation (11), price is expressed as a function of the initial undeveloped rent, the initial developed rent, the growth rate of the developed rent, and the interest rate. Unfortunately, we do not have the growth rate of rents, but it is possible to obtain the undeveloped rents and developed rents. Although our theoretical model uses only one alternative use, it can be adapted for more than one use. Land can have an option value for many different uses.

We test for the presence of an option value for farmland in three ways. The first type of option value tested is for development. Here the assumption is made that population is the only factor changing the value of developed land. While there are other factors, we expect population to be a major long-term variable when considering development prices. Therefore, in our empirical model, α, the growth rate of developed rents, is determined by the population growth rate. Population within one-hundred miles of the property is used to estimate this. The second type of option value is for conservation. This is modeled by using an indicator variable if there is a notable wildlife habitat or species on the property as deemed by the appraiser. The third type of option value that is tested for is recreational usage. The presence of a river on the property is used to proxy recreational potential. While these variables are only proxies, it seems reasonable that if these variables affect the value of the land at all, the effect would be separate from the base agricultural value of the land. However, one could argue that the presence of a river increases agricultural values.

We approximate equation (11) with a basic model of land value specified as,

$$P = b_0 + b_1 rev + b_2 pop + b_3 wild + b_4 river + e \tag{14}$$

where *P* is the price per acre of the land, *rev* is average net revenue associated with the county of the property, *pop* is population within 100 miles, *wild* indicates the presence of significant wildlife, *river* indicates the presence of a river, and *e* is an error term. Since we are estimating property values, the Hedonic method is an appropriate method of analysis (Rosen 1974). As is typical when using a hedonic property value method, a

Box-Cox transformation is applied to the dependent variable to introduce flexibility in the functional relationship linking price and the factors affecting price (Goodman 1978). The Box-Cox method can also mitigate any independence, heteroskedasticity, and/or autocorrelation problems impacting the model. Using a Box-Cox transformation, prices are transformed as

$$P(l) = (P^{l} - 1)/l \tag{15}$$

where l is estimated by using the non-linear least squares technique. Before Box-Cox was applied, the dependent variable was normalized to have a mean of 1. This made the regression feasible. None of the other variables were transformed.

Empirical Results

The estimated value of the Box-Cox parameter λ is equal to 0.4389. Feasible Generalized Least Squares (FGLS), along with ordinary least squared (OLS) were used to estimate this model. In the OLS, l has a standard deviation of 0.2709, and in the FGLS model the standard deviation is 0.2621. Therefore, the semi-log model, or $l = 0$, lies within two standard deviations of l. Also, the linear model, $l = 1$, lies within three standard deviations. Since all three models are within a reasonable interval, all three were estimated. FGLS was used to correct for heteroskedasticity, which was significant in all models. In the linear model, heteroskedasticity was modeled as

$$e_i^2 = d\left(X_{i\bullet} b\right)^g + n_i\,, \tag{16}$$

in the Box-Cox model was modeled as

$$e_i^2 = d\left(X_{i\bullet} b\, l + 1\right)^g + n_i\,, \tag{17}$$

and in the semi-log model it was modeled as

$$e_i^2 = d\left(\exp(X_{i\bullet}b)\right)^g + n_i \ , \qquad (18)$$

where d and g are unknown parameters and n is an error term. These specifications reflect heteroskedasticity of the power-mean conditional type. The results of the OLS and FGLS regressions are presented in Table 2.

Although R^2's are fairly low, especially in the FGLS linear model, the estimated effects of explanatory variables are consistent with prior expectations. In the FGLS linear model, the R^2 turns out to be 0.234, in the Box-Cox it is 0.259, and in the semi-log model it is 0.201. As the results indicate, agricultural revenues, population, and the presence of rivers seem to be significantly positively related to the price of agricultural land. Although not significant, wildlife habitat is negatively related to the price of agriculture. Although this is not the expected result, it may not come as a total surprise. Extensive wildlife habitat may hinder growing crops. Another reason may be that farmers are concerned that the government may impose restrictions on the land if endangered species are found to be on the land.

If we partition the data into five geographic regions (Pacific Northwest, Southwest, Rocky Mountain States, Midwest, and East), it is possible use the region means to estimate the option value as a percentage of the value of the land if it were only used in agriculture. The means of each variable are presented in Table 3.

The option values were calculated for all three models with both OLS and FGLS. As Table 2 and Table 4 show, the results are similar in the three different models. The option value is calculated by accumulating the value added by population, wildlife, and the presence of rivers and then dividing by the total estimate of the price per acre. Note that wildlife had the option value and was included in the model. By separating the data into regions we can determine the option value for agricultural land in each region. However, it is important to note that we have assumed that coefficients are constant across regions.

When looking at the option values, they may seem slightly high when compared to related work (Plantinga et al 2002). However, we not only examined the option to develop the land, but also examined its use for recreation, which was estimated to have a positive effect. It is also not surprising that the properties in the eastern part of the United States had the highest option value. When examining Table 3, it is evident that the east has the highest population values. It is also notable that the option value associated with the Pacific Northwest is not nearly as high as the rest of the country. This seems due primarily to low population levels. Also, although recreational considerations are significant, there is little variation between regions. This may increase the option values, but does little to differentiate between the regions.

One bias in these results may be due to the presence of rivers potentially increasing the value for agricultural purposes. If a land parcel has a river on or adjacent to it, it may receive higher agricultural revenues than the county average. Therefore, the recreational option value may be overstated, which would effect the eastern region the most. Another issue that may increase the option values when compared to other studies, is the fact that the properties we are estimating are properties that have been bought for preservation purposes. This could imply that the land is about to be developed or have a great potential for being developed. This would increase the option value associated with these properties.

Conclusions

This paper supports the notion that land not only has value for its current use, but also for future uses. It may also have value for more than one potential future use. Therefore, when agricultural land is bought for preservation purposes, part of the price can be explained by crop revenues and part of the price can be explained by potential future revenues from developing the land or using it for recreational purposes.

Our results also show that although this is more significant effect in the East, it can also be a material part of land values throughout the country. Since the properties in our data set were purchased for preservation purposes, they may represent the properties that are most threatened with land use changes. This may help explain the relatively high option values for these properties. Still, it is unexpected to obtain the result that approximately half of the value of these properties value is an option value.

This study also suggests that when the government bans development, it can have severe implications to the landowner, possibly cutting their land value in half. This helps explain why banning development has been such a big issue for landowners, and why the Supreme Court is looking at it closely. Compensation for landowners when development is banned could erase large financial losses.

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TABLE 1

Summary Statistics

Variable	**Description**	**Mean**	**Standard Deviation**
P	**Price**	**1610.5**	**2205.8**
Rev	**Average Net Revenue**	**53.092**	**148.50**
Pop	**Population within 100 miles**	**1.7626**	**2.0898**
Wild	**Wildlife**	**0.4054**	**0.3425**
River	**River**	**0.2800**	**0.4460**

Number of Obsersations = 77

TABLE 2

Semi Log Results

	OLS		FGLS	
Variable	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
Constant	**5.951108**	**23.40081**	**5.72077**	**22.85519**
Avg Net Revenue	**0.002825**	**3.077694**	**0.00441**	**2.375476**
Population	**0.233758**	**3.543721**	**0.331523**	**3.488725**
Wildlife	**-0.43422**	**-1.09085**	**-0.43566**	**-1.06023**
River	**0.869442**	**2.746841**	**0.985206**	**2.965608**
R^2		**.2599**		**.2010**

Box-Cox Results

	OLS		FGLS	
Variable	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
Constant	**-0.9009**	**-4.16756**	**-1.00403**	**-4.96651**
Avg Net Revenue	**0.002453**	**3.143593**	**0.002814**	**2.628858**
Population	**0.210479**	**3.753844**	**0.247094**	**3.752671**
Wildlife	**-0.39752**	**-1.17486**	**-0.39905**	**-1.21858**
River	**0.611514**	**2.272866**	**0.689464**	**2.670675**
R^2		**.2663**		**.2594**

Linear Results

	OLS		FGLS	
Variable	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
Constant	**681.4955**	**1.5832**	**475.7097**	**1.533559**
Avg Net Revenue	**3.985048**	**2.565032**	**4.835061**	**2.041318**
Population	**436.4683**	**3.90918**	**498.4443**	**3.759603**
Wildlife	**-611.115**	**-0.90701**	**-668.198**	**-1.26569**
River	**699.3323**	**1.305318**	**1000.228**	**2.507991**
R^2		**.2421**		**.2340**

TABLE 3
Region Means

region	PNW	SW	Rocky	MID	EAST	Total
price	609.2651	3195.3335	1136.4621	1151.4654	4367.9903	1610.4691
ag rents	13.8936	184.0642	14.6326	32.4249	44.9987	53.0924
pop	0.6302	3.3629	1.4336	1.2623	4.0076	1.7626
wild	0.4264	0.4898	0.4027	0.1756	0.4527	0.4054
river	0.2777	0.2500	0.2348	0.3750	0.5700	0.2800

TABLE 4
Option Values

Region	PNW	SW	Rocky	MID	EAST	Total
Semi Log OLS	14.81%	50.27%	27.83%	45.45%	78.17%	36.13%
Semi Log FGLS	22.38%	65.25%	39.30%	57.13%	94.68%	49.04%
Box-Cox OLS	15.04%	47.98%	31.40%	46.27%	72.66%	38.20%
Box-Cox FGLS	21.20%	54.92%	39.34%	54.13%	81.00%	46.12%
Linear OLS	22.07%	48.70%	42.37%	46.54%	68.49%	44.55%
Linear FGLS	36.12%	53.93%	55.46%	58.37%	76.57%	54.79%