Conservation Policy and Land Value: The Conservation Reserve Program

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The Conservation Reserve Program (CRP), the most ambitious conservation effort in U.S. history, was initiated in the Food Security Act of 1985 and was reauthorized in all subsequent Farm Bills. As a voluntary long-term cropland retirement program, the CRP provides participants with annual rental payment, incentive payment, and cost-share assistance. In exchange, the producers retire the highly erodible or environmentally sensitive lands from crop productions for 10-15 years. By 2004, over 34 million acres of cropland had been enrolled in the CRP with an annual rental payment of approximately $2 billion (Farm Service Agency). With about 8% of the nation's cropland enrolled into the CRP, the environmental and economic benefits from the CRP have been well recognized (Young and Osborn; Osborn and Konyar; Ribaudo et. al.). For example, based on the 33.9 million acres enrolled in sign ups 1-9, Osborn and Konyar estimated that the CRP had net economic benefits of $4.2-$9 billion in present value over the life of the program. This included benefits from farm income, timber production, soil productivity, water quality, wild life habitat, and air quality. However, as the largest conservation program in U.S. history, the effects of the CRP on farmland prices have received much less attention.

The primary objective of this study is to evaluate the effect of the CRP and amenities on farmland and developed land prices. Some previous studies on the effect of government payments (not include the CRP payments) suggest that the government payments are capitalized into farmland values (Just and Miranowski; Tweeten and Martin; Melichar; Herdt and Cochrane; Barnard et al.). For example, Just and Miranowski find that the government payments account for roughly 15 to 25% of the capitalized value of land. Barnard et al. examine the effect of eliminating the Agricultural Improvement and Reform Act of 1996 (FAIR) on cropland value, and find that cropland value would be reduced by 12% to 69% in the eight examined regions as a result of eliminating government programs. Lence and Mishra utilize county-level data from 1996-2000 to examine effects of the Deficiency Payment (DEF), the Market Loss Assistance Program (MLA), the Product Flexibility Contract (PFC), and the CRP on cash rental rates in Iowa. They find that the CRP has a positive and significant impact on cash rents when they assume there exists no spatial autocorrelation across the residuals, and a positive but insignificant impact on cash rents after the spatial autocorrelation is corrected. Shoemaker uses the first five CRP sign-up data from 1986 to 1987 to examine the effect of the CRP on farmland price in the U.S., and finds that the CRP has a minor offsetting (0.5%) effect on the overall decline in land values. In contrary to these findings, Goodwin, Mishra and Magne recently apply the traditional present value approach to evaluate the effect of the Loan Deficiency Program (LDP), the Disaster Payment (DP), Agricultural Market Transition Act (AMTA), and the CRP on farmland price and find that the CRP has a negative impact on farmland value in their aggregated model.

There are a large number of hedonic studies that estimate the effect of amenities (or disamenities) on nearby property values. For example, hedonic price models have been applied to estimate the value of proximity to oceans, lakes or rivers (Lansford and Jones, Leggett and Bockstael), parks and forests (Weicher and Zerbst; Tyrväinen and Miettinen), wetlands (Mahan, Polasky, and Adams), and general indicators of open space (Wu, Adams and Plantinga; Irwin and Bockstael; Geoghegan; Irwin). However, few studies have analyzed the effect of amenities on farmland value. This neglect is surprising given that growth premium and option value are important components of farmland price and both are affected by amenities (Capozza and Helsley).

To motivate the empirical study, we first develop a theoretical model to analyze the effect of the CRP and amenities on farmland and developed land prices. The theoretical model integrates the stochastic city model developed by Capozza and Helsley with the optimal bidding behavior model developed by Lohmann and Hamsvoort. The integration is important in the following ways.

First, the integrated model endogenizes the CRP participation and the rental payment, both of which are treated as exogenous variable in previous studies. The ignorance of endogeneity will lead to inconsistent estimates. Second, the integrated model takes into account the growth premium and option value when evaluating land prices. Growth premium is the present value of expected increases in land rents after development. Option value is the value that farmland derives from the option of postponing development to avoid adverse outcome. Both growth premium and option value are identified as important components of farmland price (Capozza and Helsley) but are often ignored in previous studies of the effect of government payments on land values. Third, the integrated model relaxes the "featureless assumption" made by Capozza and Helsley, which allows us to examine the effect of amenities on farmland and developed land prices. Finally, the integrated model provides a solid foundation for our empirical work. As Lence and Mishra point out, most previous studies include farm payments as explanatory variables of land price without providing a theoretical foundation.

Theoretical Model

Consider a piece of land randomly selected from a county. Under the presence of the CRP, the selected land is either ineligible or eligible to enroll into the CRP. If the land is ineligible to enroll into the CRP, then the owner will obtain an annual net return of A from farming. If the land is eligible to enroll into the CRP, the farmer has to decide if he is going to submit a bid. If he decides not to submit a bid, his expected return from farming is A. If he chooses to submit a bid, then he has to decide the optimal level of the bid to maximize the expected return from the CRP. The expected return is affected by both the submitted bid and the probability of the bid being accepted into the program.

Under the CRP, whether a bid is accepted into the CRP depends on whether the individual cost-adjusted environmental score is greater than the threshold scores. Individual's cost-adjusted environmental score is calculated by subtracting the cost factor (N7), from the sum of six environmental scores (N1-N6), which measure the potential environmental benefits of an offered parcel in wildlife habitat (N1), water quality (N2), soil erosion (N3), enduring benefit (N4), air quality (N5), and conservation priority area (N6) (Farm Service Agency). The cost factor (N7) is calculated based on bids submitted by the farmers. The formula for converting monetary bids into cost factor is not known to farmers, but farmers are told that a lower bid would improve their chances of acceptance. Therefore, the cost-adjusted environmental score can be decomposed into two parts: the environmental score $S = \sum_{i=1}^{6} N_i$, and the cost component ω / b, where $\omega > 0$ is the weight of bid b in the cost-adjusted environmental score. Hence, the cost-adjusted environmental score can be expressed as $S + \omega / b$.

Let $\underline{EBI}$ denote the threshold of the cost-adjusted environmental score, above which a bid will be accepted. $\underline{EBI}$ is unknown to farmers, but they can form their expectation on $\underline{EBI}$ based on the observed program behavior. The probability of a bid being accepted into the CRP can be defined as the probability that the individual cost-adjusted environmental score is greater than the threshold score

(1) $$p = pr(S + \omega / b \geq \underline{EBI}) = F(S + \omega / b)$$

where F is the farmer's expected cumulative distribution function of $\underline{EBI}$. If the bid is accepted into the CRP, then a risk-neutral landowners' net return will be b; if the bid is rejected, then the bidder's net return will be A. Landowners will submit bids to maximize the expected net payoff $bF(S + \omega / b) + A(1 - F(S + \omega / b))$, the optimal bid b^* is implicitly defined by

(2) $$b^* = A + F(S + \omega / b^*) / f(S + \omega / b^*)$$

where f is the density function of $\underline{EBI}$. The optimal bid consists of two components: foregone profit from farming and the information premium, which depends on the bidders' private information on the threshold $\underline{EBI}$. For example, farmers may form their expectation on $\underline{EBI}$ based on external information such as past rental rate. Given p and b^*, the expected return from the CRP is $pb^* + (1-p)A$, and the expected return to the selected farmland under the CRP can be expressed as

$$\text{(3)} \qquad R^a = A(1-m) + mMax(A, pb^* + (1-p)A) = Max(A, A(1-m) + m(pb^* + (1-p)A)$$

where m equals 1 if the land is eligible to enroll into the CRP, 0 otherwise.

Except farming and conservational use, landowners can convert the land to non-agriculture use. We assume the CRP participants can request an early-out release from the program any time without penalties, such that there is no restriction on the conversion time[1]. When the farmland is developed, the land earns the developed land rent. The farmland price can be written as

$$\text{(4)} \qquad P_t^a = E\{\int_t^{t+s} R^a e^{-r(\tau-t)} d\tau + \int_{t+s}^{\infty} R(t,z) e^{-r(\tau-t)} d\tau - Ce^{-rs} \mid R(t,z)\}$$

where $R(t,z)$ is the developed land rent at time t at location z, C is the cost of converting one acre of farmland to development, r is the interest rate, E{} is the expectation operator, and $t + s$ is the time when the land is developed. With the early-out assumption, there is no restriction on s, which otherwise would be greater than the contract period if the land is enrolled into the CRP. Equation (4) states that farmland price equals the present value of the expected returns to farmland (including farming return and government payment) up to the date of conversion plus the present

[1] This is not a restrictive assumption, given the fact that the Secretary of Agriculture announced two early-out opportunities in December 1994 and March 1996; and the new Federal Agricultural Improvement and Reform Act (1996 Farm Bill) provided authority for producers with contracts established before January 1, 1995, that have been in effect for at least 5 years to withdraw most lands from the CRP at anytime, subject to 60-day notice to U.S. Department of Agriculture (USDA).

value of the expected development returns, minus the conversion cost. The price of one unit of developed land at location z at time t is

(5) $$P^d(t,z) = E\{\int_t^\infty R(\tau,z)e^{-r(\tau-t)}d\tau \mid R(t,z)\}$$

Following Cappoza and Helsley, rent of developed land can be derived as $R(t,z) = y(t) - z - x(a)$, where $y(t)$ is the household income and is assumed to follow Brownian motion process with upward drift g and variances σ^2: $y(t) = gt + \sigma B(t)$[2], z is the transportation cost to the city center and $x(a)$ is the non-housing goods consumption, which is a decreasing function of amenities a[3]. This specification follows from a household utility maximization model in which households consume a fixed amount of land and derive their utilities from housing, a non-housing good, and environmental amenities, subject to a budget constraint.

Landowner chooses the conversion time to maximize the expected value of land. They convert their land to development when the developed land rent is greater than or equal to a reservation rent (Cappoza and Helsley):

(6) $$R_d(t) \geq R^* \equiv R^a + rC + (r - \alpha g)/\alpha r, \quad \alpha = [(g^2 + 2\sigma^2 r)^{1/2} - g]/\sigma^2$$

Without the CRP, the reservation land rent is $A + rC + (r - \alpha g)/\alpha r$ (Cappoza and Helsley, 1990), which is smaller since A is smaller than R^a. This result indicates that the CRP increases the hurdle to convert agricultural land and consequently the development is postponed and the developed area becomes smaller (smaller city boundary z^*). Applying the stochastic property of R and R^* to equation (4) and (5), the farmland price and developed land price can be derived following Cappoza and Helsley:

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[2] $B(t), t > 0$ is a standard Brownian motion with zero drift and variance 1.

[3] This implies $(\partial x / \partial a) < 0$, more money spent on amenities, less money available for non-housing goods consumption.

(7) $$p^a = \frac{R^a}{r} + \frac{g}{r^2} e^{-\alpha[x(a)-x(a^*)+(z_t - z_t^*)]} + \frac{r-\alpha g}{r^2 \alpha} e^{-\alpha[x(a)-x(a^*)+(z_t - z_t^*)]}, \; z > z^*$$

(8) $$p^d = \frac{R^a}{r} + C + \frac{g}{r^2} + \frac{r-\alpha g}{\alpha r^2} + \frac{[x(a^*) - x(a)]}{r} + \frac{[z_t^* - z_t]}{r,}, \; z \le z^*$$

Equation (7) shows that farmland price consists of three components: expected net returns from agriculture (including farming return and government payments), growth premium and option value. Equation (8) states that the developed land price consists of six components: expected net return from agriculture, conversion cost, growth premium, irreversibility premium, amenities premium, and accessibility premium. Irreversibility premium represents the cost of not being able to convert the land back to agricultural use once developed. Amenities and accessibility premium represents the value of amenities and the value of location close to city center.

The CRP has both positive and negative effect on farmland and developed land price. The CRP increases farmland and developed land prices by increasing the agricultural return component because $R^a > A$. The CRP has a negative effect on farmland price because it reduces the growth premium and option value as a result of the postponed development. The CRP reduces the developed land price through the accessibility premium, because for a given location the relative distance to city center becomes larger when the developed area becomes smaller.

Differentiating (7) and (8) with respect to z and a, we can examine the effect of amenities and distance on farmland and developed land price. Both $\partial p^a / \partial z$ and $\partial p^d / \partial z$ are negative[4], indicating that farmland and developed land prices decrease as one moves farther away from the city. This is because both the growth premium and option value decrease with the increased distance from the city boundary. $\partial p^a / \partial a$ and $\partial p^d / \partial a$ are positive[5], suggesting that locations with better amenities have higher farmland and developed land prices. This result implies that amenities play an

[4] $\partial p^a / \partial z = -(\alpha / r\alpha) e^{-\alpha[x(a)-x(a^*)+(z_t - z_t^*)]} < 0$ and $\partial p^d / \partial z = -1/r < 0$

[5] $\partial p^a / \partial a = -\alpha (\partial x / \partial a)(1/r\alpha) e^{-\alpha[x(a)-x(a^*)+(z_t - z_t^*)]} > 0$ and $\partial p^d / \partial a = -(1/r)(\partial x / \partial a) > 0$, where $\partial x / \partial a < 0$

important role in determining the magnitude of farmland and developed land prices, because household are willing to pay for amenities.

Empirical Specification

Equations (1), (2), (7) and (8) provide the theoretical basis for the empirical specifications. A *Logit* specification is used to model the probability of a bid being accepted

(9) $$p = F(S - \omega b) = \frac{e^{\delta X}}{1 + e^{\delta X}}$$

where X is a vector of variables affecting bid acceptance, including environmental score (S), bid price (b), and all variables affecting farmers' expectation of $\underline{EBI}$, such as average rental rates in previous sign-ups (b_{-1}) and the percentage of land already enrolled in the CRP (CRP_{-1}). Both rental rates in previous sign-up and the percentage of land enrolled in the CRP are included because they may provide valuable information on the threshold $\underline{EBI}$. Equation (9) can be rewritten as

(10) $$\ln\left(\frac{p}{1-p}\right) = \delta_0 + \delta_1 S + \delta_2 b + \delta_3 b_{-1} + \delta_4 CRP_{-1} + \varepsilon_1$$

According to equation (2), the optimal bid is a function of net farming return A, environmental score S and variables affecting individuals' expectation about $\underline{EBI}$. We assume the optimal bid takes linear functional form as

(11) $$b^* = \xi_0 + \xi_1 A + \xi_2 S + \xi_3 b_{-1} + \xi_4 CRP_{-1} + \varepsilon_2$$

To derive the functional form that can be estimated econometrically, equation (6) and (7) are written as follows:

(12) $$p^a = \frac{R^a}{r} + \frac{1}{r\alpha} e^{-\alpha[x(a) - x(a^*) + (z_t - z_t^*)]}$$

(13) $$p^d = p^a e^{\alpha[x(a)-x(a*)+(z-z*)]} + \frac{R^a}{r}(1-e^{\alpha[x(a)-x(a*)+z-z^*]}) + C + \frac{x(a^*)-x(a)}{r} + \frac{z^*-z}{r}$$

Equation (13) is derived combining equation (7) and (8). The exponential terms in (12) and (13) indicate that land price is related to explanatory variables in a highly nonlinear ways. These exponential terms are approximated by a linear function of all variables included in the terms plus all the interaction terms between g and σ in α, and the rest of the variables. Substituting the approximation into (12) and (13) gives us the following polynomial functions[6]

(14) $$p^a = \theta_0 + \theta_1 R^a + \theta_2 g * R^a + \theta_3 g * a + \theta_4 g * z + \theta_5 g * y + \theta_6 g * g + \theta_7 g * \sigma + \theta_8 \sigma * R^a + \theta_9 \sigma * a + \theta_{10} \sigma * z + \theta_{11} \sigma * y + \theta_{12} \sigma * \sigma + \varepsilon_3$$

(15) $$p^d = \eta_0 + \eta_1 p^a * R^a + \eta_2 p^a * a + \eta_3 p^a * z + \eta_4 p^a * y + \eta_5 p^a * g + \eta_6 p^a * \sigma + \eta_7 R^a * R^a + \eta_8 R^a * a + \eta_9 R^a * z + \eta_{10} R^a * y + \eta_{11} R^a * g + \eta_{12} R^a * \sigma + \eta_{13} z + \eta_{14} y + \eta_{15} a + \varepsilon_4$$

Regional dummies are included in the estimation to explore whether the coefficients in farmland price vary across regions.

Econometric Issues and Estimation Methods

Equations (10), (11), (14) and (15) comprise the simultaneous equation system for the empirical analysis. Three econometric issues arise in the estimation of the equation system: endogeneity problem, spatial autocorrelation, and contemporaneous correlations. This study uses the generalized spatial three stage least square (GS3SLS) developed by Kelejian and Prucha (2004) to address the three econometric issues. GS3SLS is particularly suited for our simultaneous equation system because GS3SLS can correct all three potential econometric issues.

The GS3SLS estimator contains three steps. In the first step, the model parameters are estimated using two stage least squares (2SLS) and instrumental variable techniques. All exogenous

[6] Polynomial function forms have been used in several previous studies (e.g., Plantinga et al and Christensen et al).

variables in the system are chosen as instrumental variables[7]. The residuals from the 2SLS estimates are used to test for spatial autocorrelation using Moran's I statistic [8] $I = N(\hat{e}'W\hat{e})/M(\hat{e}'\hat{e})$, where N is the number of observations, $\hat{e}$ is the vector of estimated residuals, W is the spatial weight matrix indicating spatial structure of the data, and M is standardization factor equal to the sum of the elements of W. Each element of W is 1 if two counties are bordered and 0 otherwise[9]. We assume the error structure takes the form $\varepsilon = \rho W \varepsilon + \upsilon$, where ρ is a scalar and υ is a vector of spherical disturbance with zero mean.

If the spatial autocorrelation is identified, then in the second step, the residuals from the 2SLS are used to estimate the spatial autoregressive parameter ρ for each equation utilizing the generalized moment estimator, equation (7) in Kelejian and Prucha (1999). After the spatial autoregressive parameter ρ is estimated, data are transformed using the matrix $\hat{P} = I - \hat{\rho}W$, where I is N by N identity matrix.

Finally, in the third step, after the endogeneity and spatial autocorrelation are corrected in the first two steps, two simultaneous equation systems (10)-(11) and (15)-(16) are estimated separately due to unbalanced equations. As errors in farmland price and developed land price equations are likely to be contemporaneously correlated, the equations are estimated using seemingly unrelated regression (SUR) estimators, which make full use of the cross-equation error covariance matrix, and can improve the efficiency of the estimators (Greene). Similarly,

[7] The instrumental variable results are not reported, but are available from authors upon request.

[8] Moran's I is a spatial analogue to Pearson's correlation coefficient. For its statistic property, see Anselin (1989)

[9] Two criteria are usually used to create spatial weight. One is contiguity-based spatial weight and the other is distance-based spatial weight. The contiguity-based spatial weight usually use two criteria: rook contiguity, which uses common boundaries to define neighbors, and the queen contiguity which uses common points (boundaries and vertices) in the definition. Distance-based spatial weight defines the neighbors according to the specified distance, or the specified k-nearest neighbors. The spatial weight matrix can be created in a variety of softwares such as Arcview 3.2, Arc GIS 9.0, SpaceStat and Geoda. In this study, we use rook contiguity spatial weight matrix, which is created in Arcview 3.2.

probability of acceptance and optimal bid price equations are estimated using SUR estimator as well.

Estimating the Effect of the CRP

Based on the estimated equations (14) and (15), we are able to evaluate the effect of the CRP on farmland and developed land prices. The effect of the CRP on farmland price can be estimated by

(16) $$p^a(p,b) - p^a(0,0) = \hat{\theta}_1 (R^a - A) + [\hat{\theta}_2 g * (R^a - A) + \hat{\theta}_8 \sigma (R^a - A)],$$

where $p^a(p,b)$ and $p^a(0,0)$ are the farmland price in the presence and absence of the CRP, respectively. The first term on the right hand side of (16) is the direct effect of the CRP on agricultural return, the second term in the blankets is the indirect effect of the CRP on growth premium and option value. $R^a - A$ reflects the relative advantage of CRP participation compared with farming.

The effect of the CRP on developed land price can be evaluated by the formula

(17) $$p^d(p,b) - p^d(0,0) = [(\hat{\eta}_2 a + \hat{\eta}_3 z + \hat{\eta}_4 y + \hat{\eta}_5 g + \hat{\eta}_6 \sigma)(\hat{\theta}_1 + \theta_2 g + \hat{\theta}_9 \sigma) + \hat{\eta}_8 a + \hat{\eta}_9 z + \hat{\eta}_{10} y + \hat{\eta}_{11} g + \hat{\eta}_{12} \sigma](R^a - A)$$
$$+ \hat{\eta}_1 (R^a p^a(p,b) - A p^a(0,0)) + \hat{\eta}_7 (R^{a2} - A^2),$$

where $p^d(p,b)$ and $p^d(0,0)$ are the developed land price with and without the CRP, respectively.

Study Area and Data

The empirical specification suggests that data on land value, agricultural returns, income, amenities, and CRP participations are needed to estimate the equation systems. The study areas include 2851 counties in contiguous 48 states[10]. All data used in this study are for the year 1997. Variables and descriptive statistics are listed in Table 1.

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[10] One hundred ninety counties are omitted due to missing data or absence of agricultural land.

The CRP data are provided by Economic Research Service (ERS) and contain individual contract information for sign-up 15th, which was held in March 1997 based on new program rules that expanded the base of eligible lands to more than 240 million acres, including about 65 percent of U.S. cultivated cropland (FSA)[11]. With the farm-level contract information, we are able to provide more accurate estimates for the probability of acceptance by calculating the ratio of the total accepted bids to total bids submitted in sign-up 15th. The average county bidding price per acre is computed by $(\sum_{i=1}^{n} b_i * acre_i) / \sum_{i=1}^{n} acre_i$, where b_i is the biding price per acre submitted by individuals and $acre_i$ is acres offered by individuals for enrollment, and n is the total bids submitted. Using the farm-level CRP data, the average county environmental score is computed by $(\sum_{i=1}^{n} S_i) / n$, where $S_i = \sum_{k=1}^{6} N_k$ is the individual's environmental score. The average past rental rates and percentage of land enrolled in the CRP in a county may provide important information for individuals to form their expectation on the $\underline{EBI}$. These two variables are created using historical county-level CRP data from ERS. The average past CRP rental rates are calculated using rental rates from all previous signups 1-14th. The percentage of land enrolled in the CRP is computed as the ratio of total land enrolled in the CRP to total cropland in a county in December 1996. Eligible land data are obtained from the 1997 National Resource Inventory. The percentage of eligible land in a county is the ratio of total eligible land to total cropland.

Net returns to farmland, farmland price, and developed land prices are obtained from Plantiga, Lobowski and Stavings (2004), who use Census of Agriculture data to calculate the average farming return A and farmland price[12]. A is calculated as (TR+GP-TC)/TA, where TR is the total revenues from the agricultural products sold, GP is the total government payments except CRP

[11] We thank Shawn Bucholtz of the Economic Research Service for providing the data.
[12]We thank Plantinga, Lobowski and Stavins for providing data.

payments, TC is the total farm production expenses, and TA is the total farmland acres. The farmland price (p^a) measures the value of land and buildings per acre, and is the county-level average of self-reported estimates by landowners. Developed land price (p^d) is the county-level average price of recently developed land[13].

Total road mileage is used to capture the effect of development pressure and transportation costs on land prices, and is the mileage of interstate and other principal arterial roads (for example, state highways). The data on road mileage are obtained from the Bureau of Transportation Statistics.

Two important parameters are annual income growth g and variance of income growth σ^2. σ reflects the uncertainty of the income growth. g and σ are calculated using the average county median household income data from 1993, 1995 and 1997 compiled by the Small Area Income and Poverty Estimates (SAIPE) program of the U.S. Census Bureau.

In order to capture the regional effect, we create regional dummy variables. The ERS divides the contiguous U.S is divided into 10 farm production regions from west coast to east coast: Pacific Region, Mountain Region, Northern Plains, Southern Plains, Lake States, Corn Belt, Delta States, Northeast, Appalachia, and Southeast region. Southeast is used as the referenced region. CRP acres were historically concentrated in the Great Plains (Northern Pains and Southern Plains) and Western Corn Belt, with some increases in Mountain areas in signup 15th.

The amenity data used in this study are generated by the National Outdoor Recreation Supply Information System (NORSIS)[14], developed and maintained by USDA Forest Service's Wilderness Assessment Unit, Southern Research Station, and Athens, Georgia. The amenity data are a comprehensive county level data set with more than 250 variables, including climate, natural

[13] See Plantiga, Lobowski and Stavins (2002) for the estimate of developed land price.
[14] We thank Professor Steve Deller of University of Wisconsin for providing us with NORSIS data.

amenity, man-made amenity and geographic information. A common practice within the literature is to confine amenities to a single dimensional attribute such as climate or to introduce an ad hoc list of selected attributes (Andrews, Gottlieb). Another approach is to condense a set of related variables into a single scalar which retains the information in original data (Miller 1976). The primary advantage of this approach is that variables are not removed from the empirical analysis due to multicollinearity problems or limited degree of freedom (Wagner and Deller). The tool used for this approach is the principal component analysis developed by Hotelling. Although there is no exact rule to select a specific principal component, two approaches are relied on in most applications. The first is to select the first principal components (e.g. Deller et al.), which is the best summary of the entire data set because it accounts for the maximum amount of variances in the correlation matrix across all of the variables. The second is to select the principal components with the eigenvalue of the correlation matrix greater than one (e.g., Wagner and Deller). In this study we use the first approach.

Principal component analysis is an approach to compress higher dimension variables into a single scalar. The single scalar is called score which is, in essence, the linear combination of the original variables where the linear weights are the eigenvectors of the correlation matrix between the set of factor variable. Because the principal component is very sensitive to scale, all variables used in the principal component analysis are standardized to zero mean and unit variance and the score is calculated by $score = \sum_{l=1}^{L} \lambda_l \tilde{x}_l$, where λ_l is the eigenvector computed from the variance-covariance matrix of the original data, $\tilde{x}_l$ is the standardized amenity variables and L is the number of variables in a category. We categorize the amenity variables into three categories: climate (e.g., January sunny day and July temperature), man-made recreation facilities (e.g., golf courses, swimming pool, campground etc) and natural recreation resources especially water resources (e.g., total outstanding river miles, white water miles etc)[15]. We include four variables to represent a region's climatic condition, fourteen variables to describe the man-made recreation facilities and four to portray water resource[16]. As Kusmin (1994) observed, the limitation of this approach is that it hard to interpret the individual component. In this study, we are interested in examining the influence of a single category on land value.

Empirical Results

Table 2-4 show the estimated results for the two simultaneous systems. Overall, the model fits the data well as indicated by the System Weighted R-Square 0.57 for probability of acceptance and optimal bid equation system and 0.86 for the farmland and developed land price equation system. Most coefficients of interests are statistically significant at 1% or 5% level. Spatial autocorrelation was detected and adjusted for each of the equations. For the probability of acceptance, optimal bid, farmland price, and developed land price, respectively, the value of the Moran's I-statistics, with the standard deviation listed in parentheses, is 0.13 (0.0135), 0.45 (0.0135), 0.31 (0.0115), and 0.27(0.0115). Assuming an approximate standard normal distribution for $\boldsymbol{I}$, the null hypothesis of no spatial autocorrelation is rejected at 1% level in each case. The estimated values of the spatial autocorrelation parameter ρ are 0.30, 0.68, 0.56, and 0.52, respectively.

Table 2 reports the parameter estimates for the probability of acceptance and optimal bid equations. All major coefficients in participation equation are statistically significant at 1% level. The environmental score positively affects the probability of acceptance. Higher environmental score is usually associated with environmental fragile land, which is the primary target of the CRP

[15] English et al. and Deller divide the amenity variables into climate, recreation facilities, land, water and winter.
[16] Variables in each category and its corresponding eigenvector are available upon request.

and therefore more likely to get accepted into the program. Current bid affects the probability of acceptance negatively as expected. A 1% increase in bidding price causes 9% decreases in the probability of acceptance. The amount of existent CRP land had negative effects on the probability of acceptance, because the U.S. Department of Agriculture is more likely to target land for the CRP in areas where CRP participation has been low. Past rental rate has positive effects on the probability of acceptance, because high past rental rate may suggest high bid cap set by the agency and therefore bids are more easily to get accepted into the program. The probability of acceptance does not vary across regions, since most regional dummies are statistically insignificant.

All variables in the model affect bid significantly. Environmental score affects current bids negatively, because higher environmental score may be associated with lower quality land and thereby opportunity costs are lower for farmers. More land enrolled in the CRP may indicate intense competition among bidders, and hence lower bids are submitted to increase the chance of acceptance. Past rental rates and net farming returns have positive and significant effect on bidding price. A $1 increase in the past rental rate results in $0.75 increase in current bid, and a $1 increase in net farming return only increases current bid by 3 cent. This suggests that farmers rely more on past rental rates to decide their optimal bids, because past rental rates may reflect government's funding availability and program's tendency.

Table 3 reports the estimated parameters for farmland and developed land prices. Because of interaction terms and nonlinear relationships, the sign and magnitude of individual coefficient do not have clear interpretations. To facilitate interpretations of results, we can derive the marginal effect of explanatory variables, and evaluate the resulting expression using the estimated coefficients and means of the independent variables. The marginal effects and the corresponding elasticity are reported in Table 4. F-statistics for the null hypotheses that the elasticity is zero was calculated to indicate the statistical significance (Judge et al., pp. 456-59).

The effects of annual income growth on farmland and developed land price are positive and statistically significant at 1% level. This result is similar with Plantinga and Miller, who use annual population change between 1990 and 1997 to approximate the income growth and find income growth affects farmland price positively. Uncertainties about income have positive effects on farmland price but negative effects on developed land price, but both effects are statistically insignificant. This supports the theory suggested by Capozza and Helsley that with the boundary of the urban area endogenously determined as in our case, the price of developed land is unaffected by uncertainty.

Current income has positive and significant effects on farmland and developed land price. A 10% increases in current income increases farmland price by 11.9%, and developed land price by 9.7%. Road miles positively affect the farmland price. Because more road miles may imply high development pressure, option value and growth premium may be higher. The effect of highway miles on developed land price is negative but insignificant. Farmland price has a positive effect on developed land price as equation (13) shows, because farmland price is one of the important opportunity costs of land development. A one percent increase in farmland pries increases the developed land price by 0.32 percent.

Table 4 also reports the effects of amenities features on farmland and developed land prices. Climate appears to have positive effect on farmland and developed land price, although it is insignificant in developed land price. The positive sign suggests households prefer location with better climatic condition. Man-made recreation facilities have positive and significant effect on farmland and developed land prices. Recreation facility index is driven by the availability of parks, tennis courts, and gold course, among other things, therefore counties with high levels of man-made recreation facilities are more attractive to households. More importantly, man-made recreational facilities can be directly affected by policy. Water resources have positive and insignificant effect on farmland price, but have negative and significant effect on developed land price. The negative effect on developed land price is unexpected. However, given that the water resource index is driven by number of lakes and ponds, white water miles, and total river miles, one possible explanation is that locations with more accesses to water resources are usually located in remote areas which may have high transportation costs, and thus are less attractive to firms and households.

The Effect of the CRP

The effects of the CRP on farmland and developed land price are evaluated using equation (16) and (17), and the results are reported in table 5[17]. The CRP has positive and significant effect on farmland price in all regions. On average, the CRP increases farmland price by $25 per acre (or 1.8%). The CRP has relatively large impacts on farmland price in Mountain area, Southern Plains and Northern Plains; it increases farmland price in these regions by 9.8%, 6.4% and 4.5%, respectively. This is not surprising, given the large amount of land enrolled in the CRP in these regions (more than 60 percent CRP enrollment are located in these three regions) and the CRP rental rates are considerably higher than net farming returns in the three regions. Net farming returns are lower than $30 per acre in Mountain area and Southern Plains, and lower than $50 per acre in Northern Plains. Compared with farming, participation into the CRP turns out to be a more profitable alternative, and the value of this profitable use is positively capitalized into farmland prices. Additionally, effects of the CRP on farmland prices are enhanced by the lower farmland prices in these three regions, where the farmland prices are lower than $630 per acre, much lower than the national average farmland price $1362 per acre.

[17] F-statistics is used to test the hypothesis that the effect of the CRP is zero to indicate the significance. Likelihood ratio suggested by Green is used to test the effect of the CRP on developed land price because of the nonlinear constraints.

Compared to the above three regions, the CRP has mild absolute effects but small relative effects on farmland prices in the Corn Belt and Appalachia. The mild absolute effects are resulted from the moderate CRP enrollment and the moderate difference between CRP rental rates and net farming returns in these two regions. The mild absolute effects account for only a small percentage of farmland prices, because farmland is rather productive and valuable in these tow regions, with average price higher than $1750 per acre. The effect of the CRP on farmland prices is the smallest in the Lake States, followed by the Northeast. In the Lake States, there is little difference between CRP rental rates and net returns to farming. The Northeast had the smallest CRP enrollment among the 10 regions. Only about 0.5% of the total CRP enrollment is located in the Northeast.

The CRP had a positive and statistically significant impact on developed land prices in all regions, except in Lake States and Southeast where the relatively small effects of the CRP on farmland price is translated to the small effects on developed land price. On average, the CRP increases developed land price by $274 per acre, which accounts for only 0.6 % of developed land price. The CRP has relatively large impacts in the Mountain, Plains States, Appalachia, and Corn Belt. It is not surprising that effects of the CRP on developed land prices in the Mountain areas and Plains States are relatively large. Because farmland price is one of the opportunity costs of developed land price as shown by equation (13), the positive and larger effects of the CRP on farmland price in these regions directly contribute to the large increases in developed land prices. However, it is unexpected to find that the effects of the CRP on developed land prices are relatively large in the Appalachia and Corn Belt, given the effects of the CRP on farmland prices are relatively small there. The possible explanation is that land in these two regions is highly developed and the limited productive farmland is very valuable there, hence the moderate increases in farmland prices from the CRP are translated into the developed land prices. The effect of the CRP on developed land price is the smallest in the Northeast and Pacific region. In the

Northeast, the small effects of the CRP on farmland price and the small enrollment acreage explain the small effects on developed land prices. In the Pacific Region, the absolute effect of the CRP on developed land price is relatively large, but it accounts for only a small percentage of the developed land price because the developed land price there is the highest of the 10 regions, with an average price $174,157 per acre.

Table 5 also reports the magnitude of the major components of farmland price and the effect of the CRP on the components. On average, agricultural return contributes about $537 per acre, which comprises 40% of farmland price. Of the 10 regions, the weight of agricultural return in farmland price is relatively high in Mountain and Northern Plain, where the farmland prices are relatively low due to low net returns to farming and less development pressure. In the U.S., growth premium and option value together are about $825 per acre, accounting for 60% of farmland price. The Northeast has the highest growth premium and option value, accounting for about 69% of farmland price because of high development pressure.

Consistent with the theory, the CRP has a positive impact on the agricultural return and negative impact on the growth premium and option value. Specifically, the CRP increases the agricultural return by about $37 per acre, but reduces the growth premium and option value by $12 per acre on national average. The positive effect of the CRP on farmland prices outweighs the negative one, and thereby the CRP increases farmland prices by $25 per acre.

Implications for Permanent Easements

By idling highly erodible and other environmentally sensitive cropland for 10-15 years, the CRP provides significant environment benefits. Compared to the short-term conservation program, a permanent easement program has an obvious advantage in providing environmental benefits. Recently, several states including Minnesota and Maryland use Conservation Reserve

Enhancement Program (CREP) and other USDA programs to convert short term easements to permanent conservation easements. The question is how much additional payment is needed to convert 15-year contract to a permanent easement. It has been suggested that since the present discount value of rental payments during a 15-year contract equals 75% of the value of perpetual payments, States only need to pay 25% more to secure permanent easements. It would be particularly appealing if 25% additional funding is enough to secure a permanent easement. The question is whether 25% additional funding is enough to convert a short term easement to a permanent easement. Our results suggest that much more is needed than 25% of additional funding to convert a 15-year contract to a permanent easement.

The CRP payment is calculated based on the relative productivity of soils within the county and the local dry land cash rent. That's to say, the easement payments only reflect the stream of agricultural returns, but not growth premium and option value. Our empirical results show that agricultural and conservational returns account for only 40% of the total farmland value, and the sum of growth premium and option value account for the rest 60%. Growth premium and option value are generated by potential development beyond the CRP period (otherwise, the land would not be enrolled into the CRP). CRP payments during the contract period account for only about 30% (0.75*0.40)of land value, where 0.75 represents the percentage of the value of agricultural returns that is covered by the CRP payment during a 15-year contract (assuming a 10% discount rate). In order to convert a 15-year CRP contract to a permanent easement, the States would have to pay the remaining 70% of the land value. That would be about $70\% / 30\% = 2.6$ times of the total CRP payment. Thus, in areas where growth premium and option value are higher, States would need to pay much more than 25% to convert a 15-year contract to a permanent easement. However, in rural areas where growth premium and option value are minimal, 25% additional may be sufficient.

Conclusions

As the largest conservation program in the U.S. history, the environmental performance of the CRP has been evaluated in a number of studies. However, the effects of the CRP on farmland prices have received relatively little attention. The limited existing empirical results on the effect of the CRP on farmland prices contradict each other.

This paper develops theoretical and empirical models to evaluate the effects of the CRP on farmland and developed land prices. The theoretical results suggest that the CRP can increase or decrease farmland and developed land prices, depending on the relative magnitude of the effects of the CRP on agriculture returns, growth premium and option value. Based on the theoretical analysis, an empirical model is specified to quantify the effect of the CRP on farmland and developed land prices. Results show that the CRP increases farmland and developed land prices by 1.8% and 0.6%, respectively, on national average. The effects of the CRP on farmland and developed land prices are largest in the Mountain, Northern Plains, and Southern Plains, where participating in the CRP is a more profitable alternative than farming. Results also show that agricultural returns account for about 40% of farmland price, and growth premium and option value together accounts for the remaining 60%. Climate and recreation amenities have positive effects on farmland price because they increase both growth premium and option value. These results provide useful information for the design and implementation of land conservation programs. In particular, they can be used to determine additional funding needed to convert short-term easements to perpetual conservation.

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Table 1. Variables and Descriptive Statistics

Variables	Description	Mean	Std Dev
b_{-1}	past rental rates from signup 1-14	54	16.16
A	Net farming returns	77	78.45
R^a	max(A, A(1-m)+m(pb+(1-p)A))	81	74.10
p^a	Farmland Price	1362	961.93
p^d	Developed land price	48837	45052.50
b	Bid price at sign up 15th	50	22.46
P	Probability of acceptance	0.65	0.31
S	Sum of (N1-N6)	140	34.90
Income	Median Household Income 1997	32377	7514.83
g	Mean of income change 1993-1997	640	2161.27
σ^2	variance of income change 1993-1997	3420	2402.17
Climate	First principal component of climate	0	1.00
Recreation	First principal component of recreation facility	0	1.00
Water	First Principal component of Water	0	1.00
CRP_{-1}	Percentage of land Enrolled in CRP	4.20	4.70
m	Average Percentage of eligible land	45.30	29.40
Road mile	Interstate and Principal arterial road (1,000 miles)	58	86.43
r1	=1 if counties in Pacific Region	0.04	0.20
r2	=1 if counties in Mountain Area	0.08	0.27
r3	=1 if counties in Northern Plain	0.11	0.31
r4	=1 if counties in Southern Plain	0.11	0.31
r5	=1 if counties in Lake States	0.08	0.27
r6	=1 if counties in Corn Belt	0.17	0.38
r7	=1 if counties in Delta States	0.07	0.26
r8	=1 if counties in Northeast Region	0.07	0.26
r9	=1 if counties in Appalachia Region	0.16	0.36
r10	=1 if counties in Southeast Region	0.10	0.31

Table 2. Parameter Estimates of Probability of Acceptance and Optimal Bid Equations

	Acceptance Equation		Bidding Price Equation	
Variables	Estimate	Standard Error	Estimate	Standard Error
Intercept	-5.19***	0. 349	2.85***	0.443
b_{-1}	0.06**	0.024	0.75***	0.023
A			0.03***	0.002
S	0.08***	0.002	-0.02***	0.005
CRP_{-1}	-4.00***	1.406	-12.79***	4.604
b	-0.10***	0.019		
r1	0.12	0.486	-5.56***	1.867
r2	-0.27	0.336	-1.88	1.274
r3	0.15	0.294	-0.31	1.364
r4	-0.31	0.307	-0.17	1.192
r5	0.06	0.322	1.39	1.384
r6	-1.15***	0.331	11.93***	1.363
r7	0.16	0.338	-3.16**	1.406
r8	0.29	0.380	0.93	1.566
r9	-0.13	0.290	2.51**	1.154
N	2206			

***denotes significance at 1% level;** significant at 5% level.

Table 3. Parameter Estimates of Farmland and Developed Land Prices

	Farmland Price			Developed Land Price	
Variables	Estimates	Standard Error	Variables	Estimate	Standard Error
R^a	6.6080***	0.2666	Intercept	-3194.95	2571.4580
g* Road mile	0.0031***	0.0009	p^a* Road mile	0.0427***	0.0102
g *Income	2.4e-6***	7.675e-7	p^a*Income	0.0003***	0.0001
g*g	-4.8e-6*	2.642e-6	p^a*g	-0.0006***	0.0002
g* R^a	-0.0007***	0.0001	p^a* σ	-0.0201	0.0214
g *climate	0.0375***	0.0010	p^a* R^a	-0.0073	0.0064
g *Recreation	0.0276***	0.0077	p^a*climate	-2.3867**	1.0429
g* Water	-0.0050	0.0066	p^a*recreation	-6.1717***	0.8894
g*r1	0.2091***	0.0358	p^a*water	2.4344***	0.9310
g*r2	0.0491*	0.1639	R^a *Road mile	-0.4562***	0.1254
g*r3	0.0366	0.0280	R^a *Income	0.0009	0.0007
g*r4	-0.0243	0.0229	R^a *g	0.0083**	0.0033
g*r5	0.0554	0.0340	R^a * σ	-0.0381	0.2923
g*r6	0.0163	0.0244	R^a * R^a	0.0268	0.0252
g*r7	0.0031	0.0270	R^a *climate	1.8259	9.4673
g*r8	0.0214	0.0312	R^a *recreation	56.8080***	10.9068
g*r9	-0.0252	0.0213	R^a *water	-0.7871	8.3361
σ *Road mile	-0.0075	0.0061	Road mile	-24.2135	19.0223
σ *Income	0.0010***	0.0001	income	0.9789***	0.1781
σ * σ	-0.2229***	0.0167	Climate	3396.07*	1743.2020
σ * R^a	-0.0297***	0.0041	Recreation	20017.07***	2024.063
σ *climate	0.3672	0.5023	Water	-5432.78***	1413.529
σ *recreation	3.1091***	0.4263	r1	141557.5***	5940.9140
σ *water	0.1949	0.2679	r2	71587.5***	4616.6090
σ *r1	-1.9001	2.0148	r3	14674.2***	4411.7600
σ *r2	-5.7861***	1.5719	r4	9724.6**	4081.0070
σ *r3	-7.3384***	1.4790	r5	-11091.4**	5303.2380
σ *r4	-3.0980**	1.3226	r6	-3818.7	4126.5500
σ *r5	-5.1817***	1.8242	r7	6164.7	4359.1630
σ *r6	-1.1558	1.3429	r8	-4220.6	5124.9980
σ *r7	0.6293	1.5165	r9	-3425.6	3702.1490
σ *r8	8.6960***	1.6980			
σ *r9	4.1327***	1.1730			
σ *g	0.0004*	0.0003			
N	2851				

*** denotes significance at the 1% level. ** significant at 5%; * significant at 10%.

Table 4. The Marginal Effect of Independent Variables on Farmland and Developed Land Prices

Independent Variables	Effect on Farmland Price ($/ acre)	Effect on Developed Land Price ($/acre)
g	0.94 (0.44) ***	0.32 (0.004) **
σ	0.94 (0.04)	-3.39 (-0.004)
Income	0.05 (1.19) ***	1.50 (0.970) ***
Road mile	1.56 (0.07) **	-2.10 (-0.003)
P^a	-	11.31 (0.320) ***
Amenities		
Climate	45*	293
recreation facilities	199***	16229***
Water resource	8	-2090***

***denotes significant at 1% level; **significant at 5%level; *significant at 10% level.

Table 5. The Effects of the CRP on Farmland and Developed Land Prices, by Region.

Region	Effect on Farmland Price		Effect on Developed Land Price		Value of Agricultural Return		Value of Growth Premium and Option Value		Effect on Agricultural Return	Effect on Growth Premium and Option Value
	$/acre	% of pa	$/acre	% of pa	$/acre	% of pa	$/ acre	% of pa	$/ acre	$/acre
Pacific	36***	2.2	540***	0.3	806	50.2	798	49.8	51	-15
Mountain	60***	9.8	843***	0.8	258	42.0	356	58.0	83	-23
Northern Plain	28***	4.5	275***	0.6	360	58.0	260	42.0	42	-14
Southern Plain	40***	6.4	244**	0.6	227	36.4	399	63.6	59	-19
Lake States	3***	0.2	63	0.1	582	42.5	788	57.5	7	-4
Corn Belt	24***	1.3	277***	0.7	648	36.4	1132	63.5	39	-13
Delta States	18***	1.6	118***	0.4	529	47.7	581	52.3	25	-7
Northeast	8***	0.3	186***	0.3	754	31.3	1656	68.7	15	-7
Appalachia	28***	1.5	347***	1.0	681	36.8	1172	63.2	38	-10
Southeast	18***	1.3	150	0.4	602	39.8	909	60.2	24	-6
USA	25***	1.8	274***	0.6	537	39.4	825	60.6	37	-12

*** significant at 1% level; ** significant at 5% level; * significant at 10% level.