Using Real Options Theory to Analyze the Impacts of Urban Development on Farm Real Estate Markets

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Abstract: This paper assesses the real option values of farmland using data from Ohio, USA. The option value of delaying the sale of a farm property was measured using an emerging, relatively new theory namely, the theory of real options pricing. As opposed to standard corporate finance theory, this new theory incorporates both the uncertainty about the future net benefits of a selling decision and the irreversibility of this action taken. Results from this option value calculation show that the vast majority of real call option values calculated for this sample are greater than zero, suggesting that deferring the decision to sell farmland is optimal for most Ohio landowners. The study then seeks to associate the impacts of urban development on Ohio farm-real estate with some important real option-determining factors suggested by the literature. To set forth this association, these option-determining factors were independently regressed on some urbanization-related variables to find out the relation between these variables. Results from this econometric analysis indicate that urban influences along with some farm and non-farm variables thought to be correlated with the land's option value are all important factors affecting the value of the state's farmland.

Key Words: Real Options, Farmland, Option Value, Irriversibility, Uncertainty

Gerçek Opsiyonlar Teorisini Kullanarak Kentleşmenin Tarımsal Arazi Kıymetlerine Olan Etkileri Üzerine Bir Analiz

Özet: Bu araştırmada, Amerika'nın Ohio Eyaletinde bulunan kiraya tutulmuş tarım arazilerinden oluşan bir örneği kullanarak arazinin reel (gerçek) opsiyon değerinin ölçülmesi amaçlanmıştır. Arazinin bu opsiyon değeri, literatüre henüz girmekte olan ve Gerçek Opsiyonlar Teorisi adı verilen yeni bir teoriyle açıklanmaya çalışılmıştır. Finansal arenada kullanılan standart fiyatlama teorisinin aksine bu yeni opsiyon teorisi, araziyle ilgili olarak alınacak bir satış kararının ardında bulunan hem belirsizlik hem de geriye dönüşüm zorluğu kriterlerini bir arada hesaba katan ilkelerden hareket etmektedir. Bu araştırmada sunulan analiz ayrıca, kentleşmenin Ohio tarım arazi fiyatlarına olan etkilerini ortaya koymaktadır. Opsiyon değeri hesaplamalarından elde edilen sonuçlara göre, örneğe alınan arazilerin opsiyon değerlerinin çoğu pozitif bulunmuş olup, bunun anlamı satış kararının daha ileriki bir tarihe ertelenmesinin, arazi sahiplerinin lehine bir sonuç doğuracağıdır. Araştırmada ayrıca, kentleşmenin Ohio eyalet tarım arazi kıymetlerine olan etkisinin, opsiyon belirleyici faktörler açısından bir değerlendirmesi yapılmıştır. Bu etkileşimin ortaya konabilmesi için opsiyon belirleyici bu faktörlerin, kentleşmeyle ilgili bir takım açıklayıcı değişkenler üzerine olan regrasyonları ayrı ayrı analiz edilmiştir. Bu analizlerden elde edilen sonuçlara göre, kentsel etmenlerin yanı sıra, arazi kıymet belirleyicileri olarak çiftçilikle ilgili olan ve olmayan ve arazinin opsiyon değeriyle alakalı olduğu düşünülen bir takım değişkenlerin, söz konusu eyaletin arazi kıymetlerini açıklamada önemli rol oynadıkları ileri sürülebilir.

Anahtar Sözcükler: Gerçek Opsiyonlar, Tarımsal Arazi, Opsiyon Değeri, Geriye Dönüşüm Zorluğu, Belirsizlik

Introduction

The financial tool most widely used to estimate economic value (discounted cash flow valuation) assumes that a predetermined plan is followed regardless of how events unfold, i.e. the traditional discounted cash flow approaches tend to ignore the value added contributions of managers and owners who have the flexibility to deviate from anticipated prescriptions and respond to changing conditions (Zinkhan, 1995). A better approach to valuation would incorporate both the uncertainty inherent in an investment or business strategy and active decision-making. In financial terms, some investments

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and business strategies are much more like a series of options than a series of static cash flows (Luehrman, 1998b). Implementing a strategy almost always involves making a sequence of major decisions. Some actions are taken immediately, while others are deliberately deferred, so managers can optimize as circumstances evolve. Therefore, firms' investment decisions may be better understood when managers consider the options approach to capital budgeting rather than traditional discounted cash flow valuation (Abel et al., 1996).

Those option-pricing applications that do not involve financial instruments are called "real" options. The real option value is a premium in excess of the expected net present value of the project, reflecting the opportunity cost of investing now and foregoing the option to delay investment until more information about the future becomes available (Plantinga, 1998). Real options that have been considered in the literature include capital investments and natural resources as well as urban land issues (Quig, 1993). Real options analysis has also been applied to real estate investments and development decisions. The rationale behind using option-pricing theory in real estate applications is the same as in financial options, i.e. there is uncertainty about the future and in an uncertain environment, and having the flexibility to postpone action after some of that uncertainty is resolved certainly has value (Merton, 1998). With this uncertainty present, there is some value associated with keeping one's options open (Reed, 1993).

Three characteristics of many investments result in real option values (Dixit and Pindyck, 1993). First, an investment is often completely or at least partially *irreversible*, which is to say that it is not possible to completely recover it in the face of unfavorable market conditions. Therefore, the option to delay an irreversible decision can be valuable, and ignoring this option, which one does when only the net present value rule is used, can be costly (Coggins, 1998). The second characteristic is the *uncertainty* over the future rewards (cash flows) from the investment. The fundamental problem of risk and uncertainty in the decision-making process has been reported by many researchers, such as Von Neumann and Morgestern (1947), Keeney and Raiffa (1976), and Von Winterfeldt and Edwards (1988) (cited in Leskinen and Kangas, 1998). The third characteristic is the leeway about the *timing* of investment; that is, one can postpone action to get more information about the future. Thus,

the use of option value theory in this respect appears relevant to many decisions in resource and environmental economics, particularly when: a) the decision to take some action is irreversible, and b) the future net benefits of that action are uncertain (Conrad, 1997).

Just like a corporate investment opportunity, holding farmland may involve a real call option because the owner/farmer has the right, but not the obligation, to keep the land in farming or to sell it for a development opportunity, e.g., residential construction. Exercising this real call option means that the owner is willing to sell his land and hence close the door to all future opportunities that might be brought by the land being sold. Thus, the selling decision has an opportunity cost that must be included in the price for the land because it is an irreversible decision (Dixit and Pindyck, 1995). A call option on land sufficiently similar to the farmland in question could very well be used to capture the value of this land more precisely, i.e. the value of this call option would tell us something about the intrinsic value of the land (Luehrman, 1998a). Thus, ignoring the value of the option to convert to an alternative land use could very well result in an underestimation of the intrinsic value of the land being used in its current form (Zinkhan, 1991).

The following investigation takes on the issues of (a) the difference between the market price of farmland and its capitalized value, and (b) the possible impacts of urban development on the option value of land. Therefore, in the first part of this paper, attention is mainly focused on calculating the option value of farmland and implied volatility of future cash flows using a random sample of Ohio farm parcels. An assessment of the impacts of urban development on this option value and implied cash flow volatility follows.

Materials and Methods

Methods of Calculating Bid Prices and Land Values

Land's capitalization bid price is typically calculated by taking the present value of a stream of cash flows. In this paper, cash flows will correspond to net cash rents being paid for the land since we are examining the case from the owner's perspective. Traditional NPV analysis discounts a perpetual stream of cash flows, i.e.

$$V = \frac{\Pi}{r} \qquad [1]$$

where V denotes the present value of a perpetuity, Π is current period cash flow from the land as measured by net farm incomes (or cash rents as might be the case), and r is an appropriate discount rate.

Methods of Deriving the Real Option Value of Farmland

Throughout this research it will be assumed that cash flow, denoted as P, evolves over time as a random walk, and, therefore, it can be described by a Brownian motion with drift using the following stochastic process (Dixit and Pindyck, 1993):

$$d\Pi = a(\Pi,t)dt + b(\Pi,t)dz \qquad [2]$$

where dz is the increment of a Wiener process, and $a(\Pi,t)$ and $b(\Pi,t)$ are known nonrandom functions. A special case of equation 2 is known as the geometric Brownian motion with drift and can be written as

$$d\Pi = \alpha\Pi dt + \sigma\Pi dz \qquad [3]$$

Here, $a(\Pi,t) = \alpha\Pi$, and $b(\Pi,t) = \sigma\Pi$, where α represents the growth rate in Π, σ is the standard deviation of percentage change (natural logarithm) in Π (α and σ are constants) and dz is the increment to a standard Wiener process with dz = $\varepsilon_t \sqrt{dt}$, dt is the incremental change in time between successive observations in Π, and ε_t is a random error term with an expected value equal to zero and standard deviation equal to 1. Equation 3 is a general description of Π, and Π should represent the residual after-tax cash flow for the investment (Turvey, 1999). Equation 3 may also be referred to as the stochastic differential equation that governs the time-variant changes in Π. The value of a parcel that includes its option value is defined as

$$F(\Pi) = E[F(\Pi)+d\,F(\Pi)]^{-rdt}.$$

After applying Ito's lemma to $F(\Pi)$ and carrying out some mechanical calculations given in Turvey (1999), the following set of equations results:

$$\beta = \frac{1}{2} - \frac{\alpha}{\sigma^2} + \left(\left(\frac{\alpha}{2} - \frac{1}{2}\right)^2 + \frac{2r}{\sigma^2}\right)^{\frac{1}{2}} \qquad [4]$$

$$\Pi^* = \left[\frac{\beta}{\beta-1}\right] I\,(r-\alpha) \qquad [5]$$

$$A = \frac{\Pi^*}{(r-\alpha)\beta\Pi^{*\beta}} \qquad [6]$$

$$F(\Pi) = A\Pi^{*\beta} \qquad [7]$$

where $I = V(\Pi)$.

Equation 5 is a result of the smooth pasting condition that solves for the trigger level cash rent at which the option to sell land should be exercised, i.e. this is *the investment trigger* at which the option valuation curve becomes tangential to the NPV profile line. Therefore, the value of the option, when exercised, is equal to the value of disinvestments resulting from the sale of land. Hence, the decision rule for the owner is to postpone the sale until $\Pi = \Pi^*$ occurs.

In a real option framework the price of farmland equals its capitalized future cash flows plus the option value due to possible future land price increases. Thus,

$$F(\Pi, t) = V(\Pi, r, t) + C\,(\Pi, \sigma, t) \qquad [8]$$

where F(.) is the market value of land, V(.) is the land's capitalization bid price, and C(.) is the value of real option on this farmland.

Along the lines of Turvey's framework, this research concentrates on computing the option value C(.) as well as the implied volatility of future cash flows. First, we observe market prices and cash rents for a sample of Ohio land parcels. We then compute the capitalization bid price for each observation using a perpetual NPV model of equation 1 previously given above. And the difference between current market price and the present value (V) of reported cash rents is defined as the implied option value. That is

Call Option Value = Market Price - Capitalization Bid Price [9]

Note that this is an indirect way of computing the option value: one could do this analysis in a direct manner if volatilities were known (or easily estimated), i.e. we could use the option valuation formulae given in equations 4-7 and calculate the real option values directly. However, because volatilities are unknown we use an indirect method to calculate call option values. We then compute the implied volatilities by using the identity given in equation 9 and by reversing the calculation procedures given in equations 4-7. Our inquiry in this paper reduces to 2 questions: What implied volatility in future cash flow is necessary to have this observed option value? And what factors affect this implied volatility?

The Model and Data

The research reported in this paper estimates 2 independent linear equations for *cash rents* received and their *implied volatility* for a sample of Ohio landowners to capture the impacts of urban development on the real option value of land. Urban influences on these real option values are captured using a gravity model similar to that given by Shi et al. (1997).

In a gravity model, an *index of urban influence potential* is developed, which combines population and distances to metropolitan areas surrounding a parcel. It is calculated as

$$U_i = \sum_{j=1}^{3} \left(\frac{P_j}{D_{ij}^2} \right)$$

where U_i is the computed urban index number, P_j is the population of the metropolitan area j, and D_{ij}^2 is the square of the distance between the particular zip code location and the relevant metropolitan area. For the sake of implementation and using a similar argument given by Shi et al. (1997), we assume that a farm tract's option value is influenced by its distance to the 3 closest metropolitan areas. Distance is measured in kilometers between the zip code location of each tract in the data set and the zip code locations of the 3 closest metropolitan areas. We determined 11 metropolitan areas in 6 states including Ohio that form the *urban influence circle* for this model. They are: Detroit, MI; Toledo, OH; South Bend, IN; Fort Wayne, IN; Indianapolis, IN; Cincinnati, OH; Lexington, KY; Charleston, WV; Pittsburgh, PA; Erie, PA; and Cleveland, OH.

Using current cash rent (RENTRATE) and its implied future volatility (SIGMA) as dependent variables, 2 independent linear equations are specified to incorporate the impacts of urban development and other farm/non-farm characteristics on Ohio farm real estate markets. Their functional forms may be written as

$$SIGMA_i = \alpha_1\ URBAN_{1i} + \alpha_2\ POPDEN_{2i}$$
$$+ \alpha_3\ LANDAREA_{3i} + \alpha_4\ QLTYDVTD_{4i}$$
$$+ \alpha_5\ DUMMY_{5i} + \varepsilon_i$$

$$RENTRATE_i = \beta_1\ PERFARMLAND_{1i} + \beta_2\ QLTYDVTD_{2i}$$
$$+ \beta_3\ PERURBAN_{3i} + \upsilon_i$$

where SIGMA measures the implied volatility in future cash rents; RENTRATE is the current cash rent paid for the parcel; URBAN is the urban influence index of the ratio of population to squared distance with respect to the 3 closest metropolitan areas surrounding the parcel; POPDEN represents the population density by parcel zip code; and LANDAREA measures the size of the county in squared kilometers in which the parcel is located. Our hypothesis is that larger counties may provide more uniform institutions (e.g., zoning codes) that facilitate conversion from agricultural to residential and commercial use. DUMMY stands for a dichotomous variable that takes on values equal to 1 if the tract is located in an area where a lot of nearby land use conversion is happening and where these uses affect the fair market value of farmland and zero otherwise. We want to see if the observation on land conversion from agricultural to developmental/industrial uses translates into a change in value. Its coefficient, therefore, is expected to be positive. PERURBAN measures the percent of population living in urban areas by county; PERFARMLAND is the percent of land area classified as farmland by county; QLTYDVTD stands for a variable, namely QUALITY, in deviation form (i.e. QUALITY deviated from its mean) to correct for *multi-collinearity* diagnosed in both models. Therefore, the QLTYDVTD variable contains the *collinearity* consistent values of the QUALITY variable measuring the parcel's normal corn yield in kilograms per hectare; and ε_i and υ_i are the error terms respectively. We hypothesize that a parcel's SIGMA (implied volatility in future cash rents) is related to regional development pressures, and local or nearby pressures. The URBAN index constructed using a gravity model is intended to capture regional development pressures and its coefficient is expected to be positive. That is, a larger regional population (the numerator of the ratio) increases the demand for land and the probability of conversion, while distance to metropolitan areas surrounding the parcel, i.e. the denominator, has an inverse effect. Local development pressure is captured by the use of population density (POPDEN) and the proportion of urban population (PERURBAN) in the vicinity. The coefficients of both variables are expected to be positive, i.e. in the first equation a higher population density translates into greater future cash flow variability, while in the second one an increasing proportion of urban population within the parcel's county works its way towards creating an increasing demand for land with increasing future cash rents as a result.

Implied future cash flow volatility is expected to be greater on those parcels with greater prospects of future land use conversion. Land use changes in Midwestern states occur more rapidly in areas with higher proportions of poor quality agricultural land (Hsieh, 2000). Thus, we hypothesize that QLTYDVTD and SIGMA are inversely related. On the other hand, current cash rent for farmland is expected to be positively related to its quality.

In addition to PERURBAN described above, current cash rents paid are also assumed to be a function of the PERFARMLAND variable. PERFARMLAND is expected to have a positive impact on a parcel's cash rent, i.e. the rental rate tends to decline as a higher proportion of land is being converted from agricultural uses to others.

Heteroscedasticity

It might be the case that in the econometric modeling of this study the assumption of constant error variance, namely *homoscedasticity*, may break down for reasons attributable to the fact that the error variances associated with farmland option values of higher rental rate zones would be greater than their lower rental rate counterparts. This is because the variation in rental rates (sigma) might be more volatile for those farmland tracts located in higher rental rate zones. *Heteroscedasticity* is likely to occur when the error variances in our econometric models show this type of volatility, and, if it is present, the ordinary least-squares parameter estimates are still unbiased and consistent but they are not efficient, i.e. the variances of the estimated parameters are no longer the variances of minimum type. When these inefficient estimates are used to draw statistical inference, tests and confidence intervals will be incorrect (Pindyck and Rubinfeld, 1991).

Although there are several techniques to test for heteroscedasticity, the *Breusch-Pagan test* procedure will be sufficient for studies of large sample sizes. Considering that the number of observations (261) in this analysis is large enough provides a rationale for using this technique. Assuming a certain form of heteroscedasticity, the following *Breusch-Pagan* regression may be estimated to render a suitable test statistic to be used in testing the null hypothesis of homoscedasticity against heteroscedasticity:

$$\frac{\hat{\varepsilon}_i^2}{\hat{\sigma}^2} = \gamma + \delta Z_i + \nu_i$$

where $\hat{\varepsilon}_i^2$ are the individual error variances (residual squares), computed from the original heteroscedastic model, which are assumed to be linearly correlated to the explanatory variables, and $\hat{\sigma}^2$ represents the regression variance computed by dividing the error sum of squares by the number of observations. The variables included in Z_i could be a combination of the independent variables used in the original *heteroscedastic* model or they could represent the power forms (squared, cubed etc.) and/or interactive terms of these independent variables suspected to relate to heteroscedasticity. The calculated *Breusch-Pagan* test statistics for both models were large enough to reject the null hypothesis of homoscedasticity in favor of the presence of heteroscedasticity for both 5% and 1% significance levels. Therefore, a correction for heteroscedasticity was carried out using the *Weighted Least Squares* technique following the guidelines suggested by Pindyck and Rubinfeld (1991). Therefore, the parameter estimates, standard errors and test statistics reported in Tables 2 and 3 all are consistent with homoscedasticity, and are reliable for that matter.

All data are in zip code and/or county units and are taken from multiple sources. Farmland market price and rental rate data are from *the Ohio Farmland Lease and Precision Agriculture Survey* conducted by the Ohio State University in 1999. Data were collected through a mail questionnaire sent to a random sample of Ohio farm operators. The characteristics of respondents closely matched age and farm size distributions from the 1997 Census of Agriculture. In the survey participants were asked questions about rental rates, estimated market values, and parcel characteristics for "a particular tract that is representative of all tracts" that they cash lease. In addition, respondents identified the county and zip code where the tract is located and "normal" corn, soybean, and wheat yields on the tract.

Average estimated market price of the parcels is $6,549.19 ha⁻¹, actual 1999 cash rents average $169.33 ha⁻¹, and the calculated capitalization bid prices average $2,991.66 ha⁻¹ (Table 1).

The parcels' average option value (difference between estimated market price and capitalization bid price) is $3,557.53 ha⁻¹. Implied cash flow volatility (SIGMA) ranges from 0.63% to 100% for the 261 observations. The mean SIGMA is 25.45%, suggesting that future cash rents for many parcels in the sample are highly volatile.

Table 1. Diagnostics of the data.

Variable	Obs	Mean	Std Dev	Minimum	Maximum
SIGMA (%)	261	25.45	22.44	0.63	100.00
CASH RENT ($/Hectare)	261	169.33	64.80	24.71	370.66
MARKET PRICE ($/Hectare)	261	6,549.19	5,191.40	1,235.52	37,065.66
BID PRICE ($/Hectare)	261	2,991.66	1,144.90	436.58	6,548.70
OPTION VALUE ($/Hectare)	261	3,557.53	5,256.21	41.03	36,410.79

To facilitate the estimation, other secondary data are used as well. Microsoft DOS based software, named ZIPFIP, is employed to calculate distances between the parcel zip code and the 3 closest metropolitan area zip codes used in this study. ZIPFIP is a set of databases that contains both census and location information organized using ZIP (zip codes) and FIPS (county) levels, and a program by which these data sets can be accessed and manipulated. It conveys some useful features such as editing and displaying data, defining spatial boundaries known as market areas, determining distances between any 2 sites (e.g., any 2 zip code locations) in the lower 48 states, aggregating observations etc. Population numbers used to calculate the URBAN index, POPDEN, and PERURBAN in conjunction with the LANDAREA variable are taken or derived from the 2000 census. All data are dated as of 1999 except for the proportion of land area the community uses for agricultural purposes (PERFARMLAND). This variable is taken from the census of agriculture data for 1997, which we think would better match the analysis data than would the 2002 census of agriculture data. The discount rate used in this study is derived by taking into consideration historical data on returns to farm real estate over a certain period of time. The 50-year average annual rate of return to farm real estate is estimated at 11.17% for the period 1942-1991. Noting that the US economy faces a 5.21% inflation rate for the same period, the rate of discount is then calculated using $r_{real} + 1 = (1 + \text{nominal rate})/(1 + \text{inflation rate})$, yielding 5.66 % (Ibbotson).

Results

Tables 2 and 3 demonstrate the parameter estimation results for these models. Table 4 summarizes the impacts of marginal change in independent variables on rental rate, implied future cash flow volatility, and the state's market value of land. A quick inspection of Tables 2 and 3 shows that all the development variables are statistically significant at an appropriate significance level, and the models explain a considerable proportion of the variation in rental rate and its implied future volatility.

The computed R-square values for the models SIGMA and RENTRATE estimated using the *weighted least squares* come out to be 0.7343 and 0.9334, respectively. These statistics indicate a good general fit, especially considering that the models deal with cross-sectional data.

The URBAN index variable quantifies the regional effects of development on option value. It has a positive coefficient, suggesting that the smaller the distance between an observation and the 3 closest metropolitan areas, the higher the implied volatility in future cash rents, and hence the higher the option value. For example, the urban influence index for the 7th observation in the data set is based on the sizes and distances from Cleveland, Toledo, and Pittsburgh and the index number for this observation is 241.85 ($2,910,616 / 83^2 + 608,976 / 96.1^2 + 2,331,336 / 130^2$). Noting that we used *weighted least squares* in estimating the models, this computed urban index number of 241.85 translates into a new index number of 16.69 after the data are transformed by the weight number of 0.069 for the 7th observation. A 10% increase in population numbers of these 3 metropolitan areas would, for example, cause the weighted index to increase by 1.669 and the implied volatility of future cash rents to increase by approximately 0.21% (0.00848* 1.669/0.069). The value of land would increase by $9.92 ha^{-1} for the 7th observation (0.41*1.669/0.069; see Table 4).

Population density also has a positive coefficient, i.e. if the area in which the farm tract is located is highly populated, then future cash flows are expected to be

Table 2. Results from the weighted least squares for the SIGMA equation.

VARIABLE	Parameter Estimate	Standard Errors	t-statistic	P-Value
SIGMA (Dependent variable)				
URBAN	0.00848	0.00272	3.11	0.0021
POPDEN	0.07370	0.01507	4.89	< 0.0001
LANDAREA	0.01046	0.00127	8.23	< 0.0001
QLTYDVTD	- 0.00122	0.00041	-2.95	0.0035
DUMMY	9.04489	2.25478	4.01	< 0.0001

R-Square: 0.7343
F- Statistic: 141.46

Table 3. Results from the weighted least squares for the RENTRATE equation.

VARIABLE	Parameter Estimate	Standard Errors	t-statistic	P-Value
RENTRATE (Dependent variable)				
PERFARMLAND	1.90802	0.08157	23.39	< 0.0001
QLTYDVTD	0.01274	0.00136	9.34	< 0.0001
PERURBAN	0.76205	0.10213	7.46	< 0.0001

R-Square: 0.9334
F- Statistic: 1204.90

more volatile. This finding means that a one unit increase in the number of people per kilometer residing in the relevant zip code area will add approximately 0.07% to the value of the standard deviation of future cash flows. Thus, for example, a 10 unit-increase in the population density for a given zip code would induce the standard deviation to increase by 0.7% and a $35.40 ha^{-1} increase in land value.

Farmland with a lower rental rate (i.e. poorer quality agricultural land) is more likely to be associated with development. By the same token, the variable QLTYDVTD has a positive impact on rental rate, suggesting that farm tracts with higher quality soils for agricultural purposes receive higher cash rents and have higher market prices, *ceteris paribus*. For instance, for the first observation (Licking County) suppose corn yield was to increase by 1000 kg ha^{-1} because of a new drainage system installed by the landlord and assume corn yield increases from 8000 to 9000 kg ha^{-1}. Annual cash rent is then expected to increase by $12.74 per hectare (0.01274* 1000). In terms of market value, a $12.74 per hectare increase in

cash rent received will result in a $225.09 increase in the capitalized value of the land per hectare (12.74/ 0.0566).

The variable PERURBAN as another aspect of development is statistically significant and has a positive coefficient of 0.76205, i.e. every unit increase in the proportion of persons living in urban areas within the close vicinity will induce a $0.76 increase in cash rents received. A 100% increase in the urban population, for example, would cause a $76.21 increase in cash rents paid.

The rural status given by PERFARMLAND (as measured by the proportion of land area the community uses for agricultural purposes) has a positive estimate of 1.90802. This is to say that for every percent increase in land area classified as farmland there will be an about $1.91 increase in cash rents paid per hectare. That is, landowners, having their farm tracts located in an area where more neighboring land is classified as farmland, tend to receive higher cash rents. This result supports the *impermanency syndrome* because more development (i.e. lower values of the variable PERFARMLAND) has a

Table 4. The effects of marginal change in independent variables.

Marginal unit change in variables	Effects on implied volatility (%/year)	Effects on rental rate per hectare ($/ha)	Effects on market price of land per hectare ($/ha)
URBAN	0.00848	---	0.41
POPDEN	0.07370	---	3.54
LANDAREA	0.01046	---	0.50
DUMMY	9.04489	---	434.15
QLTYDVTD	- 0.00122	0.01274	0.19
PERFARMLAND	---	1.90802	37.19
PERURBAN	---	0.76205	14.85

Note: Variables' dollar effect figures on market value are computed using the regression results and by totally differentiating market value with respect to the variable in question. For the urban index variable, e.g., this value is computed as follows:

$$\frac{dM}{dU} = \left(\frac{\partial M}{\partial U}\right) x \left(\frac{\partial \sigma}{\partial U}\right) + \left(\frac{\partial M}{\partial P}\right) x \left(\frac{\partial \Pi}{\partial U}\right) = 0.41 \text{ dollars per hectare.}$$

negative effect on agricultural incomes and cash rents. Farming becomes more tenuous in developing areas due to congested roads, disrupted drainage systems, smaller parcel sizes, disappearing farm input supply stores, and so forth.

Discussion

The purpose of this research was to assess the real option values of farmland for a random sample of cash rented parcels in Ohio. The results show that many of the real call option values calculated for this sample are substantial, suggesting that the prospect of development and deferring the decision to sell land affects market values. Out of 291 observations, 261 landowners have positive option values, indicating that these parcels have market values determined, in part, by option values because of uncertainties in future cash flows.

We have demonstrated that where there is a high prospect of land use conversion from agricultural to other uses arising from urban development, the land's implicit call option tends to increase in value, reflecting future land price increases due to uncertainty, which is realized through the mechanism of increasing cash flow/rent volatility. We assert that it is the urban influence measured as size/distance in conjunction with other farm and non-farm causes that results in a change in volatility reflected in the real option value of land and thus its

market value as a result. The risks inherent in agriculture are, in part, what causes these variations in the future volatility of cash rents received. It is not the simple presence of a real option value suggesting an influence on land values due to the prospect of development and deferring the sale decision but rather the significant urban influences that play a crucial role in the formation of cash flow volatility. An increasing volatility, in turn, translates into a tendency towards an increasing real option value.

Therefore, development plays a crucial role in determining the state's farmland values through the real option value of land. In turn, option values can shape the performance and structure of agriculture in a region. In regions with higher option values, capital investments in farm real estate are higher, and greater proportions of farmland are owned by off-farm landlords; furthermore, cash rents and current returns to investments in agriculture are lower, and capital gain returns are higher. With development pressure, local agricultural economics are less sustainable, i.e. parcels are less accessible and smaller, drainage systems are often adversely affected, farm supply stores disappear, and so forth. Low current returns to agricultural investments, changing ownership of farmland, and faltering local agricultural businesses are not signs of a failing agricultural economy, but rather they may be signs of a local economy in transition.

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