Preservation or Development:
Competing Uses over the Future of Farmland in Urbanizing Areas**

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Introduction

State and county government agencies in all 50 states have adopted farmland preservation programs, and over 35 state and local governments actively engage in preservation through purchase or transfer of development rights (PDR and TDR) programs. These programs rely on voluntary participation and pay landowners for development rights that are permanently separated from the land.[1]

Individual preservation and development decisions occur amidst changing conditions in land markets and in the context of changing land use patterns. Farmland preservation programs are typically implemented on the fringes of developed areas, in areas experiencing the greatest suburbanization and the greatest growth in population and/or incomes. These growth pressures almost inevitably lead to rapid increases in the development value of agricultural land. When growth pressures are strong enough, development values of land can significantly exceed the agricultural use value. This can preclude new farmers from entering the industry due to the high acquisition cost of land, leaving development as the only viable land use option when farm ownership turns over. In the absence of farmland preservation programs, the relevant land use question in these areas often is not whether a landowner develops, but when.

Farmland preservation programs that pay landowners for development rights that are permanently separated from the land offer landowners an alternative to development. In addition to considering the gains from developing at the optimal time, landowners facing this preservation alternative can also consider the gains from preserving at the optimal time. Farmland preservation programs change the nature of the landowner's land use decision from simply an optimal timing of development decision, to one that has two components: decisions about the optimal timing of development and preservation, and a discrete choice between these two land use alternatives.

Existing empirical studies that model participation in PDR and TDR programs have treated the preservation decision as a binary discrete choice problem (Bockstael and Bell 1997;

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[1] Once the landowner sells the development rights associated with a farm parcel, that parcel is restricted from being converted to developed uses by the current and all future landowners. Even when development rights have been sold, the landowner retains ownership and remaining rights in the land.

Pitt, Lessley and Phipps 1988; Pitt, Phipps and Lessley 1988). These studies ignore that development constitutes a competing land use alternative and do not reveal any information about factors that affect the optimal timing of a landowner's preservation decision. Nor do they account for the effect of preservation agency priorities on preservation decisions. The goal of the current paper is to compare two alternative approaches to empirically modeling landowners' decisions to participate in PDR/TDR programs that can explicitly account for multiple alternatives and the dynamic nature of the decision process: a multinomial logit model and a Cox (proportional hazards) model. These empirical approaches stem from two different views of how landowners make land use decisions in the absence of perfect foresight, and both have potential limitations. In doing so we investigate how a number of factors influence a landowner's decision to preserve farmland, including the value of land in alternative uses and parcel characteristics that factor into preservation agencies' priorities when funds must be rationed. With the exception of one variable, we do not include measures that are specific to the landowner himself, as this type of data is rarely available.

State and local governments are increasingly adopting PDR or TDR programs with the goal of preserving as much land as possible before landowners find it optimal to develop. As a result, understanding the factors that influence a landowner's voluntary decision to preserve – in the context of competing choices for land uses – is becoming more important to policymakers. The policy advantage of the approaches we employ is that they attempt to reveal what motivates landowners to preserve their land, using data that policymakers have readily available. These approaches also avoid the costs and other difficulties of obtaining survey data sufficient to answer such questions. The drawback is that idiosyncratic factors that affect landowners' decisions is excluded from the models. Their absence induces a random distribution of reservation prices over prospective participants.

Models

The following empirical models are based on general theoretical models of the landowner's decisions regarding preservation and development, in which landowners are assumed to be utility maximizers. Landowners are assumed to derive utility from net worth – the most significant component of which is the value of land. In addition to the value of land in an agricultural use and in a developed use, landowners considering development are assumed to derive utility from owning farmland – because they derive utility either from farming as an occupation or from holding farmland. The latter may be true if the land has been in the family for a long time or has particular recreational value to the owner. Landowners considering preservation are assumed to derive utility from avoiding farm debt. Previous studies have suggested that debt management is an important issue for farmers and motivates them to preserve farmland (Pitt, Lessley and Phipps 1988; Perry and Johnson 1996; and Maynard et al. 1998). With perfect foresight, a landowner would consider the optimal time to preserve as well as the optimal time to develop, and in the present period would make a discrete choice between the two time paths. Perfect foresight is not realistic, though, because decision makers cannot perfectly anticipate future conditions. In what follows, we describe two alternative ways of modeling this decision process in the absence of perfect foresight.

Discrete Choice Model

In the absence of perfect foresight, a landowner will form expectations about the value of his land in alternative uses and will continually update these expectations. One approach to modeling this dynamic decision process is to treat the observation period as one decision period, in which the landowner makes a discrete decision among the alternatives: preserve, develop or postpone the land use decision. In this model a landowner chooses to preserve when preserving in this decision period yields utility that equals or exceeds 1) the utility from developing in this decision period, and 2) the discounted expected utility of delaying the land use decision (thereby retaining options in the future).

The empirical counterpart to this model of the landowner's decision process is a discrete choice model which allows for three alternatives: preservation, development, or postponement of the decision beyond the observable time horizon. The net expected utility from choosing any particular alternative will not be completely observable to the researcher; if the unobservable portion has an underlying logistic distribution, the probability landowner i chooses alternative j, P_{ij}, is defined as:

$$(4.1) \qquad P_{ij} = \frac{\exp\left(w_i \boldsymbol{\alpha}_j\right)}{1 + \sum_{k=1}^{K-1} \exp\left(w_i \boldsymbol{\alpha}_k\right)}, \qquad j \in k,$$

where P_{ij} is normalized on the K^{th} alternative, w_i is a vector of explanatory variables, and α is an associated vector of parameters. The vector w_i includes parcel characteristics that can be expected to affect agricultural returns (percent of cropland with prime soils)) and returns in development (commuting distance to employment centers and the percent of the parcel that is forested).

The easement payment can not be directly measured for all landowners, because it is not observed when the landowner does not preserve his land. However, since preservation agencies will estimate the easement value as some function of the agricultural use value and the development value of the parcel, the parcel characteristics used to measure agricultural and development returns will also affect the easement payment. Other important factors affecting the easement payment are agency preferences for parcels with particular characteristics; e.g., the size of the parcel, and its proximity to other preserved parcels. These parcel characteristics are included in w as are indicator variables capturing differences among preservation programs (agricultural district requirements, whether the State program is the only preservation option, and eligibility for bonuses). w_i also includes a measure of the length of parcel ownership (own≤3yr). This is included to capture differences in debt circumstances, since individuals who have recently purchased or inherited agricultural land may find themselves in a more untenable debt position than others and may be more likely to preserve sooner as a result. In terms of the development decision, a recent purchase may be an explanation of earlier development if the buyer bought the parcel with the intent to develop but rented out the land to farmers in the interim.

In this application $K=3$; the alternatives are preservation, development and postponent. The alternative of waiting to make the land use decision is chosen as the normalized alternative, K, and its probability is given by:

$$(4.2) \qquad P_{iK} = \frac{1}{1 + \sum_{k=1}^{K-1} \exp\left(w_i \boldsymbol{\alpha}_k\right)}.$$

Parameters are estimated by maximum likelihood. The likelihood function is the product of the N landowner contributions and is specified as:

$$(4.3) \qquad L = \prod_{i=1}^{N} \prod_{j=1}^{K} \left[P_{ij} \right]^{y_{ij}},$$

where y_{ij} equals 1 if landowner i chooses alternative j and 0 otherwise.

Cox (Proportional Hazards) Model

The second approach we employed to modeling preservation behavior is to assume landowners update expectations in each period and ultimately choose the "terminal state" alternative (preservation or development) whose optimal transition time arrives first. In each period, a landowner is viewed as making two separate decisions. In the first decision, he compares the utility he could earn from preserving in the current period to the expected utility he could earn by postponing the decision to preserve. He makes a similar decision about developing, comparing the gains from developing today to delaying the decision for a period. If it is not optimal to preserve or to develop in the current period, the landowner waits, updates his expectations, and again makes the two decisions in the next period. If it is optimal to choose either path in the current period, the landowner takes that irreversible action and the decision process ends. For this approach a Cox (proportional hazards) competing risks model is estimated. This approach assumes that a landowner will choose the alternative whose optimal transition time arrives first.

Duration analysis is useful for studying the occurrence and timing of events. The basic duration model treats all transitions as if they are identical, and does not allow the researcher to distinguish between alternative destination states. The method of competing risks is an extension of this basic duration model and permits a researcher to treat multiple destination states (i.e., types of transitions) differently and to estimate type-specific risks separately. It has been used to study a variety of issues, such as employment spells (Burdett et al. 1995), commodity brand switching behavior (Gonul and Srinivasan 1993, Gould 1998) and, recently, land use changes (Nickerson, 2000; Hite et al. 2000).

The competing risks approach assumes each destination state has a mechanism that governs both the occurrence and timing of the transition. Let $Z_1, \ldots, Z_J$ be the J independent random variables representing the durations for *J* destinations. The competing risks approach assumes that the actual destination state that is entered is determined by whichever Z_j is the smallest, and that it is this duration that is observed (Lancaster).

In our problem, $J=2$ as there are two terminal states. Letting $\boldsymbol{e}_{ij}$ represent the unobservable characteristics associated with a landowner's decision, define $\boldsymbol{e}_{ij}^{*}\ (j=1,2)$. as the $\boldsymbol{e}_{ij}$ of the landowner who is just indifferent between a transition of type *j* and no transition of type *j*. Conditioned on explanatory variables, the probability that a landowner will choose a transition of type *j* at time *t* is the hazard rate for type *j* in period *t*, and is given by:

$$(4.4) \qquad h_{ij}(t) = \frac{F\left[\boldsymbol{e}_{ij}^{*}\left(V^{j}, t+1\right)\right] - F\left[\boldsymbol{e}_{ij}^{*}\left(V^{j}, t\right)\right]}{1 - F\left[\boldsymbol{e}_{ij}^{*}\left(V^{j}, t\right)\right]},$$

where $F(\cdot)$ is the cumulative distribution function for $\boldsymbol{e}_{ij}$ and V^j is land value under the *jth* alternative. The conditional probability in equation (4.4) is the probability that a transition occurs between *t* and *t+1*, and that the type of transition is *j*, given that the landowner had not already developed or preserved his parcel by time *t*. The overall hazard of a land use transition is the sum of the type-specific hazards, $h_i(t) = \sum_j h_{ij}(t)$.

The proportional hazards model (also known as a Cox model) forms the basis of the competing risks model. This type of model is useful for providing information about the effect of explanatory variables on the timing of the decision, and it handles time-varying explanatory variables well. In the Cox model the hazard rate associated with hazard type *j* for individual *i* is specified as:

$$(4.5) \qquad h_{ij}(t; w_i(t)) = \boldsymbol{l}_{0j}(t)\exp\left[w_i(t)\boldsymbol{b}_j\right], \qquad j=1,\ldots J,$$

where $\boldsymbol{l}_{0j}(t)$ is a baseline hazard at time *t*, w_i is the vector of explanatory variables, and $\boldsymbol{b}_j$ is a corresponding vector of parameters. The parameter vector $\boldsymbol{b}$ is subscripted by *j* to denote that the effects of the parameters may differ for each type of transition. In fact, some elements of w_i may affect only one type of hazard and not another, implying that some elements of $\boldsymbol{b}_j$ may be equal to zero.

In estimating the hazard of preservation, parcel characteristics in the vector w_i that help explain the order of transitions are those that affect the easement payment. Also included is a measure to capture changes in demand in the land market, which will affect expectations of changes in development returns and easement values (changes in the number of housing starts). Other characteristics included are ones that measure government preferences for particular parcels, differences between preservation programs, and the length of ownership as a measure of different debt circumstances. For the hazard of development, parcel characteristics in w_i with expected nonzero parameters are those measuring agricultural returns, returns to development, and expectations on changes in those returns. $\boldsymbol{l}_{0j}(t)$ can also vary across transition types. $\boldsymbol{l}_{0j}(t)$ is viewed as a function of time only, common to all landowners at risk of the j^{th} transition, and controls the *rate* of transitions. In the context of the land transition problem, one could think of $\boldsymbol{l}_{0j}(t)$ as being a function of economic conditions that affect all parcels equally; e.g., interest rates, growth pressures, or development fees.

The parameters of the Cox model are estimated by maximizing the log of the partial likelihood function which does not contain the baseline hazards.[2] Unlike most applications of maximum likelihood, each observation in the data set does not necessarily make a contribution to the likelihood function in the Cox model; the ones that do not are those that are not observed to make a transition during the period of observation. Information about these observations, however, appear in the denominator of each likelihood contribution. The duration model literature refers to these observations as "censored." The i^{th} landowner's contribution to the likelihood function is given by:

$$(4.6) \qquad L_i = \frac{\exp(w_i(t_i)\boldsymbol{b})}{\sum_{l\in M(t_i)} \exp(w_l(t_i)\boldsymbol{b})},$$

[2] The Cox model is called a proportional hazards model because the j^{th} hazard for any landowner is a fixed proportion of the j^{th} hazard for any other landowner. Because the baseline hazard $\lambda_0(t)$ cancels out, the ratio of the hazards remains constant over time.

This is the probability that parcel i experiences transition given thte set of parcels at risk at time t_i and given the fact that a transition takes place at time t_i. In the above expression, $M(t_i)$ is the set of parcels still "at risk" of transition at time t_i. $M(t_i)$ will not include parcels that have moved into the terminal state before t_i.

The likelihood function for a single risk would be the product of all $\tilde{N}$ contributions, where $\tilde{N}$ is the number of parcels that make the transition in the observation period. Assuming that exactly one transition occurs at each event time, the likelihood function is given by:

$$(4.7) \qquad PL(\boldsymbol{b}) = \prod_{i=1}^{\tilde{N}} \left[\frac{\exp(w_i(t_i)\boldsymbol{b})}{\sum_{l \in M(t_i)} \exp(w_l(t_i)\boldsymbol{b})} \right].$$

Note that the partial likelihood function, $PL(\boldsymbol{b})$, will depend only on the order of the transitions and not on the precise time of them. In order to learn about the rate at which transitions take place, the baseline hazard would also need to be estimated.

In competing risks analysis, more than one terminal state exists. Each hazard is treated independently, however. The partial likelihood function for all transitions taken together is the product of the likelihood functions for each type of transition. The only adjustment occurs in the relevant risk sets at each point in time. The set at risk for hazard j at time t_i is now all those parcels that have not already succumbed to either of the potential hazards. In this application, the set at risk for preservation at time t_i will be all parcels that have not already been either preserved or developed by period t_i. The expression for the partial likelihood of all transitions taken together, assuming exactly one transition occurs at each time event is:

$$(4.8) \qquad PL(\boldsymbol{b}_1, ..., \boldsymbol{b}_K) = \prod_{j=1}^{J} \prod_{i=1}^{\tilde{N}_j} \left[\frac{\exp(w_i(t_i)\boldsymbol{b}_j)}{\sum_{l \in M(t_i)} \exp(w_l(t_i)\boldsymbol{b}_j)} \right],$$

where $\tilde{N}_j$ is the number of transitions to the j^{th} terminal state and J is the number of terminal states. Again, the partial likelihood function does not include the baseline hazard rates, the $\boldsymbol{l}_{0j}(t)$,which control the rate of transitions, so estimating the model does not reveal information about whether the hazard rate is increasing, decreasing or constant over time. The partial likelihood function depends only on the ordering of the transitions, and the explanatory variables help explain the order of the transitions. If the e_{ij}'s are independent, the partial likelihood function in equation (4.8) can be factored into separate likelihood functions for each transition type. This is the usual procedure for estimating the competing risks model and allows the hazard function parameters for each type of transition to be estimated separately.

Summary of differences in modeling approaches

The discrete choice and competing risks approaches differ in their implications for landowner behavior, and also in what the methods allow the researcher to capture in estimation. Landowners make preservation and development decisions in the face of development pressures and easement payments that increase over time, as well as county priorities that change from year to year. The decision modeled is whether the landowner, during the observation period, chooses to preserve or develop or whether he postpones these decisions until some later time that is not observable to the researcher. The drawback is that the discrete choice approach is a static one that does not allow the researcher to model how these changing circumstances affect the probability of preservation or development. On the other hand, this is one of the strengths of the competing risks approach. The latter method allows a researcher to introduce these differing circumstances into the model and to identify how these changes influence the risk of preservation and development. A possible drawback is that the implicit assumption embedded in the competing risks model is that the landowner chooses between preservation and development based on whether the optimal preservation time or the optimal development time is encountered first. Another limitation of the competing risks approach is that it requires the e_{ij}'s to be independent. That is, conditioned on explanatory variables, landowners who are at particularly high (or low) risk of one type of transition must be no more or less likely to experience any other type of transition. In the context of development and preservation decisions, the unobserved attributes that were described as giving rise to the respective e_{ij}'s are expected to be different. However, factors common to both errors can not be ruled out *a priori*.

A Case Study in Maryland

Four urbanizing counties in central Maryland comprise the study area: Carroll, Frederick, Calvert, and Howard. The State of Maryland operates a PDR program, in which landowners in all counties can enroll. Calvert and Howard Counties also operate distinct county PDR and county TDR programs. Although multiple preservation options exist in these two counties, landowners in these counties consistently chose to participate in the county programs rather than the State program during the study period. Carroll and Frederick Counties have "critical farms" programs that advance easement funds to farmers buying unpreserved farmland who wish to preserve the land, but preservation ultimately occurs through the State's PDR program. Table 1 depicts summary statistics on preserved parcels in these preservation programs.

The data used in estimation consists of all parcels that were at risk of both preservation and development during the period 1993 through 1997 in these four counties. Parcels excluded from the dataset, *a priori*, were those that were identified as having been preserved or developed prior to 1993, parcels identified as parkland or other similarly protected areas, and parcels that will remain undeveloped due to required clustering regulations. Using the Maryland Division of Assessments and Taxation (DAT) database and additional data on land use and zoning, the data set was further circumscribed to include only those parcels that met the minimum requirements for participation in a preservation program (i.e., parcels located outside planned water and sewer service boundaries, parcels in certain zoning districts, and parcels that met minimum soil quality and size standards). Consistent with program eligibility criteria, parcels smaller than the minimum acreage requirements for participation (in Carroll, Frederick and Howard parcels must be at least 100 acres in size, and in Calvert the minimum is 50 acres) were included only if located adjacent to an already preserved parcel. Depending on the zoning district, the parcels at risk included those with at least 10 acres in Calvert County, approximately 20 acres in Carroll County and 25 acres in Howard and Frederick Counties. A total of 1,680 parcels were identified as being at risk of preservation and development during the five year study period.

Data on preserved parcels were provided by county and state preservation agencies and linked to the DAT database. All parcels were then linked to Geographic Information System (GIS) data available from the Maryland Office of Planning, including data such as soil types, zoning, public utilities, and distances to various features in the landscape. A parcel was considered to have been converted to developed uses if it was subdivided into at least four pieces during the study period and it no longer qualified for preservation.[3] Four housing lots was

[3] This rule of thumb prevented coding as developed those large farm parcels which subdivided to create, for example, four to six house lots on the perimeter of the parent parcel, but which still retained a sufficient amount of land in agriculture to qualify for preservation.

chosen as the rule to identify parcels experiencing commercial-scale development. Using these definitions, 97 parcels were preserved and 45 were developed during the study period (Table 2).[4]

Definition of Explanatory Variables

Descriptive statistics for all of the variables used in estimation are reported in Table 3. Almost all of the same variables are used in estimating both the discrete choice and the competing risks models. However, the two variables that vary over time are measured differently in the two models: the variables measuring length of ownership, OWN≤ 3YR, and distance to the nearest preserved farm, DISTPRES. One of the principal advantages of using a Cox model is that it allows a researcher to readily incorporate variables that change in value over the course of the study period. In the discrete choice model, (OWN≤ 3YR) is equal to one if the parcel was owned three years or less as of 1993 and zero otherwise. In the Cox model, the length of ownership is measured such that OWN 3YR will equal one from 1991 through 1993 for any parcel purchased in 1991 will equal zero in 1994-1997. If a parcel is sold during the study period, the value of OWN 3YR is reset to one in the year of sale.

The distance to the nearest preserved farm will also take on different values during the study period, as closer parcels become preserved. The value of DISTPRES is updated accordingly each year in the Cox model. Smaller distances to other preserved farms are expected to induce earlier preservation, at least in the three counties (Calvert, Carroll and Frederick) that specifically prioritize purchasing development rights from these parcels first.

Because the Cox model can incorporate time-varying covariates, the competing risks approximation to the decision making process also allows the researcher to assess how the dynamics of local economic conditions and regulations affect the expectations of changes in returns to development and changes in easement values. Overall growth pressure in the region cannot be captured, as these effects appear in the baseline hazard whose parameters cannot be easily estimated. However, variations in growth pressure and in stringency of growth controls across counties can be proxied. The variable ÄNEWHOMES is derived from the Bureau of Census data on single family housing starts by county and is included in the competing risks

[4] Note: Administrative delays caused by adoption of a new system for handling preservation applications in Howard County prevented preservation of properties in 1993 in that county. Also, Howard County's PDR program terminated at the end of 1996.

models.. The four counties in the study area differ in the rates of growth in population and incomes they are experiencing, as well as in regulatory constraints, so the coefficients on this variable are allowed to vary by county. Descriptive statistics for all of the variables used in estimation are reported in Table 3.

Results – Comparison Across Models

The multinomial logit model allows a researcher to estimate decisions with multiple alternatives in a static framework, while the competing risks model reveals more about the timing of the decision process. In this section, we compare the results from modeling the landowner's preservation decision in these two frameworks. The results from maximum likelihood estimation of the multinomial logit model are reported in Tables 4. In Table 5 are the results from estimating the hazard of preservation in the Cox model. We do not include results from modeling the development decision in the Cox model, because the paucity of parcels in the dataset that were developed makes it difficult to draw conclusions about influences on the development decision. However, the preservation decision estimation takes account of the developed parcels by adjusting the set of parcels at risk from one time period to the next.

Whether the landowner's preservation decision is estimated using a multinomial logit or a competing risks approach, the proxies for agricultural returns and net returns to development appear to affect preservation decisions similarly. Where these measures increase the odds of preservation relative to waiting in the multinomial logit model, they bring forward the expected time to preservation in the competing risks model. Both models provide evidence a) that the State program appears to be successful in preserving the most productive farmland first in Carroll and Frederick Counties, and b) that commuting costs, one proxy for development returns, affect the timing of preservation decisions, nonlinearly. The probability of preservation (vs. postponing) decreases with commuting distance, and the turning points in the quadratics of both models are similar (approximately 33 and 50 miles in Carroll and Frederick, respectively). Both models also indicate that the Calvert parcels most likely to be preserved (relative to postponing) are those with the least productive land. In Calvert County, the TDR program is the primary preservation mechanism, and in such a program developers buy development rights without regard to parcel characteristics.

The effects of length of ownership (an indicator of debt circumstances) and agency preferences for preserving farms in clusters differs somewhat between the models. This is perhaps not surprising, since these two measures are time varying but cannot be treated as such in the multinomial logit model. The results imply that when the length of ownership is appropriately measured as a time varying covariate in the competing risks model, this measure of debt circumstances significantly increases the odds of preservation relative to postponing a decision in every county but Howard. Given the structure of the various preservation mechanisms, these preferences are expected to be at least as significant in Howard as they are in Carroll and Frederick Counties. Wald tests of the equality of the coefficients on the length of ownership variable provide some evidence that behavior is not significantly different across these three counties. In Frederick and Carroll Counties, the increase in significance of this variable when the decision is estimated in a competing risks vs. the multinomial logit model could be due to its more accurate measurement. An additional explanation for its significance is the influence of Carroll and Frederick Counties' critical farms programs, which allow preservation to occur sooner for new farm owners. The significance of the effect of agency preferences for preserving farms in clusters is also greater when the preservation decision is modeled in the competing risks framework as opposed to the multinomial logit model, and again because the relevant variable is measured more accurately. In the two counties that prioritize preserving in clusters, the expected time to preservation is sooner for parcels near already preserved farmland. The multinomial logit model provides only limited evidence that this agency preference can affect preservation probabilities, and only in Calvert County.

In addition to preferring preserving parcels in clusters, the programs in all four counties also prioritize purchasing development rights from larger farms first. This additional priority given to large farms is shown to affect preservation probabilities in Howard County in both models, but not in the other three counties. Nor does the requirement in some counties that parcels be enrolled in an agricultural district prior to preservation. Though this latter result implies that an extra set of requirements may not adversely affect preservation decisions (which may be encouraging for preservation agencies), the result could merely reflect that the county in which such a requirement would be the most costly (Howard County) does not have the district requirement for that reason. A more cautious interpretation of the insignificance on the coefficient on AGDISTRICT is that district status may not be a good signal that landowners ultimately preserve.

Also, the results indicate that a county's reliance solely on the State preservation program does not appear to adversely affect preservation decisions in either model. The incentive bonus offered in Carroll County, though, increases the likelihood preservation will occur sooner for Carroll landowners who qualify for it.

Because the competing risks model can accommodate time varying covariates, it allows testing of the effect of *changes* in expectations (as signaled by ÄNEWHOMES) on development returns (and thus easement values) on the preservation decision. The preservation decisions of Carroll County landowners are affected by these changes, but the effect was not strong. That an effect was apparent in Carroll but not the other counties could be attributed to the longer consistent trend in changes in housing starts in that county.

Summary

Even though the competing risks and multinomial logit models are intended to mimic different theoretical approximations to the land use decision process, the empirical results from estimating these models are quite similar, perhaps because of the importance the censored observations take on in this empirical exercise. Where the explanatory variables increase the odds of preservation or development relative to waiting in the multinomial logit model, they bring forward the expected time of preservation or development in the competing risks model. Perhaps not surprisingly, the differences between the models are limited to the variables that capture the changing context of the decision. While these variables are necessarily measured at one point in time in the multinomial logit model, they are allowed to vary over time in the competing risks model. Also, the competing risks model provides evidence that the effects of changes in expectations of development returns over time (and thus easement values) can affect preservation and development decisions; these effects are not as readily measured in the multinomial logit model. The competing risks model introduces more information (in terms of the ordering of decisions) and more accuracy in the measurement of time varying variables. As such, it may better capture the factors that influence preservation decisions.

The results from estimating the effects on preservation decisions suggest that preservation programs can affect the spatial pattern of preserved land. Amongst the eligible parcels in Carroll and Frederick Counties, which are preserved through Maryland's State PDR program, parcels are more likely to be preserved than to have the decision postponed the closer they are to major employment centers. In Carroll and Calvert Counties, the closer a parcel is to other preserved parcels the more likely it is to be preserved (vs. having the decision postponed). Neither of these effects are evident in Howard County. The resulting spatial pattern of preserved farmland could have implications for the extent to which the public is willing to support allocations of tax dollars to farmland preservation programs.

Although information on the public's preferences regarding farmland preservation is not available for Maryland, surveys have been conducted in other states. In a survey of Rhode Island residents, Kline and Wichelns (1996) found that respondents gave considerable importance to environmental objectives, including protecting groundwater resources, wildlife habitat, and natural places, and to aesthetic objectives, such as preserving rural character and scenic quality. Access to local fresh produce was also important, as was slowing development. Preserving large blocks of open space might best satisfy several of these objectives, but the desirability for close proximity to preserved land is unclear. If Maryland and Rhode Island residents have similar priorities, then the State program and Calvert County's programs preserve land in a manner consistent with at least some of the public's preferences for preserving farmland. This research should be a useful first step in addressing broader questions about the effects of preservation programs on spatial patterns of land uses.

Table 1. Acres of Preserved Farmland in Study Area as of June 30, 1997

	Carroll	Frederick	Calvert	Howard
Acres preserved through State program	25,591	10,062	3,455	3,956
Acres preserved through County programs	--	354	7,630	13,470
% of county land preserved	8.9%	2.5%	8.0%	10.8%

Source: MDA, USDA.

Table 2. Number of Preserved and Developed Parcels

	Year preserved or developed					
	1993	1994	1995	1996	1997	Total
Preserved parcels	15	26	22	15	19	97
Developed parcels	4	9	8	10	14	45
Parcels remaining in agriculture at end of study						1,538
Total parcels in dataset						1,680

Table 3. Descriptive Statistics (N=1,680)

Variable	Description	Mean	Std Deviation	Minimum	Maximum
Ca*cropprime	Equal to %cropland, for Calvert parcels with prime soils	0.04279	0.16103	0	1
Ho*cropprime	Equal to %cropland, for Howard parcels with prime soils	0.02945	0.14826	0	1
Cr*cropprime	Equal to %cropland, for Carroll parcels with prime soils	0.05570	0.19775	0	1
Fr*cropprime	Equal to %cropland, for Frederick parcels with prime soils	0.14277	0.31601	0	1
Ca*acres	Calvert*acres in parcel	10.85187	34.35457	0	402.30000
Ho*acres	Howard*acres in parcel	10.19796	61.76108	0	2042.28
Cr*acres	Carroll*acres in parcel	29.40312	58.95116	0	393.42000
Fr*acres	Frederick*acres in parcel	71.07968	81.46977	0	566.59000
Ca*commuteDC	Calvert*commute to Washington D.C. along roads network, in miles	6.95193	16.13742	0	59.97400
Ho*commuteDC	Howard*commute to Washington D.C. along roads network, in miles	2.94517	9.53023	0	41.78000
Cr*commuteBa	Carroll*commute to Baltimore along roads network, in miles	8.95147	16.10138	0	52.18100
Fr*commuteDC	Frederick*commute to Washington D.C. along roads network, in miles	27.19856	27.62828	0	73.11500
Ca*commuteDC2	Calvert*$(\text{commuteDC})^2$	308.59076	746.54832	0	3596.88
Ho*commuteDC2	Howard*$(\text{commuteDC})^2$	99.44535	329.66786	0	1745.57
Cr*commuteBa2	Carroll*$(\text{commuteBa})^2$	339.22894	647.63520	0	2722.86
Fr*commuteDC2	Frederick*$(\text{commuteDC})^2$	1502.63	1631.91	0	5345.80
Numlots	Number of house lots allowed	11.70991	29.51556	2.10600	680.76000
Numlots2	$(\text{Number of house lots allowed})^2$	1007.77	13248.04	4.43524	463434.18
Poorbuild	Equal to 1 if house construction difficult, 0 otherwise	0.38274	0.48619	0	1
Pctforest	Percent of parcel in forest	0.19283	0.23589	0	1
Ca*(own≤3yr)	Equal to 1 if Calvert parcel owned 3 or fewer years in 1993	0.01845	0.13462	0	1
Ho*(own≤3yr)	Equal to 1 if Howard parcel owned 3 or fewer years in 1993	0.01012	0.10011	0	1
Cr*(own≤3yr)	Equal to 1 if Carroll parcel owned 3 or fewer years in 1993	0.02321	0.15063	0	1
Fr*(own≤3yr)	Equal to 1 if Frederick parcel owned 3 or fewer years in 1993	0.05178	0.22166	0	1
Ca*distpres	Calvert*distance to nearest preserved farm in 1993 in meters	254.64303	900.97683	0	8972.04
Ho*distpres	Howard*distance to nearest preserved farm in 1993 in meters	106.77842	622.31021	0	9695.59
Cr*distpres	Carroll*distance to nearest preserved farm in 1993 in meters	356.84389	895.43709	0	8644.89
Fr*distpres	Frederick*distance to nearest preserved farm in 1993 in meters	1508.73	2070.52	0	12636.44
Agdistrict	Equal to one if parcel's county requires agricultural district enrollment, 0 otherwise	0.91131	0.28438	0	1

Table 3. Descriptive Statistics, continued

Variable	Description	Mean	Std Deviation	Minimum	Maximum
Stateonly	Equal to one if only the State PDR program is a preservation option, 0 otherwise	0.75059	0.43280	0	1
Crbonus	Equal to one if Carroll parcel was eligible to receive incentive bonus, 0 otherwise	0.05000	0.21801	0	1
Ca*(Δnewhomes)	Calvert*change in annual housing units authorized	-0.01529	0.03495	-0.09513	0
Ho*(Δnewhomes)	Howard*change in annual housing units authorized	-0.03208	0.10285	-0.36167	0
Cr*(Δnewhomes)	Carroll*change in annual housing units authorized	0.08008	0.14029	0	0.32572
Fr*(Δnewhomes)	Frederick*change in annual housing units authorized	-0.00587	0.00581	-0.01163	0

Note: The time-varying variables (own≤3yr, distpres, Δnewhomes) are reported for the first year of the study period.

Table 4. Results from Multinomial Choice Model –
Log Odds of Preservation Relative to Waiting

(N=1,680)

	Variable	Parameter Estimate	Standard Error	t-ratio	Prob |t| >= x
	Constant	-34.63122	27.227	-1.272	0.20339
*	Ca*cropprime	-1.683699	0.98558	-1.708	0.08758
	Ho*cropprime	1.176003	0.94979	1.238	0.21565
**	Cr*cropprime	1.098849	0.55922	1.965	0.04942
*	Fr*cropprime	1.005051	0.52987	1.897	0.05786
	Ca*commuteDC	-0.4235449	0.34503	-1.228	0.21961
	Ho*commuteDC	1.693369	1.5938	1.063	0.28801
**	Cr*commuteBa	-0.609221	0.25684	-2.372	0.01769
**	Fr*commuteDC	-0.3650562	0.17109	-2.134	0.03286
	Ca*commuteDC2	4.71E-03	3.94E-03	1.197	0.23144
	Ho*commuteDC2	-2.27E-02	2.33E-02	-0.975	0.32944
**	Cr*commuteBa2	9.44E-03	3.52E-03	2.681	0.00734
**	Fr*commuteDC2	3.70E-03	1.58E-03	2.34	0.01926
	Ca*pctforest	-0.8241648	0.92235	-0.894	0.37156
	Ho*pctforest	-0.2571128	2.114	-0.122	0.9032
	Cr*pctforest	-0.6421278	1.3196	-0.487	0.62655
	Fr*pctforest	-3.553019	2.3975	-1.482	0.13835
*	Ca*(own<=3yr)	0.992578	0.5408	1.835	0.06645
**	Ho*(own<=3yr)	1.797828	0.68864	2.611	0.00904
**	Cr*(own<=3yr)	0.9036933	0.42684	2.117	0.03424
	Fr*(own<=3yr)	0.5832862	0.40729	1.432	0.15211
	Ca*acres	5.18E-03	4.12E-03	1.257	0.20871
**	Ho*acres	7.54E-03	3.59E-03	2.101	0.03568
	Cr*acres	-1.38E-03	3.52E-03	-0.393	0.69445
	Fr*acres	-5.24E-03	4.02E-03	-1.306	0.19168
*	Ca*distpres	-4.89E-04	2.76E-04	-1.776	0.0757
	Ho*distpres	-5.73E-04	8.87E-04	-0.646	0.51798
	Cr*distpres	-1.12E-04	2.04E-04	-0.548	0.58343
	Fr*distpres	-5.74E-05	1.06E-04	-0.542	0.58798
	Agdistrict	42.19431	28.223	1.495	0.13491
	Stateonly	-1.858423	8.7688	-0.212	0.83216
**	Crbonus	2.500341	0.40675	6.147	0

log L -451.5550
**significant at 5% level
*significant at 10% level

Table 5. Results from Competing Risks Cox Model – Hazard of Preservation
(N=1,680)

	Variable	Parameter Estimate	Standard Error	Wald Chi-sq	Prob > Chi-sq
*	Ca*cropprime	-1.670554	0.94011	3.15763	0.0756
	Ho*cropprime	1.016652	0.83921	1.46758	0.2257
**	Cr*cropprime	1.285123	0.47366	7.36122	0.0067
**	Fr*cropprime	1.048374	0.51523	4.14024	0.0419
	Ca*commuteDC	-0.34229	0.32229	1.12793	0.2882
	Ho*commuteDC	0.98757	1.38062	0.51167	0.4744
**	Cr*commuteBa	-0.808281	0.20472	15.5892	0.0001
**	Fr*commuteDC	-0.526975	0.14003	14.16241	0.0002
	Ca*commuteDC2	0.003825	0.00367	1.08531	0.2975
	Ho*commuteDC2	-0.013115	0.02036	0.41497	0.5195
**	Cr*commuteBa2	0.01186	0.00278	18.22492	0.0001
**	Fr*commuteDC2	0.005158	0.00131	15.60312	0.0001
	Ca*pctforest	-0.989708	0.84509	1.37155	0.2415
	Ho*pctforest	-0.350081	1.795	0.03804	0.8454
	Cr*pctforest	0.361626	1.14618	0.09954	0.7524
	Fr*pctforest	-3.458848	2.33505	2.19418	0.1385
**	Ca*(own<=3yr)	1.385531	0.51769	7.16308	0.0074
	Ho*(own<=3yr)	1.10385	0.70964	2.41958	0.1198
**	Cr*(own<=3yr)	1.277558	0.36959	11.94889	0.0005
**	Fr*(own<=3yr)	0.96439	0.42324	5.19191	0.0227
	Ca*acres	0.005947	0.00391	2.30975	0.1286
**	Ho*acres	0.001911	0.00075	6.43876	0.0112
	Cr*acres	0.000006464	0.00285	5.15E-06	0.9982
	Fr*acres	-0.004696	0.00389	1.4609	0.2268
*	Ca*distpres	-0.000811	0.00044	3.45062	0.0632
	Ho*distpres	-0.000402	0.0007	0.32689	0.5675
**	Cr*distpres	-0.001181	0.00036	10.67582	0.0011
	Fr*distpres	-0.000185	0.00012	2.56177	0.1095
	Agdistrict	26.698157	24.2911	1.208	0.2717
	Stateonly	4.264358	7.88884	0.2922	0.5888
**	Crbonus	2.387112	0.36066	43.80724	0.0001
	Ca*(newhomes)	3.521146	3.13345	1.26276	0.2611
	Ho*(newhomes)	13.143252	23.20041	0.32093	0.571
*	Cr*(newhomes)	-1.942766	1.08055	3.23258	0.0722
	Fr*(newhomes)	-1.250312	2.12242	0.34704	0.5558

log L -430.0585
**significant at 5% level
*significant at 10% level

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