The Timing of Rapid Farmland Conversion Events: Evidence from California's Differential Assessment Program

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Abstract

Using county-level panel data, we estimate duration models to study the timing of rapid farmland conversion events. Results suggest that income and the proximity to major highways are the principal determinants of rapid conversion events (and also responsible for prolonging these events). In particular, an increase in income of 1% is found to hasten the time to a rapid conversion event by 111% and to extend the time back to a slow state of conversion by 76%. On the other hand, valuable agricultural land and high property taxes extend the time to a rapid conversion event (and also hasten the time back to a slow state of conversion). An increase in the value of agricultural production per acre extends the time to a rapid conversion event by 14% and hastens the time to a slow state of conversion by 106%. Knowledge about the timing of rapid farmland conversion will help counties to better predict infrastructure needs and take steps to mitigate the traffic and environmental impacts.

1 Introduction

California has a rich history of agriculture and the conversion of agricultural land to developed uses. Urban growth is incremental, but over a long period of time, such as forty years, the effect can be dramatic. The San Fernando Valley of 1970 bore little resemblance to that of 1930; the Santa Clara Valley of 1990 was vastly different from that of 1950. Today, the development of agricultural land in California continues, and at a rapid pace. One-sixth of all land developed in California since the Gold Rush was developed between 1990 and 2004. By 2050, the conversion of 2.1 million more acres of California land, much of it farmland, is predicted [1].

The Williamson Act Program (WAP) of California preserves agricultural land through property tax incentives - known generally as differential assessment for agricultural land. Private landowners voluntarily restrict their land to agricultural and compatible open-space uses under minimum ten year rolling term contracts with local governments. In return, restricted parcels are assessed for property tax purposes at a rate consistent with their actual use rather than potential market value. Non-renewal initiations indicate that the private landowner wishes to withdraw their land from the Williamson Act Program. Following a non-renewal initiation, the property tax assessment gradually increases from the Williamson Act level over the ten year non-renewal period to the full market value when the contract is terminated through a non-renewal expiration. Non-renewal initiations are often filed with the anticipation of converting farmland to other uses.

The conversion of farmland is of concern because this land produces positive externalities that the market for land does not internalize. Developers purchase open space for less than its social value because there may be no mechanism for the landowner to receive payments from households that value the locally grown agricultural commodities and the open space. In addition, developers do not bear all the infrastructure costs that their projects generate because of the government subsidization of road and sewer construction and mortgage interest deductions. Rapid, low-density development (urban sprawl) in particular is known to have private costs distorted below social costs (e.g. traffic congestion, poor air quality, and run-off).

The conversion of farmland is the topic of several recent studies [18, 17, 21, 6, 11]. The option of a "purchase of development rights" (PDR) program [18] and also the presence of sunk costs and uncertainty [17] delay the land development decision. A parcel level examination of the timing of residential, industrial, and commercial land development in Delaware County, Ohio finds that industrial development precedes or occurs concurrently with residential development, and zoning policies that attract industry also promote residential development. Infrastructure taxes delay development, but school taxes have little influence on residential development because of the public good provided although strongly deters industrial and commercial development [11]. Determinants of the conversion of agricultural land for residential uses in Medina County, Ohio include limited agglomeration economies, weak local jurisdiction regulations, and spillover effects from spatially adjacent developments [6]. Land use regulations in five western states (California, Oregon, Washington, Nevada, and Idaho) reduced the supply of developed land by 10% between 1982 and 1997 [21].

The focus of this paper is a county level analysis of i) the proportion of enrolled farmland in non-renewal status, and ii) the timing of rapid farmland conversion events, measured by non-renewal initiations, in the WAP of California. A log-odds panel model examines the proportion of enrolled land in non-renewal status, and a duration analysis examines the transition between slow and rapid states of farmland conversion. The data of the non-renewals in the WAP include fifty-three California counties from 2000 to 2007.

We examine, at the county level, the influence of the net returns, costs, and the uncertainty of development on the transition between slow and rapid farmland conversion events. A limited number of parcel level studies make use of duration models to study farmland conversion [18, 11, 12], but this is the first study to apply duration models to the county level to examine the timing of slow versus rapid farmland conversion. Since land use regulations are often set at the county level, the findings of this study are of use to policy makers that need to predict infrastructure needs and takes steps to mitigate traffic and environmental impacts.

2 A Model of Farmland Conversion

Recently authors have recognized that land development is an investment that is irreversible, that returns are uncertain, and that the decision to convert can be postponed [4, 5]. While the net present value rule predicts land will be developed as soon as the present value of development, net of conversion costs, exceeds the present value of current use, recent models recognize the effects of risk by introducing a value of waiting, as more information emerges. The net returns, R, evolve over time according to a geometric Brownian motion as

$$\mathrm{d}R = \alpha R\,\mathrm{d}t + \sigma R\,\mathrm{d}z \tag{1}$$

where α is the rate of growth in expected net returns, σ is the standard error of the development value, and $\mathrm{d}z$ is an increment of a Weiner process of the continuous time equivalent of a random walk.

The net present value rule would predict conversion as soon as $R(t) \geq C(t)$, where $R(t)$ is the value of development in time t minus the lost net revenues due to the non-developed use in perpetuity, and $C(t)$ is defined as the cost of development in time t. Recent models introduce a wedge between the net returns and the costs

$$R(t) - O(R) \geq C(t) \tag{2}$$

where $O(R)$ is the value of the option to wait to develop the land. The value of the option to wait is defined by

$$O(R) = \max_T E[(R_T - C)e^{-\rho T}] \tag{3}$$

where T is the conversion time and ρ is the discount rate. The solution to (3), that specifies the optimal development time, is increasing in both α and σ, and thus the rate of growth of expected net returns and the standard error of the development value slow development[8].

Thus, the explanatory variables of the farmland conversion decision relevant for the empirical models include i) the net returns to development that reflect development value less the opportunity cost of the land in agricultural use, ii) the cost of development for the developers, and iii) risk variables, such as α and σ, that reflect uncertainty in the net returns to development.

3 Panel and Transition Models of Farmland Conversion

The empirical models include a i) log-odds panel model for the proportion of enrolled land in non-renewal status, and ii) Cox transition models for the timing of farmland conversion: a) transition between slow to rapid states of conversion, and b) transition between rapid to slow states of conversion.

3.1 Panel Models of Farmland Loss

Panel models pool a cross-section of observations (California counties) over several time periods. The major advantage of panel models is greater precision in estimation due to the increase in the number of observations from combining several time periods for each county. However, for valid statistical inference, a control for likely correlation of regression model errors over time for a county is necessary. This is accomplished with individual-specific effects models, in particular we use the fixed effects and the error component two stage least squares (EC2SLS) random effects models.

The attraction of the fixed effects model is consistent estimation of parameters even if unobserved heterogeneity is correlated with the regressors, assuming that the unobserved heterogeneity is additive and time-invariant. However, the fixed-effects model only permits identification of time-varying regressors. Therefore, estimation of the marginal effect of proximity to an urban area is not identified. The random effects model permits identification of all regressors, but the key assumption is that there is no unobserved heterogeneity correlated with the regressors. In order to estimate time-invariant regressors of interest, while correcting for potential correlation found between unobserved heterogeneity and the regressors, we use the efficient EC2SLS estimator [2].

The non-renewal status indicator for the panel models is the proportion of enrolled farmland in the WAP that is in non-renewal status. We indicate the non-renewal status indicator by the proportion (p_{it}) for county i in time t. The form of the dependent variable is the log-odds ratio of the non-renewal status indicator, $\log(p_{it}/(1-p_{it})$, which is commonly used in econometric models of proportions like aggregate voting results [13, 20]. The standard form of a general individual-specific effects model is:

$$\log(p_{it}/(1-p_{it})) \quad = \quad \mathbf{x}_{it}^{'}\beta + \alpha_i + \varepsilon_{it}, \tag{4}$$

where $\mathbf{x}_{it}^{'}$ are explanatory variables related to net returns, costs, and risks of development, including time and location dummies; α_i are random variables that capture unobserved heterogeneity in county i, and ε_{it} is iid for county i in time t.

The fixed effects estimator measures the association between county specific deviations of regressors from their time-averaged values and county specific deviations of the dependent variable from its time-averaged value. To see this, by taking the average over time of (4), yields $\overline{\log(p_i/(1-p_i))} = \alpha_i + \overline{\mathbf{x}}_i^{'} + \overline{\varepsilon}_i$. Subtracting this from $\log(p_{it}/(1-p_{it})$ in (4) yields the fixed effects mdoel:

$$\log(p_{it}/(1-p_{it}) - \overline{\log(p_i/(1-p_i))} \quad = \quad (\mathbf{x}_{it} - \overline{\mathbf{x}}_i)^{'}\beta + (\varepsilon_{it} - \overline{\varepsilon}_i), \tag{5}$$

where the α_i terms cancel.

The EC2SLS estimator is fully efficient though the efficiency gain compared to pooled OLS need not be great. The IV estimator of the model

$$\log(p_{it}/(1-p_{it}) - \widehat{\lambda}\overline{\log(p_i/(1-p_i))} \quad = \quad (\mathbf{x}_{it} - \widehat{\lambda}\overline{\mathbf{x}}_i)^{'}\beta + (1-\widehat{\lambda})\alpha_i + (\varepsilon_{it} - \widehat{\lambda}\overline{\varepsilon}_i), \tag{6}$$

with instruments $\tilde{z} = (z_{it} - \widehat{\lambda}\overline{z}_i)$, where $\widehat{\lambda}$ is a consistent estimate of $\lambda = 1 - \sigma_\varepsilon/\sqrt{\sigma_\varepsilon^2 + T\sigma_\alpha^2}$, is the EC2SLS estimator. The instruments for the endogenous regressors are the regressors of the spatially adjoining counties. The regressors of the spatially adjoining counties are correlated with the regressors of the county of interest, but are not correlated with the unobserved heterogeneity in the county of interest. An important restriction is that the instruments be strongly exogenous, which means the error component term is assumed to have mean zero conditional on past, current, and future values of the instruments.

3.2 Transition Models of the Timing of Rapid Farmland Conversion

Models known as transition, duration, and survival models are used to identify and measure temporal patterns and causes of change. Economists have used the models to investigate the length of unemployment spells, duration of strikes, and job search and migration patterns[14, 10, 7]. Recently, transition models have been applied to the study of factors associated with land-use change[18, 11, 12].

We study the transition of counties from i) a slow to rapid state of farmland conversion, and ii) a rapid to slow state of farmland conversion. The indicator for the transition between slow and rapid states of farmland conversion is the proportion of non-renewal initiations to cumulative non-renewals in the WAP. A high proportion of this indicator means more farmland conversion than is typically observed, and thus a rapid state of conversion. The transition between states is of interest to a counties planning for future infrastructure and concerned about the negative traffic and environmental impacts.

Transition data are often censored, as some spells are incompletely observed. That is, the spells of a particular state are only observed in the study period. If a county transitions before the study period, this county is left-censored, contains very little information for measuring hazard rates, and is dropped from the data set. If a county survives transition throughout the study period, then the county is right-censored, and we do not know if it will transition at some point in the future, although the estimated model can provide a prediction.

We adopt a widely used method in the analysis of transitions: the proportional hazards model. In a proportional hazards model, the conditional hazard rate $\lambda(t|\mathbf{x(t)})$ factors into separate functions:

$$\lambda(t|\mathbf{x(t)}) \quad = \quad \lambda_0(t|\mathbf{x(t)})\phi(\mathbf{x(t)}, \beta), \tag{7}$$

where $\lambda_0(t|\mathbf{x(t)})$ is the baseline hazard and is a function of t alone, and $\phi(\mathbf{x(t)}, \beta)$ is a function of $\mathbf{x(t)}$ alone. Usually $\phi(\mathbf{x(t)}, \beta) = \exp(\mathbf{x(t)}'\beta)$. All hazard functions $\lambda(t|\mathbf{x(t)})$ of the form (7) are proportional to the baseline hazard, with scale factor $\phi(\mathbf{x(t)}, \beta)$ that is not an explicit function of t. The proportional hazards model is popular because the parameters β can be consistently estimated without specification of the functional form for $\lambda_0(.)$.

Rather than estimate a fully parametric proportional hazard model, such as the exponential or Weibull, that produce inconsistent parameter estimates if any part of the parametric model is misspecified, we use the Cox semi-parametric method that requires a less than complete distributional specification. The functional form for $\lambda_0(t)$ is left unspecified and the functional form for $\phi(\mathbf{x(t)}, \beta)$ is specified as $\exp(\mathbf{x(t)}'\beta)$.

Cox defined the log partial likelihood function to be:

$$\mathrm{lnL}_p(\beta) \quad = \quad \sum_{i=1}^{N} \delta_i \left[\mathrm{ln}\phi(\mathbf{x}_i(t_i), \beta) - \mathrm{ln}\left(\sum_{l \in R(t_i)} \phi(\mathbf{x}_l(t_i), \beta) \right) \right], \tag{8}$$

where the indicator variables $\delta_i = 1$ for uncensored observations and equal zero otherwise, $R(t_i) = \{l : t_l \geq t_i\}$ is the set of spells at risk at t_i, and the baseline hazard factor $\lambda_0(t_i)$ has dropped out as a consequence of the proportional hazard assumption.

Time-varying covariates, $\mathbf{x(t)}$, may not be strictly exogenous as is usually assumed in duration models. For example, the duration of a slow state of farmland conversion may depend on the production value of agriculture, but the latter may change as the duration of the slow state of farmland conversion lengthens. This may be because a farmer knows that agriculture is the best use for their land for an extended time and chooses a crop mix accordingly. To address this potential feedback, we replace time-varying covariates of concern with their predicted values from a regression on instruments and time-invariant covariates.[1]

The data involve multiple spells for the slow to rapid state transitions and for the rapid to slow state transitions. Rather than study possible dependence structures between the transitions, we assume the spells are independent and thus can be analyzed by single-spell methods. However, indicator variables included in $\mathbf{x(t)}$ specify if the spell is a second or third spell; a county has no more than three spells in the given study period. Temporal dependency among repeated observation for a county is likely since the risk of a transition for a county in a given year is not independent of its status in previous years. We handle this temporal dependency by specifying temporal dummy variables since the number of years covered in the data set is small.

Unobserved heterogeneity is a serious consideration since there are relatively few included variables. We attempt to address this first with a mixture Cox model of a gamma-distributed random effect that multiplicatively affects the hazard. This mixture model does not converge to consistent estimates, and instead we use a stratified Cox model that estimates equal coefficients across stratum but with baseline hazard unique to each stratum. The stratified Cox model is able to place some of the unobserved heterogeneity into the baseline hazard unique to each stratum which is then removed as a consequence of the proportional hazard assumption.

4 Study Area and Data

The study area is the fifty-three counties of California that participate in the Williamson Act Program (WAP).[2] California is home to the most productive agricultural counties in the nation. According to the 2002 Census of Agriculture's ranking of the market value of agricultural products sold, nine of the Nation's top ten producing counties are in California[15]. Although California farm land is valuable, there is also pressure to develop the land for residential, commercial, or industrial use. One pressure is California's population is projected to grow from 37 million to 42 million by 2025 [16].

The data on farmland conversion is based on the non-renewals in the California Department of Conservation's WAP. The WAP has been California's differential assessment program for agricultural land since its enactment in 1965. Private landowners voluntarily restrict their land to agricultural and compatible open-space uses under minimum 10-year rolling term contracts with local governments. In return, restricted parcels are assessed for property tax purposes at a rate consistent with their actual use, rather than potential market value. Non-renewals are often filed with the anticipation of converting farmland to other uses.

The enrollment, cumulative non-renewals, and the non-renewal initiations in the WAP for the fifty-three California counties in the program were collected from California Division of Land Resource Protection for the period of 2000 to 2007.[3] The time frame of the study of 2000 to 2007 includes a period of significant change in non-renewals starting in 2003 with the boom in the California housing market, which slowed considerably in early 2008. The increase in the non-renewal initiations are most significant, in terms of the absolute number of acres, for the San Joaquin Valley and the South Coast regions.

There are two non-renewal status indicators that form the dependent variables for the panel and transition models, shown in the last two columns of Table 1, for the panel models, i) cumulative non-renewals proportion of enrollment, and, for the transition models, ii) non-renewal initiations proportion of cumulative non-renewals. The first dependent variable, for use in the panel models, is most significant in the Foothill and the South Coast regions. The second dependent variable, for use in the transition models, is most significant in 2005 in the Central Valley and the South Coast regions.

The description of the county level explanatory variables for the models are in Table 2 and 3. The variables include those related to agriculture, employment, demography, taxes, topography, location, and time dummies that are separated into the categories for i) returns to development, ii) opportunity costs (such as agricultural returns), iii) costs of development, and iv) risk variables for the uncertainty of returns to development.

We represent the returns to development with population, income, and location variables. The annual population growth (LNPOP) is from the California Department of Finance. The annual per capita personal income growth (LNINCOME,LNINCADJ) is from the Bureau of Economic Analysis. Both population and income growth are indicators of higher returns to development. The variables for location that increase returns to development include the distance in miles from metropolitan areas of greater than one and a half million people (CITY25DUM,CITY50DUM,CITY75DUM) and the distance in miles from metropolitan areas of greater than one hundred thousand (TOWN25DUM,TOWN50DUM, TOWN75DUM). There are also variables for the distance in miles from the nearest coast line (COAST25DUM,COAST50DUM, COAST75DUM).[4] An indicator variable distinguishes the counties where the prominent Highway 99 of the Central Valley is present (HWY99). The proximity of farmland to a city, town, coast line, or highway is an indicator of higher returns of development.

The opportunity costs of development (or returns to agriculture) are represented by agricultural and employment variables. The agricultural variables for the acres per farm (LNFRMSIZE), government payments per acre (LNGPAY), and the value of agricultural production per acre (LNAGVALUE,LNAGADJ) are from the 1997 and 2002 Census of Agriculture and the annual California Agricultural Statistics reports collected and compiled by National Agricultural Statistics Service. The effect of farm size is ambiguous, as economies of scale may be evident in both farming and development. Government payments and the value of agricultural production per acre are indicators of higher returns to agriculture. Agricultural employment per farm (LNAGEMPLY) is from the California Employment Development Department's annual Agricultural Labor Survey. Greater agricultural employment per farm is an indicator of higher intensity agriculture, which suggest higher returns to agriculture.

We track the cost of development with variables that include the proportion of land in pasture to cropland (PCRATIO) or woodland to cropland (WCRATIO) from the 1997 and 2002 Census of Agriculture. The hilly terrain characteristic of pasture or woodland increase the cost of construction. A direct measure of the cost of construction per single-family home (LNBLDGCOST) is from the Employment Development Department. Annual employment variables for non-farm, farm, service, and manufacturing employment (LNNOFARM,LNSERVICE) are from Bureau of Economic Analysis. The effect of the proportion of non-farm to farm employment is ambiguous because strict development regulations and the demand for development may both be evident. The proportion of service to manufacturing employment indicate strict development regulations and higher density development, both costs of development.

The annual property tax rate (PROPTAX) is the proportion of property taxes to assessed property value (in thousands) from the *Counties Annual Report* of the California State Controller. The rate of property tax is a deterrent to developers that pay new construction property taxes pegged at the rate of the property tax. The elevation (LNELEV) is from the US Geologic Survey of fifteen hundred foot elevation intervals. There are also variables for the distance in miles from the nearest edge of the Sierra Nevada mountains (SIERRA25DUM,SIERRA50DUM,SIERRA75DUM). The effect of elevation or proximity to the Sierra Nevada mountains is ambiguous because weak development regulations, natural amenities, (which promote development) and steeper terrain (which deters development) all prevail at higher elevations. The index of steepness of the topography (LNTOPO) is created by inverting sum of the squared proportion of land at the fifteen hundred foot elevation intervals. A county with a small proportion of land in several elevation intervals has a high index value, which physically speaking is usually the edge of a mountain range. Steeper topography increases the costs of construction for development.

The drift (DRIFT) and standard error (VARIANCE) of sales prices of single- and multi-family homes in all California counties from 1997 to 2007 is from a real estate information company called DataQuick.[5] The drift is constructed as the average for the last three years of the year-over-year growth of the median sale prices of each county. The variance is the standard deviation for the last three years in the median sale prices of each county weighted by average value of sale prices for the last three years. Since the empirical models already control for agricultural, employment, demographic, tax, topographic, and location variables, we believe that the measures of drift and variance of returns are a reasonable proxy for the uncertainty developers face.

Five regions of the Williamson Act Program - Bay and Central Coast (BAYDUM), Foothills and Sierra (FOOTDUM), Sacramento Valley (SACDUM), San Joaquin Valley (SANJDUM), South Coast and Desert (SOUTHDUM) - have 0,1 indicator variables, with the North Coast and Mountain the omitted region. These regions of California represent different cultures that are potentially relevant to development patterns. The boom in the California housing market starting in 2003 makes time an important consideration in the analysis. Seven 0,1 indicator variables for each year from 2001 to 2007 (YR01,YR02,YR03,YR04,YR05,YR06,YR07) capture the influence of the year specific effects, with the year 2000 the omitted year. Also, the transition models study the effect of second and third spells that follow the initial spell in the rapid and slow states of farmland conversion (SPELL2,SPELL3,SPELL).

5 Empirical Panel Models of Farmland Loss

The empirical panel models allow for the possibility that time-invariant unobserved heterogeneity is correlated with the regressors.[6] The fixed effects (or within) estimators eliminate time-invariant unobserved heterogeneity, by taking differences from time-averaged values, from the variation in the data over time. The EC2SLS estimator relies on instruments of regressors to control for unobserved heterogeneity potentially correlated with those regressors.

Hausman's specification test suggests that for the empirical panel models that instruments are necessary for the following covariates: the value of agricultural production per acre, the average value of agricultural production per acre of adjacent counties, the per capita personal income, the average per capita personal income of the adjacent counties, the the cost of construction per home, and the variance of the net returns for development. Since this set of variables appears to be determined simultaneously with farmland conversion, appropriate instruments for these regressors are needed.

The excluded instruments are the spatial lags of the regressors of the adjoining counties i) the adjoining county with the most spatial contact and ii) the simple average of all other adjoining counties. This choice of excluded instruments is because these instruments are correlated with variation in the regressors of concern but uncorrelated with the unobserved heterogeneity causing the simultaneity bias. We compute Sargan's statistic to test and confirm the joint null hypothesis that i) the instruments are valid, and ii) the instruments are correctly excluded from the estimated model.[7] Another approach to correct for the simultaneity is to replace the regressors with their temporal lags. The model results with the temporal lags are similar to the model results with the instruments. However, because of the short time-series of the data set, the use of the temporal lags causes a non-trivial reduction in the size of the data set. For this reason, the instrumental variables approach using spatial lags is preferred.

6 Empirical Transition Models of the Timing of Rapid Farmland Conversion

There are two states defined by the proportion of non-renewal initiations to cumulative non-renewals: 1) a county is in a slow state of farmland conversion if the proportion is less than 0.15; and 2) a county is in a rapid state of farmland conversion if the proportion is more than 0.15. According to Table 1, none of the regions of the WAP were in the rapid state in 2001, but 33% were in 2003, then 66% in 2005, and finally all of the regions in 2007.

There is an analysis of both the i) transition from the slow to the rapid state and ii) the transition from the rapid to the slow state of farmland conversion. This reflects the policy maker's interest in knowing the duration of time until a rapid state to decide if urban sprawl is an issue of future concern. There is also the interest of a policy maker in knowing the duration of time before the end of a rapid state to decide whether to take measures to contain development. Both models allow for counties to have more than one transition spell. We assume the spells are independent and thus can be analyzed by single-spell methods.

For the analysis of the transition from the slow to the rapid state, if the ratio of non-renewal initiations to cumulative non-renewals is less than 0.15, at time t_i, then the county is part of the risk set $R(t_i) = \{l : t_l \geq t_i\}$. Otherwise, the county has already transitioned and is no longer part of the risk set $R(t_i)$. Duration periods range from zero years (left-censored – the county transitioned to the rapid state prior to the analysis period) to seven years (right-censored – the county has survived the transition to the rapid state). Similar reasoning describes the risk sets for the analysis of the transition from the rapid to the slow state.

Table 4 provides the number of counties in each duration period along with their empirical hazard and survivor rates for both transition analyses. About 17% of the spells are left-censored for the slow to rapid state analysis, that is transitioned to the rapid state prior to 2000. Over half of the spells transition to the rapid state within two years. Only about 2% of the spells survive transition for the full study period of seven years. For the analysis of the rapid to slow state, more than 38% of the spells had transitioned to the slow state prior to 2000. Over 80% transition to the slow state within one year, and none of the spells survive the transition for the full study period.

We observe that counties transition differently depending on the WAP region, the proximity to a metropolitan area, and the ratio of pasture to cropland. To control for these effects, two stratified Cox models for the slow to rapid transition are estimated. The model Region Strata stratifies (estimates a different baseline hazard) by the six WAP regions. The model Region-Metro Strata further stratifies a WAP region into counties close to a metro area (within 34 miles) and those distant from a metro area. Two stratified Cox models for the rapid to slow transition are also estimated. The model Region-Metro Strata stratifies by the eleven strata for the six WAP regions and the proximity to metro area.[8] The model Region-Metro-Pasture Strata further stratifies the eleven region-metro strata into counties with relatively more pasture (more than double) and counties with relatively more cropland.

The transition between states of farmland conversion may be simultaneously determined with time-varying covariates. We use Hausman's specification test and find that the following covariates are of concern: value of agricultural production per acre, the cost of construction per home, the ratio of non-farm to farm employment, the rate of property tax, and the variance of the net returns. We instrument for these variables with spatial lags.

We allow for multiple transitions of a county during the study period. The assumption is that there are no dependencies between the spells and thus single-spell models are appropriate. For the slow to rapid transition models, we include dummy variables for the second and third spells since later spells transition at different rates. For the rapid to slow transition models, a single dummy variable suffices for both the second and third spells since there are only three counties with a third spell.

7 Results

The results include a sub-section for the panel model results shown in Tables 5 and 6 and a sub-section for the transition model results shown in Tables 7 and 8.

7.1 Panel Model Results

The Wald statistic for the log-odds panel models shown in Tables 5 and 6 indicate a better fit for the IV Random-Effects (or EC2SLS) estimator. This is because the county-specific variables only present in the random-effects model have a lot of explanatory influence. Standard errors of the covariate estimates are corrected for latent heteroskedasticity using White's heteroskedastic consistent covariance method. The component of the error term attributable to county-specific effects, ρ, is 0.980 for the fixed-effects estimator and much lower at 0.129 for the EC2SLS estimator. This suggests that the proportion of enrollment in non-renewal status is heavily influenced by county-specific variables that the EC2SLS estimator captures. Temporal dependency is accounted for using year-specific dummy variables. The panel models measure the effect of covariates on the log-odds ratio of a county's proportion of enrollment in non-renewal status. A positively signed covariate increases the percentage odds that an acre of land enrolled in the WAP program is in non-renewal status, and a negatively signed covariate decreases the percentage odds that an acre of land enrolled in the WAP program is in non-renewal status.

The two panel model estimators are similar in sign for the significant covariates. The significant covariates for the fixed-effects model are the value of agricultural production per acre (LNAGVALUE), the population growth (LNPOP), the drift and the variance of net returns (DRIFT,VARIANCE), all with the expected sign, except for the drift. Although a positive effect for drift is not consistent with conventional real options theory, this is consistent with the notion that competition can induce developers to act in periods of both expected price increases and decreases [9]. None of the year-specific dummy variables are significant in the fixed-effects model possibly because of the absence of county-specific variables to reduce the considerable noise. There are no instruments for the value of agricultural production, income, or the variance of net returns in the fixed-effects model since the fixed-effect is eliminated in estimation to remove possible correlation with unobserved heterogeneity. Here the sign for the value of agricultural production per acre is negative and significant, as is expected since valuable agricultural production is a deterrent to farmland conversion.

The EC2SLS estimator provides a more complete picture of the determinants of the proportion of enrolled land in non-renewal status, since county-specific variables are found to have a lot of explanatory power. The variables for the returns to development have the expected signs. Counties with higher population growth (LNPOP), adjacent to counties with high income growth (LNINCADJ), or are close to the coast (COAST25DUM) have proportionally more land enrolled in non-renewal status, presumably because the development pressure is higher. CITY25DUM counties are within a metro area of more than one and a half million people and any agricultural land that could be developed easily already has been developed. However, counties at rural-urban interface, i.e. within fifty miles, of these large metro areas (CITY50DUM), have agricultural land that is easily developable in areas of significant urban influence and have proportionally higher enrolled land in non-renewal status.

The variables for the opportunity costs and the costs of development also have the expected signs. Government payments to agriculture (GPAY) increase revenue from agricultural production, and thus reduce the proportion of enrolled land in non-renewal status. As expected, counties with high building costs (LNBLDGCOST) and high rate of property taxes (PROPTAX), which is pegged to the rate of new construction property taxes, have less enrolled land in non-renewal status. A high proportion of pasture land to cropland (PCRATIO) in a county reduces the enrolled land in non-renewal status, possibly indicating that pasture land is more rugged and difficult to build on than cropland or, alternatively, that pasture land is more distant from urban influence. SIERRA25DUM counties are in the Sierra Nevada mountains where there are few towns that exert urban influence. SIERRA75DUM counties are squarely within the Central Valley of California where most of the highly intensive agricultural land is located, and these counties have less enrolled land in non-renewal status.

The signs for the drift and variance of net returns across the EC2SLS and fixed-effect estimations are not consistent. Other studies have had difficulty translating real options theoretical concepts into empirical measurements, and have found that the results depend on the scale of development (Towe 2008). The counties in the Foothill-Sierra region (FOOTDUM), which includes counties in the central and northern Sierra Nevada mountain range, have more enrolled land in non-renewal status because this region has the least enrolled land of the six WAP regions and four of the eleven Foothill-Sierra counties are in the growing Sacramento metro area. The temporal dummy variables indicate that in 2006 and 2007 (YR06 and YR07), when the housing market was booming, counties had proportionally more enrolled land in non-renewal status.

7.2 Transition Model Results

The Cox transition models for the slow to rapid state are shown in Table 7 and for the rapid to slow state are shown in Table 8. We test the proportional hazards assumption for the Cox transition models with Schoenfeld residuals. Both the analysis time and the rank of the analysis time specify the time scaling function for the proportional hazards test based on the Schoenfeld residuals[19]. The Not Stratified Cox transition models exhibit violation of the proportional hazards assumption. Greater stratification appears to reduce the influence of unobserved heterogeneity and preserve the validity of the proportional hazards assumption. We multiply the time-varying covariates by the analysis time to account for the possibility that the influence of the time-varying covariates on the hazard of a transition changes over time. Standard errors of the covariate estimates are corrected for latent heteroskedasticity using White's heteroskedastic consistent covariance method. Temporal dependency is accounted for using year-specific dummy variables. Duration spell dependency is accounted for using spell-specific dummy variables.[9] The Wald statistics and the signs of the coefficients for the slow to rapid models indicate that the Region-Metro Strata model is the preferred Cox model for studying this transition, and the Wald statistics and signs of the coefficients for the rapid to slow models indicate that the Region-Metro-Pasture Strata model is the preferred model for studying this transition.

Elasticity measures are reported in Tables 7 and 8. Elasticities provide standardized measures of the effect of a covariate on the hazard of transition - they are the percent change in the hazard rate for a 1% change in the covariate (dummy variables are with versus without the attribute). Since the hazard is the transition from one state of land conversion to another, a positively signed elasticity increases the risk of transition, while a negatively signed elasticity decreases the risk of transition.

The transition models for the slow to rapid state are similar in sign, but the model Region-Metro Strata is preferred based on fit and satisfaction of the proportional hazards assumption, in addition to the many more significant covariates with expected signs than the other two models. The transition model with the Region-Metro strata offers insights into what keeps a county remaining in a slow state of land conversion. The variables for the returns to development have the expected signs. Population (POP) and Income (INCOME) aid the transition to the rapid state - a l% increase results in a 25.62% and 111.59% increase in the hazard rate respectively. As expected, proximity to cities and towns (CITY60DUM,TOWN25DUM), the coast (COAST25DUM,COAST60DUM), and major highways (HWY99) also increases the hazard of transition to the rapid state. For instance, a county within twenty-five miles of a town (TOWN25DUM) increases the hazard rate by 8.59%.

The variables for the opportunity cost of development have the expected signs. An increase in farm size (FARMSIZE) by 1% decreases the hazard of transition to the rapid state of land by 8.67%, presumably because large farms benefit from returns to scale. Higher government payments per acre (GPAY) slows the transition to the rapid state, presumably because agriculture generates more revenue with a higher government subsidy. An increase in the value of agricultural production per acre (AGVALUE) by 1% decreases the hazard of transition by 14.10% since more valuable farmland is more resistent to development.

Greater agricultural employment per farm (AGEMPLY) slows the transition to the rapid state, presumably because this is an indicator of higher intensity agriculture.

The cost of development variables generally have the expected signs. Close proximity to the Sierra Nevada mountain range (SIERRA25DUM) slows the transition to the rapid state, presumably because there is limited urban influence in those counties. However, counties in the foothills of the Sierras (SIERRA60DUM), where there are growing metropolitan areas like Sacramento and Fresno, transition sooner to the rapid state. The proportion of non-farm to farm employment (NOFARM) and the rate of property tax (PROPTAX) reduce the transition to the rapid state - a 1% increase results in a 8.62% and 24.51% decrease in the hazard, respectively. This is because counties with a proportionally more non-farm employment likely have stricter land development regulations. The rate of property tax is pegged to the new construction property taxes, and thus this deters development. The proportion of woodland to cropland (WCRATIO) and elevation (ELEV) aid the transition to the rapid state - a 1% increase results in a 2.67% and 99.53% increase in the hazard, respectively. The finding that WCRATIO aids the transition to the rapid state is unexpected, but may reflect the attraction of households to the amenities of the woodlands that counterbalance the higher costs of construction. The positive influence of elevation, and the large magnitude of this coefficient, may be due to the amenities of a cooler climate or to weak land development regulations of these counties.

The risk variables do not have the expected signs, though none of the variables are significant. The weak results for the risk variables reflect the difficulty of translating real options theoretical concepts into empirical measurements. A potential limitation is that landowners are assumed to respond similarly to uncertainty, regardless of the scale of development possible on their agricultural land (Towe 2008). The temporal and duration spell dummy variables are important covariates for the models (although the results are not shown in the tables for brevity). In the later years of the study period, the risk of a county's transition to the rapid state increases - in 2005 (YR05) and 2006 (YR06) the hazard rate increases by 5.56% and 7.35%. Some counties have multiple transition spells, and the spells that come later have a lower risk of a transition to the rapid state. Second and third spells

(SPELL2,SPELL3) decrease the hazard rate by 2.61% and 6.90%, respectively.

For the Cox transition models of the rapid to slow state, the model Region-Metro-Pasture Strata is preferred based on fit and satisfaction of the proportional hazards assumption, in addition to the many more significant covariates with expected signs than the other two models. For the rapid to slow state transitions, a significant proportion of the counties are left-censored (i.e. transitioned prior to the study period), and no counties survive in the rapid state until the end of the study period. The variable for returns to development generally have the expected sign. Population (POP) and the proximity of a county to a town (TOWN25DUM,TOWN60DUM) increase the hazard of transition to the slow state - a l% increase results in an increase of 17.47%, 2.84%, and 3.97% in the hazard rate, respectively. These signs are somewhat unexpected, but may indicate that counties with faster growing populations or close to large towns have more stringent land development regulations that are effective at halting rapid farmland conversion. As expected, a 1% increase in income (INCOME) and the proximity to a major highway (HWY99) decrease the hazard rate by 76.00% and 1.04%, respectively. This suggests the urban influence of wealthy counties and counties beside major highways on rapid conversion is substantial.

An increase in the value of agricultural production per acre (AGVALUE) by 1% increases the hazard of transition to the slow state by 106.56%, presumably because valuable agricultural land is resistant to development. Unexpectedly, higher government payments per acre (GPAY) slow the transition to the rapid state, perhaps because there is uncertainty in the continued support of the government payments versus the certain opportunity of profit from the development of farmland in a housing boom. The statistically significant cost of development variables hasten, as expected, the transition to the rapid state. The rate of property tax (PROPTAX), ratio of non-farm to farm employment (NOFARM), ratio of service to manufacturing employment (SERVICE), and the proportion of pasture to cropland (PCRATIO) increase the hazard of transition - a l% increase results in a 8.01%, 11.02%, 10.31% and 5.72% increase in the hazard rate, respectively. Counties with a high rate of property tax, strict land development regulations, and pasture land, where there is minimal urban influence, transition quickly back to the slow state. Also, counties close the

Sierra range (SIERRADUM25), where there is minimal urban influence, transition more quickly back to the slow state.

A increase in the drift of net returns to development (DRIFT) by 1% decreases the hazard rate of transition to the slow state by 2.36%. Although this unexpected effect for drift is not consistent with conventional real options theory, this is consistent with the earlier results of the log odds models and the notion that competition can induce developers to act in periods of both expected price increases and decreases [9]. For the temporal and duration spell dummy variables, none of the years from 2002 (YR02) to 2006 (YR06) have a consistently positive or negative, nor significant, influence on the transition to the slow state. For the counties with multiple spells, later spells (SPELL) have a lower risk of transition to the slow state of 0.47%.

Estimation of Cox models for both the slow to rapid state transition and the rapid to slow state transition allows for the opportunity to assess whether the covariates that increase the hazard of a transition to the rapid state are the same as the covariates that decrease the hazard of a transition back to the slow state. The covariates that accelerate the transition to the rapid rate and decelerate the transition to the slow state are income and proximity to a major highway. Policy makers in counties with high income and in proximity to a major highway should be concerned for rapid farmland conversion, and thus they might want to identify regulations to encourage growth at a slower pace and higher density. The covariates that decelerate the transition to the high state and accelerate the transition to the slow state include the value of agricultural production per acre, ratio of non-farm to farm employment, rate of property tax, and the proximity within twenty-five miles to the Sierra Nevada mountains. This suggests slow farmland conversion for counties with valuable agricultural land, strict regulations on land development, significant property taxes, or limited urban influence. This suggests that regulations and property taxes are effective at slowing the pace of farmland conversion, but neither is necessary if agricultural land is very valuable or there is limited urban influence.

8 Conclusions

This study produces empirical estimates for the timing of rapid farmland conversion at the county level. Using data on non-renewals in California's differential assessment program, we quantify the effect of net returns, costs, and risk on land development. The focus is to understand how measurable characteristics of counties influence the timing of the rapid conversion (e.g. urban sprawl) events. We use a duration modeling approach, which explicitly accounts for the probability a given acre of farmland will enter non-renewal status in the next period conditional on the fact it did not convert in any previous period. The policy significance is that if counties know better when to expect rapid farmland conversion events (and how long they will last) the better the county will be able to predict its infrastructure needs and take steps to mitigate the traffic and environmental impacts.

We find statistically significant evidence that income and the proximity to major highways are the principal determinants of rapid conversion events (and also responsible for prolonging these events). In particular, an increase in income of 1% is found to hasten the time to a rapid conversion event by 111% and to reduce the time to a slow conversion event by 76%. There is also evidence that amenity variables such as woodland, elevation, and proximity to the coast promote rapid conversion, but some of these areas may also have weaker land development regulations. On the other hand, valuable agricultural land and high property taxes slow the time to a rapid conversion event (and also hasten the return time to a slow state of conversion). An increase in the value of agricultural production per acre reduces the time to a rapid conversion event by 14% and hastens the time to a slow conversion event by 106%. These results help to fill a gap in knowledge on the timing of rapid farmland conversion at the county level and suggest, since high property taxes slow the time to rapid conversion, that differential assessment programs help to reduce urban sprawl and thus provide benefits to taxpayers.

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Notes

[1]This 2SLS approach requires a correction to the standard errors. Since the R^2 of the first stage regression is found to be high, potential bias to the standard errors is likely low.

[2]There are fifty-seven counties in the California, but four California counties (Del Norte, Inyo, San Francisco, and Yuba) do not participate in the Williamson Act Program.

[3]Data from the program before 2000 has missing data for particular counties for some years or the complete absence of data for any counties in other years.

[4]These distances are always from the center of the county to the nearest edge of the metropolitan area or coast line.

[5]The sale prices are inflation-adjusted to 2000 dollars by the CPI for housing.

[6]There is the possibility of time-varying unobserved heterogeneity that is correlated with the regressors causing inconsistent estimates. We attempt control for this by including all relevant time varying regressors in the empirical model.

[7]The finding for the Sargan statistic, distributed $\chi(7)$, is 3.468, which is certainly not significant at the 10% level.

[8]Note this would be twelve strata, but the North Coast and Mountain WAP region has no counties in close proximity to a metro area.

[9]The results for the temporal and duration spell dummy variables are omitted for the brevity of exposition. The signs and magnitude for these variables are as expected.

Table 1: Enrollment and Non-renewals in the Williamson Act Program by Region in 2001, 2003, 2005, 2007

Region	Enrollment (Acres)	Cumulative Non-renewals (Acres)	Non-renewal Initiations (Acres)	Cumulative Non-renewals Proportion of Enrollment	Non-renewal Initiations Proportion of Cumulative Non-renewals
2001					
North Coast	1,626,103	22,339	0	0.014	0
Central Coast	3,201,584	38,947	5,649	0.012	0.145
Sacramento	2,599,054	38,802	2,228	0.015	0.057
San Joaquin	7,232,342	73,890	4,282	0.010	0.058
Foothill	775,208	32,134	1,467	0.042	0.046
South	904,467	16,734	2,361	0.019	0.141
2003					
North Coast	1,667,830	18,391	184	0.011	0.010
Central Coast	3,211,255	44,615	1,481	0.014	0.033
Sacramento	2,646,136	26,444	3,254	0.009	0.123
San Joaquin	7,271,982	81,128	20,175	0.011	0.249
Foothill	776,445	24,244	4,962	0.031	0.205
South	981,813	19,894	1,048	0.020	0.053
2005					
North Coast	1,768,094	15,537	297	0.009	0.019
Central Coast	3,143,476	35,368	3,832	0.011	0.108
Sacramento	2,664,201	37,408	12,355	0.014	0.330
San Joaquin	7,244,336	141,231	44,456	0.020	0.315
Foothill	775,276	30,413	5,124	0.039	0.169
South	982,552	58,768	20,877	0.066	0.355
2007					
North Coast	1,808,246	22,682	4,954	0.013	0.218
Central Coast	3,147,996	52,316	11,522	0.017	0.220
Sacramento	2,687,305	72,714	18,709	0.027	0.257
San Joaquin	7,203,506	257,133	65,252	0.036	0.254
Foothill	774,345	65,007	14,940	0.084	0.229
South	991,207	92,248	27,378	0.093	0.297

Number of observations: 424.

Table 2: Variable Definitions for Panel and Transition Models of Non-Renewals

Variable	Definition	Variable	Definition
Returns to Development			
LNPOP	Natural log of population	LNINCOME	Natural log of per capita personal income
LNINCADJ	Natural log of the average per capita personal income of the adjacent counties	CITY25DUM, CITY50DUM, CITY75DUM	0,1: Twenty-five, fifty, or seventy-five miles from metro area with 1.5+ million
TOWN25DUM, TOWN50DUM, TOWN75DUM	0,1: Twenty-five, fifty, or seventy-five miles from metro area of 100+ thousand	COAST25DUM, COAST50DUM, COAST75DUM	0,1: Twenty-five, fifty, or seventy-five miles from the nearest California coast line
HWY99	0,1: Central Valley Highway 99 passes through the County		
Opportunity Costs of Development			
LNFRMSIZE	Natural log of acres per farm	LNGPAY	Natural log of government farm payments per acre
LNAGVALUE	Natural log of the value of agricultural production per acre	LNAGADJ	Natural log of the average value of agricultural production per acre of the adjacent counties
LNAGEMPLY	Natural log of agricultural employment per farm		
Costs of Development			
PCRATIO	Ratio of pasture land to cropland	WCRATIO	Ratio of woodland to cropland
LNBLDGCOST	Natural log of the cost of building a single-family home	LNNOFARM	Natural log non-farm to farm employment
LNSERVICE	Natural log of service to manufacturing employment	PROPTAX	Ratio of tax to assessed value of property
LNELEV	Natural log of elevation	SIERRA25DUM, SIERRA50DUM, SIERRA75DUM	0,1: Twenty-five, fifty, or seventy-five miles from the nearest Sierra Nevada mountains
LNTOPO	Natural log of an index of the topographical steepness		

Table 3: Variable Definitions for Panel and Transition Models of Non-Renewals (Continued)

Variable	Definition	Variable	Definition
Risk Variables			
DRIFT	Drift in sales price	VARIANCE	Standard error of sales price
Region, Year, and Spell Indicator Variables			
BAYDUM	0,1: Bay-Central Coast	FOOTDUM	0,1: Foothill-Sierra
SACDUM	0,1: Sacramento Valley	SANJDUM	0,1: San Joaquin Valley
SOUTHDUM	0,1: South Coast-Desert	YR01, YR02	0,1: Year is 2001, 2002
YR03, YR04	0,1: Year is 2003, 2004	YR05, YR06, YR07	0,1: Year is 2005, 2006, 2007
SPELL2, SPELL3	0,1: Second or third spells of the slow to rapid state Cox transition models	SPELL	0,1: Second and third spells of the rapid to slow Cox transition models

Table 4: Transitions in the Pace of Non-Renewal Initiations, 2000-2007

	Slow to Rapid Indicator[a]				Rapid to Slow Indicator[b]			
Duration in Years	Number of Transitions[c]	% of All Transition Spells	Hazard Rate[d]	Survivor Rate[e]	Number of Transitions[c]	% of All Transition Spells	Hazard Rate[d]	Survivor Rate[e]
0	15	16.67	–	–	39	38.24	–	–
1	26	28.89	0.347	0.544	48	47.06	0.762	0.147
2	16	17.78	0.327	0.366	10	9.80	0.667	0.049
3	10	11.11	0.303	0.256	3	2.94	0.6	0.019
4	8	8.89	0.348	0.167	1	0.98	0.5	0.009
5	4	4.44	0.267	0.122	1	0.98	1	0
6	5	5.56	0.455	0.067	0	0.00	–	–
7	2	2.22	0.333	0.044	0	0.00	–	–

[a] Non-Renewals Slow to Rapid Indicator = Non-Renewal Initiations/Cumulative Non-Renewals ≥ 0.15

[b] Non-Renewals Rapid to Slow Indicator = Non-Renewal Initiations/Cumulative Non-Renewals < 0.15

[c] Counties may have more than one transition spell. For the Slow to Rapid Indicator, twenty-six counties have a second spell and eight counties have a third spell. For the Rapid to Slow Indicator, thirty-eight counties have a second spell and three counties have a third spell.

[d] Hazard rate = number transitioned in year t/number at risk in year t

[e] Survivor rate = cumulative proportion surviving to t = (1- hazard rate$_t$)*proportion surviving$_t$

Table 5: Log-odds Panel Models of the Cumulative Non-renewals Proportion of Enrollment

	Fixed-Effects		IV Random-Effects	
	Coefficient	t-stat	Coefficient	z-stat
Returns to Development				
LNPOP	3.614^b	2.16	0.772^a	3.88
LNINCOMEˆ	-0.958	0.53	-0.198	0.20
LNINCADJˆ	-0.488	0.34	0.985^a	1.99
CITY25DUM	–	–	-1.628^b	3.30
CITY50DUM	–	–	1.182^a	2.48
CITY75DUM	–	–	-0.517	1.11
TOWN25DUM	–	–	0.045	0.11
TOWN50DUM	–	–	-0.096	0.24
TOWN75DUM	–	–	0.618	0.94
COAST25DUM	–	–	0.812^b	1.94
COAST50DUM	–	–	-0.168	0.41
COAST75DUM	–	–	-1.128^c	2.25
HWY99	–	–	-0.453	1.03
Opportunity Costs of Development				
LNFARMSIZE	-0.682	0.27	0.275	1.02
LNGPAY	0.201	0.34	-0.537^c	3.20
LNAGVALUEˆ	-0.566^a	2.59	0.071	0.29
LNAGADJˆ	-0.007	0.02	-0.166	1.34
Costs of Development				
PCRATIO	–	–	-0.202^a	3.05
WCRATIO	–	–	-0.282	1.03
LNBLDGCOSTˆ	-0.069	0.11	-1.307^b	1.94
LNNOFARM	-0.119	0.36	0.079	0.38
LNSERVICE	-0.610	0.95	-0.440	1.29
PROPTAX	0.030	0.13	-0.321^c	1.81
LNELEV	–	–	0.201	0.78
LNTOPO	–	–	-0.650^c	1.77
SIERRA25DUM	–	–	-1.559^a	2.59
SIERRA50DUM	–	–	-0.475	0.63
SIERRA75DUM	–	–	-1.178^c	2.10
Risk Variables				
DRIFT	0.029^c	1.72	-0.062	1.23
VARIANCEˆ	-0.031^b	2.19	0.116^c	1.61

ˆ Hausman's test indicates this regressor is a potential cause of simultaneity bias. Instruments (spatial lags) correct for this problem.

Table 6: Log-odds Panel Models of the Cumulative Non-renewals Proportion of Enrollment (Continued)

	Fixed-Effects		IV Random-Effects	
	Coefficient	t-stat	Coefficient	z-stat
BAYDUM	–	–	-1.013	1.31
FOOTDUM	–	–	3.925[a]	3.66
SACDUM	–	–	0.898	0.95
SANJDUM	–	–	0.698	0.69
SOUTHDUM	–	–	-0.194	0.21
YR01	-0.132	0.70	-0.031	0.14
YR02	-0.317	1.44	0.167	0.57
YR03	-0.264	0.86	-0.081	0.33
YR04	-0.149	0.35	-0.189	0.67
YR05	-0.021	0.04	0.109	0.33
YR06	0.307	0.48	1.169[a]	2.77
YR07	0.776	0.95	1.674[a]	3.85
CONSTANT	-25.479	0.69	-3.966	0.70
RHO	0.980	–	0.129	–
F(16,306)	6.02	–	–	–
Wald χ_{39}	–	–	319.09	–
No. Obs.	373	–	369	–

Table 7: Cox Transition Models, Slow to Rapid Non-renewal Initiations, 2000-2007

	Not Stratified		Region Strata		Region-Metro Strata	
	Elasticity	z-stat	Elasticity	z-stat	Elasticity	z-stat
Returns to Development						
POP	-0.375	0.08	-9.855^c	1.88	25.616^b	1.97
INCOME	-20.167^c	1.85	0.606	0.05	111.589^a	3.36
CITY25DUM	-0.073	0.68	-0.147	0.8	-0.027	0.21
CITY60DUM	-0.188	0.47	-0.127	0.17	5.495^b	2.26
TOWN25DUM	0.195	0.92	0.648^c	1.87	8.591^b	3.05
TOWN60DUM	0.907	1.09	-2.153^c	1.65	1.844	0.84
COAST25DUM	-0.149	0.35	1.512	1.58	3.188^b	1.96
COAST60DUM	0.547	0.96	-1.295	1.46	6.013^a	2.52
HWY99	-0.018	0.22	0.463	1.43	0.881^c	1.67
Opportunity Costs of Development						
FARMSIZE	1.950	1.39	2.754	0.88	-8.670^a	2.7
GPAY	-0.056	0.43	-0.632^b	1.94	-2.200^a	3.32
AGVALUEˆ	3.013	0.77	9.989^b	2.19	-14.104^b	2.14
AGEMPLY	-0.648^b	2.35	-1.105	1.59	-2.083^a	4.29
Costs of Development						
PCRATIO	-0.634^c	1.87	-1.062	1.53	-1.683	1.61
WCRATIO	-0.058	0.32	-0.056	0.16	2.674^a	3.19
BLDGCOSTˆ	1.885	0.18	-18.428	0.57	-12.369	0.48
NOFARMˆ	1.047	1.35	1.196	0.87	-8.616^b	2.21
SERVICE	-0.077	0.08	-0.154	0.14	-3.042	1.34
PROPTAXˆ	1.281	0.45	-7.504^b	2.02	-24.510^b	2.19
ELEV	-3.031	1.17	12.865^c	1.84	99.533^a	3.07
TOPO	5.596	1.56	-5.692	1.14	-4.246	0.32
SIERRA25DUM	0.138	0.82	-0.537	1.46	-3.756^a	2.85
SIERRA60DUM	-0.070	0.29	-1.177	1.6	1.729^b	2.06
Risk Variables						
DRIFT	0.402	1.09	0.160	0.16	0.509	0.6
VARIANCEˆ	-0.576	0.69	1.465	0.56	0.873	0.36
Wald χ_{30}	114.09	–	240.72	–	1868.88	–

Number of observations: 127.
Note: The number of strata for the models i) region strata and ii) region-metro strata are 6 and 11. Region indicates the six Williamson Act regions; Metro indicates if DISTTOWN is less/more than 34 miles; each strata of a model has a different baseline hazard. Other included variables with results not shown are YR02, YR03, YR04, YR05, YR06, SPELL2, and SPELL3. ˆ Hausman's test indicates this regressor is a potential cause of simultaneity bias. Instruments (spatial lags) correct for this problem.

Table 8: Cox Transition Models, Rapid to Slow Non-renewal Initiations, 2000-2007

	Not Stratified		Region-Metro Strata		Region-Metro-Pasture Strata	
	Elasticity	z-stat	Elasticity	z-stat	Elasticity	z-stat
Returns to Development						
POP	2.398	0.88	4.857	0.99	17.472^b	2.14
INCOME	0.607	0.05	6.651	0.32	-76.001^a	2.86
CITY25DUM	-0.028	0.76	-0.030	0.48	-0.433^a	3.88
CITY60DUM	0.154	1.33	0.284	1.39	0.667	1.26
TOWN25DUM	-0.223	1.42	-0.895	1.49	2.840^b	2.18
TOWN60DUM	-0.036	0.08	1.776	1.1	5.189^b	2.03
COAST25DUM	0.181	1.49	0.191	0.55	-1.163	1.58
COAST60DUM	0.154	0.60	0.348	0.58	0.315	0.34
HWY99	-0.113	0.96	-0.387^c	1.77	-1.039^b	2.17
Opportunity Costs of Development						
FARMSIZE	-0.553	0.40	-3.331	1.14	3.403	0.70
GPAY	0.094	0.75	0.079	0.22	-4.217^b	2.00
AGVALUEˆ	-1.022	0.33	1.418	0.2	106.564^a	3.13
AGEMPLY	0.252	1.04	-0.638	1.59	-0.984	0.51
Costs of Development						
PCRATIO	0.081	0.28	0.718	1.16	5.718^a	3.01
WCRATIO	0.004	0.04	-0.097	0.65	0.855	1.30
BLDGCOSTˆ	30.138^c	1.61	14.560	0.32	-107.086	1.30
NOFARMˆ	-0.545	1.03	0.716	0.35	11.015^a	2.69
SERVICE	0.041	0.09	1.364	0.73	10.313^a	2.55
PROPTAXˆ	1.448	1.16	1.905	1.39	8.013^a	2.02
ELEV	-0.743	0.43	-10.276^c	1.74	-18.283	1.09
TOPO	-2.336	1.53	1.138	0.35	-6.368	0.49
SIERRA25DUM	0.191^c	1.94	0.431	1.56	0.971^c	1.61
SIERRA60DUM	-0.053	0.29	0.646	1.42	-0.286	0.45
Risk Variables						
DRIFT	0.086	0.21	-0.512	-0.86	-2.361^a	2.68
VARIANCEˆ	-0.391	0.71	0.131	0.2	2.335	1.40
Wald χ_{29}	122.23	–	100.40	–	171.83	–

Number of observations: 125.

Note: The number of strata for the models i) region-metro strata, ii) region-metro-pasture strata are 11 and 15. Region indicates the six Williamson Act regions; Metro indicates if DISTTOWN is less/more than 34 miles; Pasture indicates if PCRATIO is less/more than 2.24; each strata of a model has a different baseline hazard. Other included variables with results not shown are YR02, YR03, YR04, YR05, YR06, SPELL. ˆ Hausman's test indicates this regressor is a potential cause of simultaneity bias. Instruments (spatial lags) correct for this problem.