Land Use Change and Property Taxes: An Empirical Study of the Effect of Property Taxes on the Timing of Land Conversion from Agriculture to Residential Development.

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ABSTRACT

This study explores how property taxes affect the timing of development. The theoretical literature suggests that higher taxes increase the time to development, although there is some disagreement in the literature. We present a simple theoretical model to motivate an empirical model that explores how land use change decisions are made over time. A hazard model is used to predict factors that influence the time to development over an 11-year period in an urbanizing county in the Midwestern corn belt. The results suggest that higher taxes slow development, as expected. Over the 11-year period for our sample, we predict that 25% more agricultural land would have converted to development if taxes had not risen. We also find, however, that the effects are not constant across different land qualities. In particular, we find that higher taxes make higher quality agricultural land more susceptible to development.

INTRODUCTION

In recent years, large areas of agricultural land have converted to urban uses, such as houses, industrial or commercial sites, or new roads. There is considerable concern that as this development continues, high quality farmland could be lost forever, water quality could decline, and congestion could increase. In response, a number of policymakers have considered a range of options for reducing conversion of land to developed uses. These include land use planning, favorable tax assessments for agricultural land, purchase or transfer of development rights, zoning, and exactions or impact fees to name several. Given that land use is traditionally a local concern, it is useful to consider how factors that are under local control affect land-use change.

The theoretical literature now has many studies that explain factors affecting land use change. The early optimal timing literature rested conversion decisions largely on interest rates and growth rates in land rental values (Shoup, 1970). Arnott and Lewis (1979) and Anderson (1986) extend this literature to show how differential tax rates before and after development can affect timing. Cappozza and Helsey (1989) add a spatial dimension to show how optimal timing decisions depend on distance from a central business district and growth premiums. Anderson (1993) extends the literature by showing that positive externalities, such as open space, speed up development relative to the social optimum. More recently, authors have focused on the importance of uncertainty and option values in determining how quickly agricultural parcels will develop (see Cappozza and Li, 1994; Batabyal, 1996).

These studies provide compelling arguments for economic forces that affect land use change. Some important phenomena, however, are left unexplained. For instance, two parcels that are equidistant from the central city may be observed to change land use at different times. Mills (1981) suggests that this may result from heterogeneous preferences among landowners. Such behavior is plausible, given a distribution of reservation prices across new landowners. Alternatively, however, there are different costs for developing different properties. While developers may be able to get higher sale values for properties developed in sloping terrain with trees, unit costs of development may be lower for large developments installed on flat agricultural land. It is unclear which of these factors may be most important for determining which properties develop and which properties do not. Existing landowners, i.e. farmers, also are likely to have a range of expectations about future price appreciation (option value), and a range of alternative opportunities (Cappozza and Li, 1994). This can affect their reservation price for selling a property.

Although there are a range of supply and demand side variables that influence land conversion, many of these are related to land quality and location. For instance, greater access to environmental characteristics increases the value of land in developed uses, and it likely increases the probability that a parcel will be developed. For instance, terrain characteristics (slope and soils), proximity to infrastructure (roads, sewers, and other factors), proximity to central and outlying business districts, and how development proceeds in nearby regions all should affect the value of a property and hence the timing of conversion. Some environmental characteristics, such as industrial sites, may reduce the value of land in houses, therefore putting off additional residential development nearby for some time. Across a landscape, a number of factors can be expected to increase or decrease the value of land for development, thus affecting the development process.

Given that most land-use decisions are made at the local level, it is useful to consider how policies enacted locally can affect the timing of land-use change decisions. While policy makers have a number of tools at their disposal, we consider the role of local property taxes in this study. Local property taxes are rarely used to affect land use change, however, growing regions often increase taxes as they grow in order to raise revenues for infrastructure. Given the wide use of property taxes for raising revenues, it is useful to consider how property taxes may affect land use decisions. A number of authors have shown theoretically that taxes have distortionary effects on the timing of land conversion. For instance, Arnott and Lewis (1979) show that increases in pre-development taxes reduce the time to development, while higher taxes afterward increase the time to development. Anderson (1986) extends these results to show that higher post-development taxes increase the time to development only under certain conditions. Anderson also shows that if land market values are rising, then higher taxes reduce the time to development, exactly the opposite effect of what one might think is the effect of taxes. More recently Cappozza and Li (1994) have explored a stochastic land use change model. In their model, as in others, higher taxes on raw land reduce the time to development. When taxes are the same before and after development, higher taxes delay conversion.

This study builds on these theoretical results by developing an empirical model to explore how taxes affect the timing of development near the urban-rural fringe in the

Midwestern U.S. The empirical analysis is a competing risks-accelerated failure time model that explores the timing of land-use change over an 11-year period in a rapidly developing county of Ohio. The competing risks framework recognizes that residential landowners compete with commercial and industrial enterprises for the same land over time, and that these different uses can often impact the value of the land for the alternative use. In addition to tax variables, we control for a range of other factors that are likely to have important effects on the timing of land-use conversion.

A MODEL OF LAND USE CHANGE

Theoretical Framework

Our main interest in this paper is to show how taxes affect land use conversion decisions and to test whether changes in taxes affect the timing of development. This paper focuses on the effects of property taxes because they are widely used throughout the United States to raise revenues. Exactions, or impact fees are often proposed as exclusionary devices (Gyourko, 1991; Brueckner, 1997), but we do not consider these types of taxes in this paper. Further, we ignore some of the general equilibrium effects of taxes in this theoretical treatment. For instance, an increase in taxes could signal an improvement in public goods, which could raise the rental stream from developed uses, which in turn could speed up development. Alternatively, taxes could shift development from one region to another. We return to some of these issues in the empirical section below.

The literature on the optimal timing of development suggests that timing may be positively or negatively affected by changes in taxes (Table 1). In general, the literature seems to suggest that higher taxes before development would tend to reduce the time to development and reduce capital intensity. Higher taxes after development would tend to increase the time to development and reduce capital intensity. Anderson (1986), however, suggests that if taxes are uniformly levied on both the before and after conversion uses, raising taxes during growth periods can speed up development. Thus, raising taxes to reduce growth may actually result in accelerated development. Cappozza and Li (1994) show that with uncertain future returns, higher uniform taxes tend to slow development down.

Although the theory suggests that higher taxes are likely to slow down development, few authors, however, have considered the more typical case where changes in taxes affect the value of alternative uses both before and after conversion in non-linear ways. While agricultural landowners often have favorable tax treatment in the form of lower land valuations, the same change in millage rates affects both uses. There are thus tax benefits associated with maintaining land in agriculture. Raising taxes has three effects on the decision to convert from agriculture to urban uses: it changes the value of the developed use, it changes the value of the tax benefits associated with holding land in agriculture, and it changes the taxes farmers pay. On some land, higher taxes could increase costs to farmers and reduce the tax benefits associated with holding land, thereby speeding up development on that land.

We model the land use conversion decision similarly to Anderson (1986). We extend it to allow for heterogeneous land quality across both agriculture and developed uses. In our empirical model, developed uses will include both residential and commercial/industrial uses, although we ignore the distinction between these developed uses here. Tax rates are assumed to be the same before and after conversion, but we allow the tax assessments before and after conversion to differ. This is consistent with the agricultural use value taxation used widely across the US. Annual rent from a representative acre of agricultural land is given as $A(t;q)$, where t is time and q is vector of land quality characteristics. Annual rent from this same acre in developed uses is given as $R(t,T;q)$, where T is the time of development. The cost of development per acre is given as $c(q)$. In this model, the derivatives of A, R, and c with respect to the elements in q could be both positive and negative. For instance, slope could enhance the value of land in development, detract from the value of land in agriculture, and increase the cost of developing an acre of land. Taxes are assessed on the capitalized value of land at the rate t, and the discount rate is r.

The value of land at time 0 is thus given as:

$$(1)\ \ \underset{T}{Max}\, V(0,T) = \int_0^T \left[A(u;q) - tV_F(u;q)\right] e^{-rT} + e^{-rT}\left[\int_T^\infty \left[R(u,T;q)\right] e^{-(r+t)(u-T)} du - c(q)\right]$$

$V_F(u;q)$ is the capitalized value of land if it were to remain in agriculture. Landowners choose T to maximize the value of land. The derivative of (1) with respect to T is:

(2)

$$A(T) + rc(q) + t\int_T^\infty R(u,T;q)\, e^{-(r+t)(u-T)} du + \int_T^\infty R_T(u,T;q) e^{-(r+t)(u-T)} du = R(T,T) + tV_F(T;q)$$

The left hand side of (2) is the marginal benefit of waiting an extra moment to develop land. The first term is the benefit of additional agricultural rent. The second term is the benefit of avoiding the costs of conversion. The third term is the benefit of avoiding a moment's taxes at the higher capitalized value of the developed land use, and the final term captures the effect of waiting a moment to develop on the revenue stream from development. In a growing market, $R_T > 0$, and there is a benefit associated with waiting to develop. The right hand side is the opportunity cost of not capturing rent from development today plus the additional taxes on agricultural land.

Taxes appear on both sides of equation (2), so it is difficult to determine the net effect on the timing of development. Further, the effect of an increase in taxes on the third and fourth terms on the left hand side is complicated. If we set equation (2) equal to 0 and call it V_D, we can assess how a small change in taxes would affect the optimal time to develop the land. For this, $dT/dt = (-V_{Tt}/V_{TT})$, where $V_{TT} < 0$ for a maximum to hold. The derivative V_{Tt} is thus,

(3) $$V_{T\tau} = -V_F(T;q) + \int_T^\infty R(u,T;q)e^{-(r+t)(u-T)}du - t\int_T^\infty (u-T)R(u,T;q)e^{-(r+t)(u-T)}du$$

$$-\int_T^\infty (u-T)R_T(u,T)e^{-(r+t)(u-T)}du$$

The sign of equation (3) is indeterminate: An increase in taxes can have both positive and negative effects on the timing of development (Anderson, 1986). Noting that the second term is the value of land in development at the time of development, or $V_D(T;q)$, an increase in taxes will increase the time to development if

(4)

$$V_D(T;q) - V_F(T;q) - t\int_T^{\infty}(u-T)R(u,T;q)e^{-(r+t)(u-T)}du - \int_T^{\infty}(u-T)R_T(u,T)e^{-(r+t)(u-T)}du > 0$$

In areas where agricultural values are close to development values ($V_D \approx V_F$), equation (4) will be negative, and higher taxes will reduce the time to development. Where the differences between development values and agricultural values become large, equation (4) is likely positive, and higher taxes will increase the time to development. For the most part, equation (4) is likely to be positive, particularly where development values far exceed agricultural values, and increases in taxes lengthen the time to development. Further, when considering different land qualities, the largest differences between development values and agricultural values are likely to occur on the lowest quality agricultural land because landowners prefer the amenities consistent with low quality agricultural sites. Thus, higher taxes are likely to reduce the potential for development on the lowest quality agricultural land. On the other hand, higher taxes could make higher quality land more susceptible to development pressures.

In addition to the effect of taxes on development timing, the results in Table 1 support the idea that higher taxes can shift development towards higher quality agricultural land. Higher quality agricultural sites are likely to be cheaper to develop for a number of reasons: The best agricultural soils are typically well drained, they have few or no trees, and they have low slopes. These factors reduce the cost of development, and hence the capital intensity associated with developing higher quality agricultural land. If, as Cappozza and Li (1994) suggest, higher taxes reduce capital intensity associated with development, then higher taxes would tend to shift development towards sites that are easier, or less costly to build. In other words, developers will respond to higher taxes by building on high quality agricultural land that is less appealing for residential customers. The homes built on such land will be less valuable and thus have a lower tax bill than homes built on attractive, low quality, agricultural land.

Empirical Model of Land Use Change

Our empirical model estimates the time to development for agricultural parcels over an 11-year period (1987 – 1998). The data is derived from a Midwestern county in Ohio, Delaware County. Delaware County is located directly north of a growing metropolitan area (Columbus, Ohio), on the eastern edge of the Midwestern Corn-belt. It experienced rapid development during this time period, including expansion of both job opportunities (industry and commercial developments) and houses. In addition to being north of a growing metropolitan area, a medium size city and employment center, the city of Delaware, sits in the center of the county. Two major highways cross the county from south to north, and there are four large water storage reservoirs serving residents in central Ohio.

Starting at time 0, we are interested in the length of time that a parcel remains in agriculture T. This depends on the rental value of land, the costs of development, agricultural rents, taxes, and other variables (equation 2). We employ an accelerated failure time (AFT) survival model to investigate the timing of this decision, with a simple survivor function in which T follows a Weibull distribution

(5) $$S_i(t) = \exp\{-[t_i \exp(-b' Z)]^{1/\sigma}\}.$$

Equation (5) can be linearized as

(6) $\ln(T) = \beta' Z + \sigma\varepsilon$.[1]

Z represents a vector of k property characteristics, $\{z_i \mid i = 1\ldots k\}$, that explain time to conversion (T), parameterized by β. ε is the error component, which in the case of the Weibull model, has a standard extreme value distribution. The value of σ determines the shape of the hazard function that represents the instantaneous rate of land conversion. When $\sigma > 1$, the hazard rate decreases with time, when $0.5 < \sigma < 1$, the hazard increases at a decreasing rate, and when $0 < \sigma < 0.5$ the hazard function increases at an increasing rate.

While we would prefer to observe actual land rents at each location over time and use this to predict the time of conversion, land rents can be measured only imprecisely for each parcel. For instance, while land rents can be derived from sale prices, sales only occur at locations where conversion takes place. Alternatively, assessed values for taxation purposes could be used to provide some information, but assessed values are estimated irregularly. We thus rely on the set of variables in the vector Z to control for the rental value of land in development. We do not control for the quality of development (i.e. the size of houses) in this study.

A number of variables in $Z(t)$ depend on time while others do not (see table 2). For instance, the location of a parcel relative to existing roads, central business districts, streams, or other factors that are not expected to change significantly over time. Alternatively, some of the z_i's in this analysis are allowed to change over time. For

[1] The actual form of the econometric model is more complicated given that it involves censoring.

instance, the effective tax rate in a given township at the time a parcel converted from agricultural to another use may be a factor that negatively or positively influences the probability of conversion.

An important feature of survival models is that data are almost always censored. Censoring occurs because many properties converted to developed uses prior to our study period, and also because there are properties that remain in agriculture at the end of the study period. In addition to the direct censoring of parcels that had already converted to developed uses by 1988 and those that remained in agriculture in 1998, we further censor the data to account for commercial/industrial development. Thus, once a property has converted from agricultural use to industrial or commercial use, it is no longer available for conversion to residential use. This suggests that the model should be estimated as a competing risks model in which censoring takes place as land changes from agriculture to industrial or commercial use. [2] To control for spatial effects, we employ a fixed effects model, which are often employed in survival analysis to control for unobserved heterogeneity. Fixed effects allow baseline hazard rates, s, to vary among individuals or groups. Thus, we assume that individuals in each of the fixed regions have similar baseline hazards, but that these baseline hazards can differ among the groups. Rather than relying on spatial units tied to political boundaries, we develop a set of fixed effects specifically tied to growth rates. Many political regions (i.e. townships, cities, tax districts) had non-uniform growth rates, and thus would have had different hazard rates within the units. To determine the appropriate set of fixed effects for this sample, we calculated local conversion rates per acre within a mile for each plot, and then ranked and

[2] Over an extremely long time period land can likely convert between these uses (depending on costs), but over the relatively short 11-year horizon examined in this paper, we expect that industrial/commercial land does not convert to residential land and vice-versa.

grouped the conversion rates into 15 fixed effects regions.[3] Dummy variables were assigned to each grouping, and can be interpreted as identifying areas with differential growth rates.

EMPIRICAL ESTIMATES AND ANALYSIS

We estimate a model that includes a number of variables to help control for factors such as access and environment that may make one property more attractive than another. However, we are most interested in the effect of policy changes, particularly changes in tax rates, on the time of conversion of agricultural land to developed uses. The theoretical literature provides some guidance on the effects of a change in taxes, but it does not fully answer the question, nor have any studies attempted to empirically estimate how taxes affect residential development. The results of a model based on agricultural to residential usage that treats industrial and commercial sales during the time period as censored is estimated and used to make predictions on the impact of tax policy.[4]

The variables used in the regression are shown in table 1. Most variables are self-explanatory. *TAX* is a time-varying covariate representing the annual tax millage rate for a particular region within the model. There are 46 regions within our dataset with different millage rates. The rates are lagged 4 years to avoid potential endogeneity (tax hikes may follow rapid increases in development), and to accommodate the long term planning horizon of many developments, including planning, zoning, and negotiating with contractors. *AGLEFT* is the proportion of agricultural land left in the taxing region

[3] The number of fixed effects was determined by AIC comparison of different numbers of groupings. In addition, Fixed effects dummy variables based on other criteria were tested, including tax regions and geographic segmentation, but were significantly outperformed by the growth rate fixed effects variables.
[4] We employ a standard MLE procedure to estimate the model.

at the time when development occurs. This variable is included to account for the scarcity value associated with conversion. That is, as conversion takes place within a taxing region, less and less land will be available for future conversion, and the value of land in development should increase. The effect of this on the timing of development is uncertain. On the demand side, higher land values would reduce the demand for developed land in a particular region. However, on the supply side, higher land values would induce additional farmers to convert their land to development. We can only determine the net effect of this variable on the land conversion timing decision.

One practical issue for estimation of this model is that it is difficult to sign the effects of marginal changes in attributes on the timing of development. We only know the net effect of the attribute on both buyers and sellers. As suggested by Zuehlke (1987), the main implication of this is that it is difficult to know whether an attribute with an insignificant effect is really 0, or whether there are offsetting effects from the value purchasers place on a sale versus the value sellers think they should get. We therefore include two additional variables that should help to identify the model. First, we interact taxes with slope to see the way in which local taxes are affected by quality of agricultural land as measured by terrain, and we also include a 24 period moving average of monthly corn prices in order to see if land conversion is affected by farm prices.

The residential model contains 15,569 observations of parcels that were in agricultural use in 1988. Of those, 6,683 observations are censored, and 8,886 lots converted to residential use. The dependent variable, *log(Days)*, measures the natural logarithm of the number of days from the beginning of the observation period (01/01/87) until conversion. Any properties that remained in agricultural use by 12/31/98 were treated as censored, as were any properties that converted to uses other than residential.

Table 3 presents the results of the residential model. In general the variables behave as we expect. The greater the distance from streams, the city of Delaware, and industrial sites reduces the time to residential development (i.e. speed development up). Commercial developments, however, do not appear to have a negative effect on residential development. Greater distance from roads (logged), electric transmission lines, water lines, and schools increases the time to residential development (i.e. slows development down). Being inside a municipality reduces the time to residential development. Overall, higher taxes have the expected theoretical effect: They increase the time to development. Greater slope reduces the time to residential development. Thus, residential development appears to migrate towards lower quality agriculture land on the margin. Higher soybean yields also increase the time to residential development, although this effect is not significantly different from 0. As expected, the interaction of taxes with slope increases the time to development. An increase in taxes is more effective in slowing down development on lower quality agricultural land. Interestingly, higher corn prices reduce the time to development. This is a somewhat surprising result, although it may just indicate that most development occurred after the early 1990's, and corn prices were relatively high during this time period (until approximately 1997/98). We interpret this result, however, as suggesting that agricultural policies aimed at increasing farm revenues may have little effect on farmer decisions, particularly at the urban-rural fringe.

These results seem to indicate that the overall effect of raising taxes is to delay future development. However, the interaction effects with land quality suggest that taxes do have differential effects on different quality land. In particular, lower quality land tends to be chosen first for development. Table 4 shows the average predicted time to development for different soybean yields and slopes. Note that we include the censored data points in this analysis. The low soybean yield and high slope combination generates the lowest average predicted days to development, while the high soybean yield and low slope combination generates a prediction of 1/3 more days to development. Both higher soybean yield and lower slope increase the predicted time to development, as would be expected. Table 5 presents the relationship between tax rates and slope. Higher taxes and lower slope generate predictions of more days until development while lower taxes and greater slopes suggest fewer days to development. For either high or low tax rates, higher slope lands are developed more quickly than lower slope lands.

We consider two policy simulations to provide some indication of the effect of taxes on development. First, we compare predicted conversion times generated by our model to predicted conversion times generated when we assume that taxes remain at the levels consistent with our initial period, 1987 (that is there were no tax increases). There were 211,477 acres of farmland in Delaware county in 1987. Our model predicts that 186,573 acres of agriculture should remain in 1998 based on the tax increases that actually occurred within our data. With no tax increases, this number is predicted to be 180,446 acres. With no increases in taxes, approximately 6000 additional acres of farmland would have converted to residential use, or approximately 25% more land than actually converted. Second, we look forward to the 1998-2008 time period, and consider the impact of a 20% tax increase across all of the taxing regions. Table 6 presents the results of this policy analysis. On average, the predicted days to development increase by 25%, from 3661 days to 4582. However, the distribution of remaining land shifts towards lower quality land. If taxes remain the same as in 1998, 65% of the agricultural land remaining in 2008 would be in our top quality class (low slope and high yield). If taxes increase 20%, 63% of the agricultural land remaining in 2008 would be in this same (high) quality class. Note that higher taxes will conserve both high and low quality agricultural land relative to no tax increases, but higher taxes shift some development towards higher quality agricultural land.

CONCLUSION

This paper explores how land taxes affect the conversion of agricultural land to developed uses at the urban-rural fringe. Theoretical results from the literature suggest that higher taxes increase the optimal time to convert land (that is, they reduce the conversion of land in a given time period), although few studies have explored how land quality interacts with taxes. We present a theoretical model to explore the relationship between taxes, land quality, and the timing of development. Our results, similar to those in the literature, suggest that taxes can have complicated, and potentially unexpected effects on the timing of development for some properties. In particular, we suggest that higher taxes could make some parcels, particularly higher quality agricultural land, more susceptible to development. These results are supported by theoretical results which suggest that higher taxes reduce the capital intensity of development. If capital intensity is related to land quality such that higher quality agricultural land is less expensive to develop, higher taxes can shift some development from lower quality agricultural land to higher quality agricultural land.

While the theory about how taxes affect development has been widely explored in the literature, no studies to our knowledge have explored the empirical strength of the results. We thus develop an empirical analysis with 11 years of land-use change data for parcels from a central Ohio county. A survival model is employed to predict the days to residential or commercial/industrial development. A competing risks approach is used so land that converts to commercial/industrial uses during the time period is censored from the residential model. Fixed effects are used to allow baseline hazard rates to differ among regions that have different growth rates across the dataset. In general, the results of the survival model are consistent with theoretical expectations.

With respect to tax policy, the results suggest that higher taxes increase the time to development. This result is expected. The strength of the result however, suggests that taxes play an important role in determining where development occurs across a region that is developing quickly. Looking at the cross section of taxing regions within our study area, the regions with the highest taxes (above 46.2 mills), had 30% more predicted days to development on average than the regions with the lowest taxes. This result was born out in a policy analysis. We found that a 20% increase in taxes would increase the days to conversion by 25%. Regions that raise taxes slow down development, and likely shift development to nearby regions that do not raise taxes.

While higher taxes can reduce the overall area of land that develops in a given time period, higher taxes come with a cost, namely, they shift some conversion from low quality agricultural land to higher quality agricultural land. If taxes remain the same as in 1998, by 2008 there are 2 acres of high quality farmland remaining for every 1 acre of low quality farmland. However, this ratio declines to 1.75 to 1 by 2008 if taxes increase by 20%. We stress that higher taxes do reduce overall development, but they marginally shift some development towards higher quality farmland. This is unfortunate, because many taxing authorities often raise taxes as development occurs. Although the increases are typically aimed at raising revenue rather than at preventing additional land conversion, they may have the unintended consequence of causing more prime agricultural land to convert to development.

These results also suggest that agricultural policy intended to raise farmer revenues may have little effect on the conversion decision at the urban-rural fringe. While we do not explicitly model agricultural policies, we do include the price of commodities. Higher prices reduce the time to development. Policies intended to change commodity prices would not appear to have an effect on development patterns at the rural urban fringe.

While this approach has numerous advantages, there are some issues that need to be addressed with future analysis. For instance, we have not completely addressed the issue of general equilibrium price effects. As land is developed in one taxing region, the price of land will increase. Price increases in one taxing region may have price effects in other taxing regions. We have attempted to control for this with the variable *AGLEFT*, however, we have not fully specified a demand function for total land in the region, nor have we attempted to model the effect of these prices changes on the value of development. We will continue to explore this and other issues in further analysis.

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Table 1: Comparative Static Results from the literature on the effect of taxes on development timing and capital intensity:

Study	Effect On	t_b	t_a	$t_b=t_a$
Arnott and	Time (T)	-	+	NA
Lewis (1979)	Capital (K)	-	0	NA
Anderson	Time (T)	-	?	$H_D>0 \Rightarrow$ -
(1986)				$H_D<0 \Rightarrow$ +
	Capital (K)	NA	NA	NA
Cappozza and	Time (T)	-	+	+
Li (1994)	Capital (K)	-	-	-

H_D = growth in development values; $H_D>0$ means that the market is growing.

Table 2: Variables used in analysis

Variable	Description
STREAMSD	Distance to nearest stream (non ephemeral)
DELAWD	Distance to the city of Delaware (located in the center of the county)
LNROADD	Natural log of the distance to the nearest roadway
TRANSD	Distance to the nearest electrical transmission line
WATERLD	Distance to the nearest water line
SCHOOLSD	Distance to nearest school
COMMERCD	Distance to nearest commercial property
INDUSTD	Distance to nearest industrial property
INMUNI	Dummy variable: Located inside a municipality (1) or not (0).
TAX	Tax millage rate in effect 4 years before the time of conversion. There are 46 regions within the county with different tax millage rates (TIME VARYING)
SLOPE	Slope of the lot
TAXXSLP	Tax times slope interaction variable (TIME VARYING)
SOYIELD	Soybean Yield
CORNP	Corn price: 12 month moving average of the price 24 months prior to conversion (TIME VARYING)
AGLEFT	Area of agricultural land left in the taxing region at the time of conversion. (TIME VARYING)
TAXXSYLD	Tax time soybean yield interation variable (TIME VARYING)
CHANGE1-CHANGE14	Fixed effects variables based on 15 percentile ranking groups from highest to lowest growth rates

Table 3: Residential Survival Model

Residential Survival Model
Weibull Accelerated Failure Time Form
Dependent Variable: Days to Conversion

Variable	**Parameter Estimate**	**Standard Error**	**Chi Square**	
Intercept	8.3976	0.0676	15420.0	***
STREAMSD	-0.0662	0.0113	34.6	***
DELAWD	-0.0131	0.0013	96.4	***
LNROADD	0.1151	0.0044	674.8	***
TRANSD	0.0125	0.0043	8.6	***
WATERLD	0.0962	0.0134	51.4	***
SCHOOLSD	0.0480	0.0048	100.2	***
COMMERCD	0.0062	0.0120	0.3	
INDUSTD	-0.0531	0.0067	62.0	***
INMUNI	-0.0573	0.0138	17.2	***
TAX [a, b]	0.0219	0.0007	1086.9	***
SLOPE	-0.0297	0.0050	35.0	***
TAX XSLP [a]	0.0004	0.0001	20.9	***
SOYYIELD	0.0005	0.0009	0.3	
CORNP [a]	-0.2282	0.0083	760.6	***
AGLEFT [a]	0.0005	2.9e-5	314.0	***
Fixed Effects Parameters				
CHANGE1	-0.4173	0.0367	129.5	***
CHANGE2	-0.5198	0.0384	183.4	***
CHANGE3	-0.3803	0.0344	122.2	***
CHANGE4	-0.4569	0.0377	146.9	***
CHANGE5	-0.5919	0.0389	323.8	***
CHANGE6	-0.4444	0.0332	178.6	***
CHANGE7	-0.4118	0.0312	174.3	***
CHANGE8	-0.3578	0.0310	133.3	***
CHANGE9	-0.3323	0.0301	121.8	***
CHANGE10	-0.2450	0.0318	59.4	***
CHANGE11	-0.3457	0.0285	147.0	***
CHANGE12	-0.2985	0.0285	109.4	***
CHANGE13	-0.2847	0.0270	111.2	***
CHANGE14	-0.2325	0.0248	87.5	***
Weibull Scale Parameter	0.3810	0.0036		

N = 8,908
Log Likelihood: -10,901.05

Table 4: Predicted Days Until Conversion Based on Topography and Soybean Productivity (standard errors in parentheses).

	Soybean Yield < 34 bu/ac	**Soybean Yield > 34 bu/ac**
Slope ^{3} 4	3,315 (1366.25)	3,860 (1662.68)
Slope < 4	4,131 (1807.82)	4,544 (1973.16)

Table 5: Predicted Days Until Conversion Based on Topography and Lagged Tax Rates (standard errors in parentheses).

	Tax $_{-4}$ < 46.2	**Tax $_{-4}$ > 46.2**
Slope ^{3} 4	2,853 (932.59)	3,891 (1565.59)
Slope < 4	3,419 (1521.94)	4,704 (1826.97)

Table 6: Impact of a 20% Tax Increase on Predicted Conversion Time

	Mean	**Standard Error**
Predicted Days to Conversion	3,661	1614
Predicted Days to Conversion—20% Tax Increase	4,582	2125