Household and Farm Transitions in Environmental Context

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Introduction

We know that farm operators manage their resources in a dynamic way, responding to the conditions in which they work. Those conditions include personal attributes such as age and family, market prices for the supplies they use and the commodities they produce, characteristics of the communities they live in, and the environmental context, including short- and long-term environmental suitability for the commodities they plan to produce. We describe this process as dynamic because there is good evidence to suggest that farmers adjust their plans and activities as all of these conditions change, and they do so in ways that adapt -- as best they can -- to their complexity.

The role of household and family has been one of the most difficult parts of this process to understand in its historical context because researchers have rarely had closely coupled data that allow them to see how changes in family determine changes in farm operation, and vice versa, over time. Without simultaneously knowing the size and structure of the farm household and the farmer's choice of crops, for example, it is difficult to study the dynamic choices that the farmer might make, and without the ability to study those choices, the impact of structural factors such as the farmer's age become difficult to understand. The role of family is difficult to measure, but it is absolutely crucial for evaluating theories of how agriculture and family interoperate, and therefore extremely valuable to understand.

This paper is an attempt to shed light on the dynamic processes that connected family and farm in the western United States during the second half of the nineteenth century and the first half of the twentieth century. It makes use of unique data that link families and farms in 25 representative townships in the state of Kansas for the years from 1875 to 1930. In doing so we validate elements of basic theory about families and agriculture by showing that farm size and the decisions farmers make about how much of their land to devote to crops are correlated to the age of farmers and to the number, age, sex, and relationship of other persons who live in the household. What we show, in short, is that the size of farms and the amount of cropland is a function of farmer's age, the size of the household, and of the presence of males in the household above the age of 18, whether they are the head's own male children or not. The presence of younger males and of females of any age are much less important. All this takes into account time periods, environmental context, and locality reflected in a multi-level statistical approach that includes significant random effects for townships.

Theoretical background.

Although there are many ways to describe the processes by which households form and change, and the relationship of that development to economic activity such as agriculture, the concept of a family economy (following Chayanov 1966) and a household lifecycle (following Hareven 2000) are frequently used as starting points, and have been particularly useful in studying population, agriculture, and environment (de Sherbinin et al. 2007). It is not always explicit about this, but household lifecycle theory brings together the roles of household resource accumulation and distribution, household labor, and household consumption into a single process where the age, sex, and life stage of each individual family member contributes to how resources are obtained, kept, and consumed at any moment in time. What it says -- and what we will discuss in this paper -- is that farm couples accumulate resources as they age and as a way to provide for their family in both the shorter and longer term. Part of this is the accumulation of their labor and that of others and part of it is a result of their learning how to maximize the productivity of their land. The ability to make use of their resources (often agricultural capital in land, tools, or livestock) is also a function of the labor available to them, either through family members or others. Finally, their ability to maintain their resources and accomplish their goals as a family and a farm enterprise is a function of the short-term consumption needs of their family (specified by age and sex), by the couple's need to provide for themselves as they reach old age, and by their desire to pass their property on to one or more heirs. All this takes place in the context of environment, locality, time period, and markets.

The relationship of household lifecycles to farm size, practice, and division, and to changes in land use and farming practices has received a great deal of attention in the past 20 years, particularly in the developing world (Barbieri, Bilsborrow, and Pan 2005; Fox et al. 2003; VanWey, D'Antona, and Brondizio 2007; Perz, Aramburú, and Bremner 2005; Perz, Walker, and Caldas 2006; Entwisle et al. 2005; Foster and Rosenzweig 2002; Moran, Brondizio, and VanWey 2005; de Sherbinin et al. 2007; Walker et al. 2002; Walsh et al. 2005). This literature provides a set of hypotheses based on a behavioral model that says that farm couples accumulate property over the course of their marriage, and that they try to use their children's labor to benefit the family enterprise. Therefore farmers increase land holdings over their life course as they age, and over the household life cycle as their families grow and children become old enough to work. Farmers increase labor-intensive activities when labor is available (mid-cycle), and avoid risky practices late in life. Farm size may decrease towards the end of a farmer's life if *inter vivos* transfers have been made or if the land has been sold in the absence of a successor.

A number of studies of contemporary land use and population have shown that changes in household demographic composition are related to land use change in ways predicted by household lifecycle theory, but not all studies are confirmatory. Drawing on work in agricultural household models (for an overview, see Taylor and Adelman 2003), Walker and colleagues found in their study of Uruará, Brazil, that falling household dependency and the number of workers predicted farm practice in terms of mix and specialization. Perz and colleagues (Perz, Aramburú, and Bremner 2005) compared studies across the Amazon Basin and found the number of adults and children to have the predicted associations with land allocation between extensive and intensive uses (Perz, Walker, and Caldas 2006). Other groups found the expected associations between extensive, long-horizon land-use choices and the number of males (Pan and Bilsborrow 2005), while still others have found a role for young women (Flora and Stitz 1988; VanWey, D'Antona, and Brondizio 2007). On the other hand, a substantial number of studies do not support the hypotheses. In a review of the literature on the Amazon, Walker and colleagues (Walker et al. 2002) found that household size and head's age generally did not have significant effects on land use and land-use change (see Table 2, pp.179-82). This may be a measurement problem in which the analyses use the age of the operator or time since settlement to indicate the stage of the household lifecycle, confusing potentially different mechanisms of property lifecycle, agricultural learning, and difference in the timing and pace of family formation (de Sherbinin et al. 2007).

Our approach attempts to understand the relationship between family and farm in environmental context while solving some of the problems that earlier research has encountered. Because so many studies have used simplified proxies for family attributes rather than detailed family information (and therefore produced ambiguous results), we are specifically interested in separating key elements in the household lifecycle by including in our analysis the age of the head, the number of individuals in the household, and their distribution by age and sex. Another important element in our analysis is the ability to follow families over a long time horizon (up to eleven points in time), which is significantly more than the two or three times that many other studies have been able to observe. We recognize that even with these refined data we cannot explain everything that happens, but we believe that our analysis is a significant advance.

The theory we have just described is relatively simple, as Figure 1 shows in a stylized way by representing the relationship between farmer age, farm size, and amount of cropland. As a farmer approaches the middle of his adult life, his family is growing, and he increases his farm holdings (Panel A). As he and his children age, he either transfers control to his successor or sells his land to support his retirement or other family needs, and his holdings shrink. At the same time, his use of the land changes as his labor pool develops. Crop acreages are also increased, but not until a bit later in life (Panel B), and control over these labor-intensive acres will be transferred earlier and more completely over the older generation's lifetime. Testing these simple theories requires rich data, which we have developed in our work on Kansas.

Data, Context, and Methods

The data we use in this paper are drawn from a larger database of linked individual-level census records for 1860 through 1940 of the population and farms of 25 Kansas townships in 25 different counties (Sylvester et al. 2002, publ. 2006). These counties were chosen because they represent the full variety of environmental regime, location, and time of settlement within the state. We chose Kansas for this project because within the broad central portion of the United States it has uniquely rich data about population and agriculture that were collected by both the federal and state governments. Our approach links individual-level records cross-sectionally (population to agricultural censuses) and longitudinally (one time period to the next) from state and federal population and agricultural censuses. The data are available every five years from 1860 to 1940 except for 1890 (no records available), 1900, and 1910 (no agricultural records).   In this paper we use data for every ten years from 1875 to 1925, plus 1920 and 1930, because data for those years are directly comparable. There are 15,967 observations of 9,686 farming households.

We demonstrate the value of these data and their usefulness for understanding the theoretical questions we introduced earlier by looking at the Sparks family of Logan Township in Rooks County, which is located in north-central Kansas (see figure 3). Joseph Sparks was born in Indiana, raised and married in Illinois, and arrived in central Kansas when he was 29 with his wife and four children (two sons and two daughters) just before the 1880 census was taken. Between 1880 and 1895 he and his wife had five more children, reaching a total of nine. Five of his children were sons, and four were daughters.

The agricultural data reveal his history as a wheat farmer. As Joseph approached middle age he increased his farm acres from a half-section (320 acres) to nearly a full section, culminating at 617 acres in 1895 when he was 44 years old (shaded area, top panel Figure 2). Twenty years later, when he was aged 64, Joseph had decreased his farm to about a quarter-section, which he kept until at least the age of 79. (In 1935, at age 84, Joseph had no farm or crop acreage, but he still owned livestock. He died in 1937.) His eldest son, William, left home sometime in his 20s, taking over one-third of the farm acres with him to establish his own farm in Logan Township (unshaded area, top panel of Figure 2). As William approached middle-age, he too increased the size of his farm, to 345 acres which he kept through his 50s, when our records end.

Land cropped by the Sparks family shows an even more dramatic shift from the older to younger generation, one that clearly reflects household labor supply (bottom panel of Figure 2). This change, as predicted, occurred earlier in Joseph's life and was more complete than the transfer of farm land. As Joseph's older sons reached their teen and young adult years, he increased his acres in crops three-fold, from 90 acres to 270 acres (shaded area, bottom panel of Figure 2). That census (1895) was the last one in which William, George and Charles lived in Joseph's household. With John and Benjamin still at home but also still young, Joseph reduced his crop acres by about one third over the next 10 years. After all his sons had left home and Joseph reached his mid-60s, the transfer of cropping was complete and Joseph raised only a few acres of sorghum. William, in turn, began to increase his crop acreage as his brothers left the area and his sons matured (unshaded area, bottom panel of Figure 2).

We have similar information for thousands of Kansas households, telling us who lived in the household, how they used their land, and how household land use changed across time and varied across the landscape. It is important to understand the environmental dimension because these characteristics determine the types of agricultural activity that can be successfully undertaken (Sherow 2007; Burke et al. 1998; Bradford et al. 2006; Malin and Swierenga 1984; Miner 2006). Kansas becomes higher and drier as one moves east to west, gaining some 2000 feet in elevation and losing about 15 inches in annual rainfall. In addition, the land surface is cut by sharp gulleys in different portions of the state, rendering some land unsuitable for cropping. James Malin (1947, 1955) demarcated this variation into five agricultural land-use zones (Figure 3). Key elements of the sample townships vary significantly across Malin's zones (Table 1). The Mixed Farming zone along the eastern boundary has the most precipitation, on average, and can support most types of agricultural activity. It is also the lowest in elevation and has significantly less non-productive farmland than the other cropping zones. The Bluestem Pastures zone, in the Kansas region known as the Flint Hills, has more productive soil and receives enough precipitation for continuous cropping and good pasture, but rocky limestone soils interfere with cultivation. Malin called the area from the northeastern corner of the state west along the Nebraska border the Corn Belt. Located in the northern tier of Kansas counties, it has significantly lower summer and winter temperatures. Of our townships, those in the Corn Belt have the highest percentage of non-productive farmland. This area has adequate moisture for corn, but topography and soil quality less well-suited to wheat cultivation. The Central Wheat Belt is south of the Corn Belt and east of the Bluestem Pastures zone. This area is too dry for reliable corn crops, with lower precipitation and July humidity, but has near perfect weather conditions for growing wheat and little poor-quality farmland. Development of this area during the 1870s helped shift Kansas' economy from cattle to crop production. The western quarter of Kansas forms the Wheat Cattle Sorghum zone. Expanses of smooth prairie cut by gullies and breaks contribute to the high percentage of non-productive land. Farms and ranches were generally larger in the west, because drier land requires more acres to support crops or livestock. As a result farm size and acres in crops have an inverse relationship with moisture (precipitation and humidity). Farms were significantly larger with more cropped acres in the Wheat Cattle Sorghum and Central Wheat Belt zones. The two most eastern zones, Mixed Farming and Bluestem Pastures, were similar in that they had smaller farms and fewer cropped acres than the wheat-growing zones. The Corn Belt, with the highest proportion of poor farmland, had smaller farms than the other zones, but more acres in crops than the eastern areas.

The timing of settlement loosely followed the moisture gradient captured in the land-use zones. The eastern portions were established in the mid-1850s before statehood and during a time of political and social upheaval. Settlement proceeded generally east to west across the state, with lands best suited for farming settled first and more densely and the drier lands in the west settled later and with lower density. In addition to settlement, changes in technology, development of a land market, growing familiarity with the land and what it could produce, adverse weather, and events that affected commodity markets could all have influenced farmers to buy or sell land, or plant more or less acres. The average farm in our townships grew from just over 140 acres in 1875 to over 340 acres in 1920, before declining to just over 300 in 1930. More land was cropped per farm as well, from an average of just over 40 acres in 1875 to about 150 acres by 1920. Early increases in farm size were largely due to the entry of farms in the western sections of the state and unclaimed, state, or railroad lands used in common as pasture were incorporated into the agricultural census. Later increases in cropped land were at least partly in response to the demands of wars in Europe. By the second decade of the 20th century most suitable land was in production, and the average acres of crops on Kansas farms stabilized.

Environmental and historical contexts are important in understanding how Kansas farms used their land and their labor. In the multi-level regression analyses to follow, we analyze how trajectories of land-use change were affected by the development of an economy based on family farms, the environmental endowments encountered by farm families, and the changing composition of agricultural households. Specifically, we test the hypothesis that land and labor were interconnected in the basic lifecycle trajectories of farmers and farm households across time and space in Kansas. We do this by estimating two series of three-level mixed regressions with repeated measures of household land use nested within townships to look at land use transitions over the life course of household heads, conditional on place and time. The dependent variables in our models are (1) size of the farm and (2) number of cropped acres. Our analysis of farm households is an application of individual growth models (cf. Singer 1998; Singer and Willett 2003). Therefore we model the annual absolute change in farm size (and number of cropped acres) as a linear function of time (in years) since household and the effects of all other covariates in our models are interpreted as shifts, up or down, in the annual absolute change in the dependent variable. We also allow the level of farm size (and number of cropped acres) at the time of household formation to vary between households and townships and the trajectory of annual absolute change to vary by age of household head. We use the routines for longitudinal/panel data multilevel mixed-effects linear regression (xtmixed) in Stata version 10 to estimate our models (StataCorp 2007; West, Welch, and Galecki 2007).

In its simplest form, our three-level individual growth model may be written as:

$$\begin{aligned} y_{ijk} &= \pi_{0jk} + \pi_{ijk} A_{ijk} + \varepsilon_{ijk} \\ \pi_{0jk} &= \beta_{00k} + r_{0jk} \\ \pi_{ijk} &= \beta_{10k} + r_{1jk} \\ \beta_{00k} &= \gamma_{000} + u_{00k} \\ \beta_{10k} &= \gamma_{100} \end{aligned} \qquad \text{eq. 1}$$

where *i* indexes the sequence of measurement (in years), *j* indexes the cross-sectional units (household), *k* indexes the location (township), and A_{ijk} is initialized as 0 for the first measurement and increments according to the aging (in years) of the household head at each successive measurement.

The first line of equation 1 may be referred to as the “within-household” or “level-1” individual growth model. The structural part of the level-1 model contains two unknown constants referred to as individual growth parameters whose values determine the trajectory of “true” individual change over time. In equation 1, change is hypothesized to be linear, so π_{0jk} represents the initial level of the dependent variable and π_{ijk} represents the “true” linear absolute change in *Y*. In our models, π_{0jk} is allowed to vary randomly over households and townships, while π_{ijk} is allowed to vary randomly over households but without between-township variability. Lines two and three of equation 1 give the "level-2", or between-household, model. The level-2 model expresses variation in parameters from the growth model as random. Lines three and four of equation 1 give the "level-3", or between-township, model. At this level we are only allowing additional between-township variability in π_{0jk}. By further assuming independence between the lines of equation 1, we are thereby partitioning the total error variance into four distinct components:

$\sigma^2 = \mathrm{var}(\varepsilon_{ijk})$, representing the variability of level-1 units in the *y* outcome,

$\tau_{h00} = \mathrm{var}(r_{0jk})$, representing the variability of level-2 units (households) in the initial level of the outcome,

$\tau_{h11} = \mathrm{var}(r_{1jk})$, representing the variability of level-2 units (households) in the linear absolute change in the outcome, and

$\tau_{t00} = \mathrm{var}(u_{00k})$, which gives the variance component associated with variability in the initial level of the outcome over level-3 (townships) units.

These variance components are useful in that they allow us to calculate (1) the total variance potentially to be explained at each level of the model, (2) the proportion of variance explained at level-1 (the trajectory of change in the outcome) after addition of a level-2 (household-level) attribute, and (3) incremental variance explained by additional household-level attributes (Raudenbush and Bryk 2002). In order to clearly see how the total variance is allocated, it is instructive to write equation 1 in reduced form by substituting expressions from line 5 into line 3, from line 4 into line 2, and then ultimately into line 1:

$$y_{ijk} = \lfloor \gamma_{000} + \gamma_{100} A_{ijk} \rfloor + \lfloor \varepsilon_{ijk} + (r_{0jk} + r_{1jk} A_{ijk}) + u_{00k} \rfloor \qquad \text{eq. 2}$$

Equation 2 illustrates how the random variability in the coefficients yields two components in the "mixed" model. One is constant, and corresponds to the mean intercept and slope across all households and townships. The other is random and is incorporated into the regression error structure. It combines the cross-sectional variability in the intercept (through r_{0jk} and u_{00k}), the cross-sectional variability in the age-dependent trajectory (through r_{1jk}), and an individual and age-specific random element (in ε_{ijk}). Further we can conclude that the total variance is partitioned as:

$$\begin{aligned} Var(y_{ijk}) &= Var(\varepsilon_{ijk}) + Var(r_{0jk} + r_{1jk} A_{ijk}) + Var(u_{00k}), \text{ where} \\ Var(r_{0jk} + r_{1jk} A_{ijk}) &= Var(r_{0jk}) + Var(r_{1jk} A_{ijk}) \qquad \text{eq. 3} \\ &= \tau_{h00} + A_{ijk}^2 \tau_{h11} \end{aligned}$$

thus showing that the total variance at level-2 depends on age of household head. It follows then that the proportion of variance potentially to be explained at each level differs by age of household head, with general expressions given by:

$$\frac{\hat{\sigma}^2}{\hat{\sigma}^2 + (\hat{\tau}_{h00} + A_{ijk}^2 \hat{\tau}_{h11}) + \hat{\tau}_{t00}}$$, for proportion of variance over level-1 units,

$$\frac{(\hat{\tau}_{h00} + A_{ijk}^2 \hat{\tau}_{h11})}{\hat{\sigma}^2 + (\hat{\tau}_{h00} + A_{ijk}^2 \hat{\tau}_{h11}) + \hat{\tau}_{t00}}$$, for proportion of variance over level-2 units, and

$$\frac{\hat{\tau}_{t00}}{\hat{\sigma}^2 + (\hat{\tau}_{h00} + A_{ijk}^2 \hat{\tau}_{h11}) + \hat{\tau}_{t00}}$$, for proportion of variance over level-3 units.

Our discussion of the three-level individual growth model has thus far been of a linear and unconditional (no covariates other than age of household head) form. We model, y_{ijk}, the farm size (and then acres in crops) for the j^{th} household in the k^{th} township, as a nonlinear function of time since we first observe each household by initializing age of household head to zero (that is, $A_{ijk} = 0$), but we allow the trajectory of change to follow a quadratic form $A_{ijk} + Age_{ijk}^2$. However, we do not treat the squared-term as random, thus our treatment of the variance components of the mixed model given above remains essentially unchanged.

We also model change in farm size (and acres in crops) as a function of calendar year, Malin zone, the number of household members, and a series of variables that indicate whether the household contained dependents and potential laborers. The role of household members and their relationship to labor and land use are theorized to differ by relationship to the household head, age, and sex . We divide head's adult children into those below the median age for leaving home (18-22); those above the median age but still within the range of home leaving (23-29); and those old enough that we consider them to be unlikely to leave home (30 and over) (Gutmann, Pullam-Piñon, and Pullum 2002). We contrast these to adults who are not children of the head. There was very little overlap between sons and other males. Fewer than 1% of households had sons and other males in the same age group. All covariates are assumed to have fixed effects, that is, we assume that the effect of each predictor is the same for all households.

The incremental addition of fixed effects leads to two additional proportion of variance calculations that are informative. One may be termed "the proportion of variance explained at level-1 after addition of a level-2 (or level-3) predictor." This is easily found by using the within-household variance components:

$$\frac{\hat{\sigma}^2(\text{baseline}) - \hat{\sigma}^2(\text{model with additional covariate})}{\hat{\sigma}^2(\text{baseline})} \qquad \text{eq. 4}$$

The solution to equation 4 quantifies the impact of household (or township) characteristics on the change in farm size (or acres in crops). It is also instructive to quantify the impact of a household-level predictor on the trajectory of change by comparing the estimate of $\hat{\tau}_{h11}$, the variability of level-2 units (households) in the outcome after the addition of that predictor, relative to the estimate of $\hat{\tau}_{h11}$ before that addition:

$$\frac{\hat{\tau}_{h11}(\text{before}) - \hat{\tau}_{h11}(\text{after})}{\hat{\tau}_{h11}(\text{before})} \qquad \text{eq. 5}$$

Equation 5 gives the incremental variance explained by additional household-level attributes. This procedure can be extended to quantify the impact on initial level of the outcome using either estimates of $\hat{\tau}_{h00}$ (between households) or $\hat{\tau}_{t00}$ (between townships).

We first fit baseline models with no covariates, and then elaborate the models first with head's age and the square of head's age to establish the basic trajectory over the life course and then with calendar year and Malin zone to adjust for the effects of time and location on the age trajectory of land use change. We next included household composition characteristics to examine alterations to land use trajectories due to labor availability within the household. Finally, interactions between labor and the other fixed effects were entered into the model to look for pattern shifts. Model fit was improved in each case with the exception of adding the land-use zones. Local effects captured in the model by including the township level incorporate much of the variation expressed in these zones. The core models that we discuss are presented in Tables 2 and 3.

Results

In all specifications of our models explaining farm size and acres in crops the non-linear relationship between head's age and land use was as predicted by lifecycle theory. Farmers increased both their overall acres and cropped acres over the earlier years of their adult lives and then contracted their farm operations (top panel Tables 2 and 3). The effect of time on the trajectory of household land use was fairly stable across all model specifications for farm size and remarkably so for crop acres. Farm size grew over the time period except in 1920 when farm size was smaller than in 1930, the reference year (second panel of Table 2). Growth was more rapid before the turn of the century, as the western townships were settled and more land was included in the agricultural census returns. Cropping increased steadily from 1875 to 1930 (second panel of Table 3), and the shape, strength and significance of time effects on cropping were unchanged across specifications. The univariate relationships between Malin land-use zone and farm size were also maintained in all specifications of the multi-level multivariate models, with farms smallest in the Mixed Farming and Corn Belt zones, larger in the Bluestem Pastures and Central Wheat Belt, and significantly larger in the Wheat, Cattle, Sorghum region (third panel of Table 2). Cropped acres were significantly higher in the two western zones, also as expected (third panel of Table 3). The effect of ecological zone on acres in crops was virtually unaffected by household composition effects.

Larger households had larger farms and more acres in crops in the multivariate regression, just as theory would lead us to expect. Each additional household member [was associated with] a roughly 5% increase in farm or crop acres (Model 4, Tables 2 and 3). The magnitude of the effect of household size was mitigated somewhat by the indicator variables for age-sex-relationship groups within the household, but remained highly significant and positive for both farm size and crops. Child dependency, as indicated by the presence in the household of children aged 10 and under, was associated with smaller farms and slightly more cropped acres, but neither relationship was statistically significant. Similarly, the presence of girls and women of laboring age did not significantly increase or decrease the size of the farm or the number of acres in crops. On the other hand, the presence of men of all ages is associated with larger farms even when controlling for time, location and household size. Men in their 20s who were not sons of the head were associated with larger farms than were sons in their 20s. The magnitude of the effect was larger with age for sons (although not statistically different), but not for other men. Men of all ages were also associated with more acres in crops, as were teenaged boys. Men who were not sons showed a stronger association with increased cropped acres only in their late 20s. As with farm size, the magnitude was larger with age for sons (although these differences were not statistically significant). Accounting for household labor shifts some of the explanatory power away from head's age, while maintaining the direction and strength of that effect. Models with interactions between main effects were estimated with some improvement in the overall fit but with no clear patterns of interaction between time, location and age that would contribute to a coherent explanation.

In our baseline farm size model with no fixed effects (not reported) 62% of the total variation in farm size can potentially be explained by aspects related to the life course of household heads, 22% to characteristics of households, and 16% to location/township. The partition of variance in the baseline model for acres in crops is somewhat different, with less allocated to the life course of household heads (44%), and somewhat more to level-2 and level-3 characteristics (29 and 27%, respectively). Aging of the household head introduces the fourth variance component and affects the partitioning of variance once head's age is included in the models (see equation 3). With increasing age, for both outcomes the proportion of variance that may be explained shifts from head's lifecycle (level 1) and township characteristics (level 3) to the variability of households in change (level 2 slope), across all models. In the cropland models, this age pattern is more accelerated with the addition of Malin zones (Model 3) and again when the household labor components are added (Model 4). Nevertheless, variation associated with head's lifecycle continues to account for the vast majority of the variance in the farm land models, and the proportion increases so that in Models 3 and 4, the proportion of variance attributable to level 1 is 88 percent at initial observation and still nearly 80 percent 30 years later. Variation at level 1 accounted for a smaller proportion of variance in the cropland models than in the farmland models, but also increased across the models to about 70% of the variation in Models 3 and 4 at initial observation and about 60% after 30 years. The proportion of variance explained at level 1 after addition of household composition characteristics was 15% higher than at the baseline model for crops and 4% higher for farmland.

Township-level variation played an important role in the cropland models, as did variation in the initial acres in crops. Introducing the land-use zones to the fixed-effects portion of the model dramatically decreased the variance explained by the township-level intercept for both farm size (by 71%) and acres in crops (by 52%). Adding the household composition variables (Model 4) shifted the proportion of variance slightly away from the household-level components in the farm model and away from lifecycle variance in the crops model. The greater role level 1 variation in the farmland models fits our expectation that increasing acres is tied to household head's lifecycle. A greater impact of household characteristics in the cropland models fits our expectation that labor is more important in decisions about cropping.

Discussion and conclusions

Our goal has been to use our unique data about Kansas to test a core set of theories about agricultural families in the era before modern mechanized farming. Those theories link household head life course and household lifecycle development with farming, and explain the size of farms and the amount of land devoted to crops as a function of the age of the farmer and the labor endowment of the family, all within a broad context that takes into account time period, locality, and environment. These core theories are important because they support an extensive tradition of economic and demographic analysis that asserts that farm households adapted their families and their economic behavior synergistically. Our basic question was whether that could be measured and confirmed. This paper validates those important and simple theories by showing that in the context of a complex setting of farm, family, community, time, and environment farmers behaved as lifecycle theory would suggest.

The life course of farm household heads, household life cycle, and the availability of male labor were key elements in land use and land use change in Kansas. Farmers grew their farms as they aged, using the labor of sons and other men to accumulate land or to maintain their investment. Large farms particularly demanded the labor of additional men. When the household labor force was coming into its strength, farmers increased intensive land use by putting more acres into crops depending equally on the labor contributions of sons and other men. Later in life, operators began to divest themselves of farm acres. Farmers adjusted their land use based on household composition, or adjusted their household composition based on their plans for their land. Household dependents and the labor of girls and women did not figure into farmer's calculations, at least at the scale and for the farm activities that we have used here. Head's life course and household life cycle are not competing explanations for farmers' behavior but rather manifest intersecting goals of farm entrepreneurs – to grow their operations and to maintain the family's livelihood. These goals may in turn be synergistic, with investment of all kinds of capital in increased crop production leading to accumulated money capital invested to extend land holdings.

Historical and environmental contexts reveal the importance of time and place without diminishing the force of head's lifecycle trajectory or the household lifecycle. Farm operations grew rapidly through the 19^{th} century, and in more arid areas were larger. More farm acres were cropped over time, yet the rate slowed as the limits of conversion from native grassland to cropland were realized and reached. Location at a finer scale affected land use choices, capturing differences across townships in environmental conditions, the timing of settlement, orientation to markets, and demographic characteristics. The semi-arid grasslands of Kansas imposed constraints and shaped opportunities in ways that left families little choice but to adapt or leave. Many, such as the Sparks of Rooks county, did adapt and stayed for generations. Viewing adaptation through lifecycle and lifecourse helps us understand how families manage their resources to build and maintain farms in different environments.

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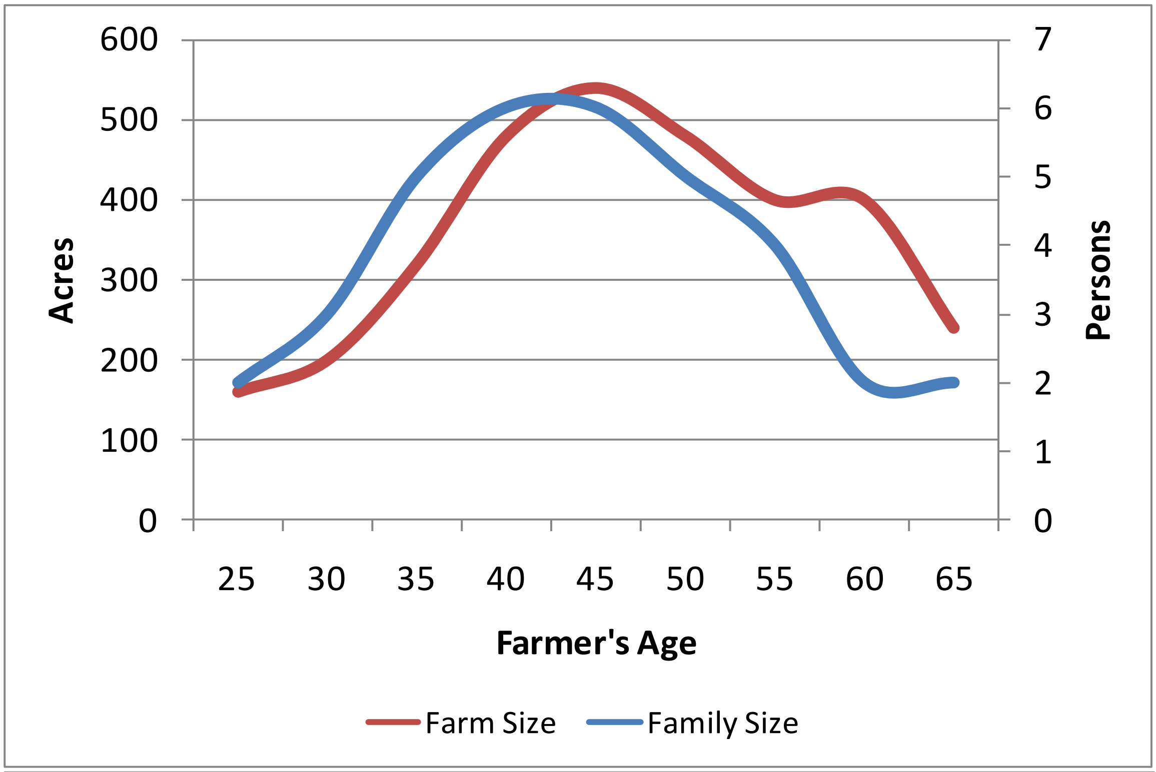
Figure 1. Lifecycle and land use change: family labor and land use



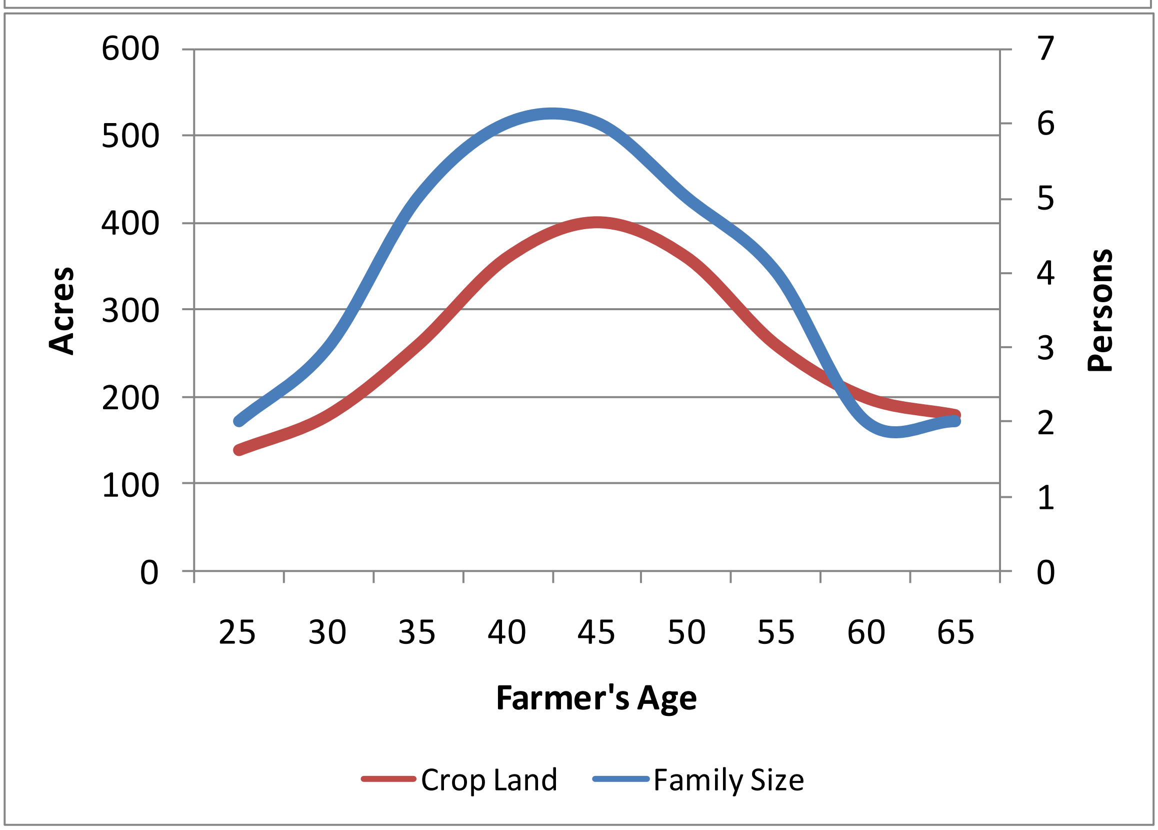
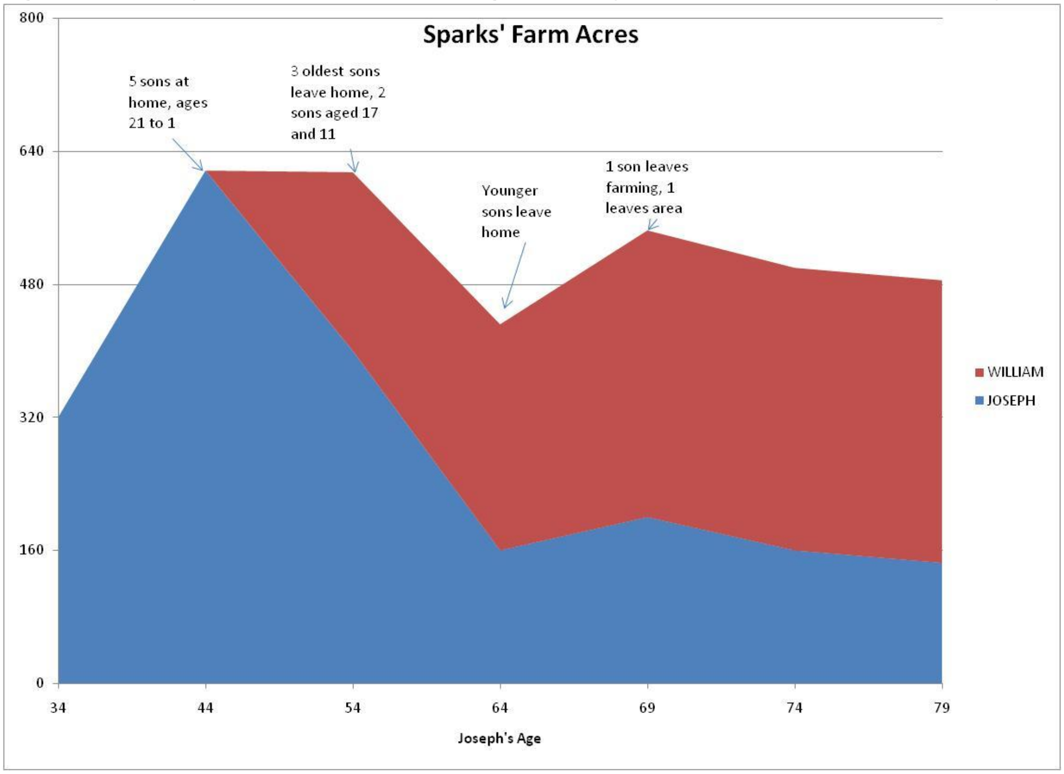


Figure 2. Lifecycle and land use change: family labor and land use on the Sparks family farm.



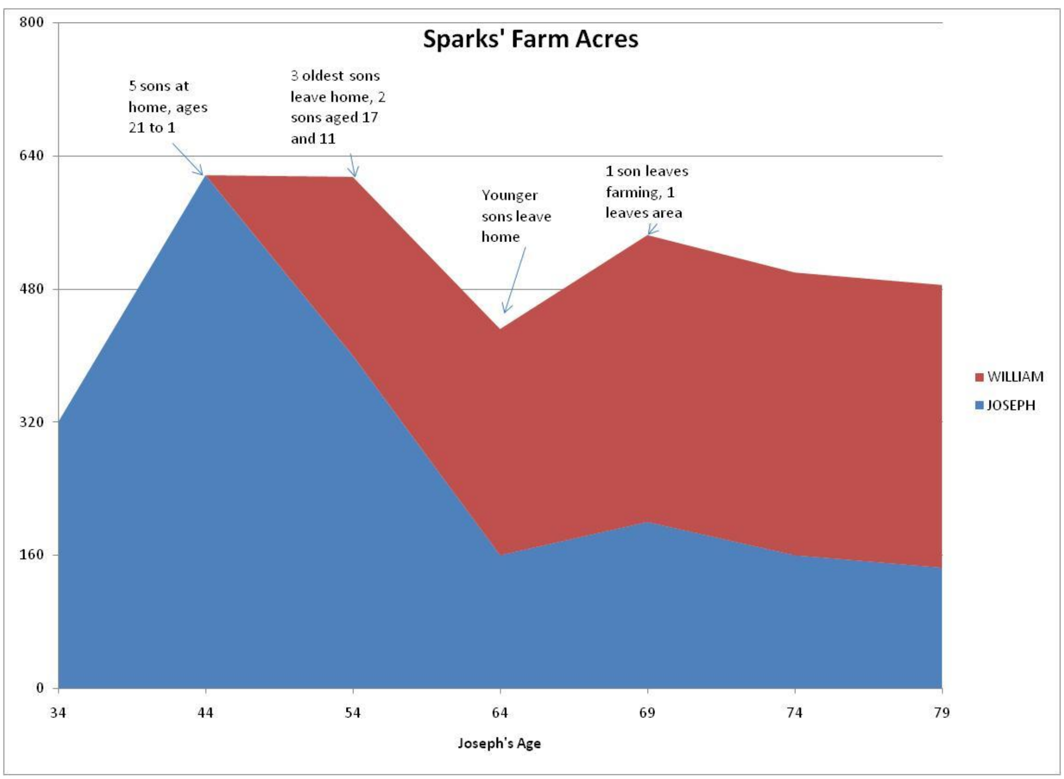


Figure 3. Map of Kansas showing sample townships and Malin land-use zones.

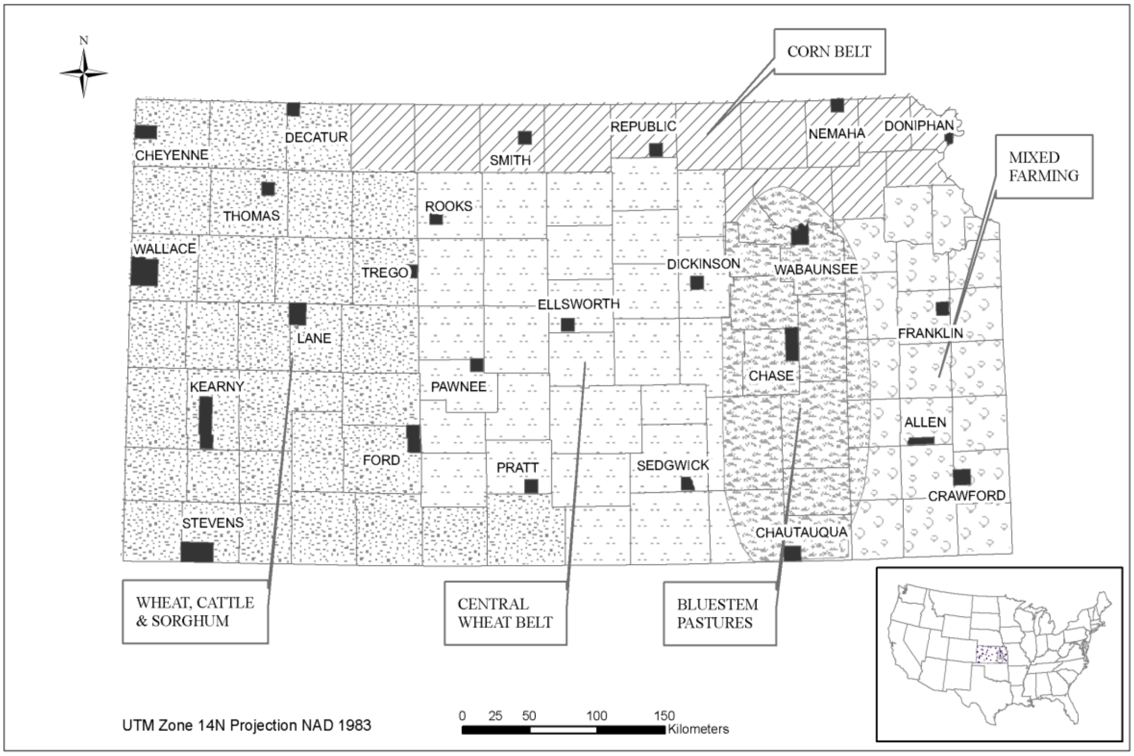


Table 1. Characteristics of Malin zones

	Mixed Farming	Bluestem Pastures	Corn Belt	Central Wheat Belt	Wheat, Cattle, Sorghum
Elevation (feet)	929.67	1150.33	1396.50	1659.17	2973.22 [a]
Mean Annual Precipitation	32.66 [a]	27.33 [a]	23.85 [a]	20.98 [a]	15.04 [a]
Relative July Humidity	53.67	52.67	54.50	47.33 [a]	41.67 [a]
Mean July Temperature (F)	79.37	79.37	78.58	79.92	78.22
Mean January Temperature (F)	32.43	31.10	26.65 [a]	30.55	30.33
Non-productive Farmland (%)	16.61 [a]	10.20 [a]	29.57 [a]	5.63 [a]	23.95 [a]
Topography	Irregular plains	Open hills	Irregular plains Open low hills	Irregular plains Plains with hills	Smooth plains Irregular plains
Farm size (acres)	167.79	229.05	162.81 [a]	248.02 [a]	509.03 [a]
Cropped land (acres)	67.24	69.48	79.28 [a]	153.22 [a]	188.85 [a]

[a] Different from all other Malin zones at p > .01 in OLS regression with Wald post-estimation tests for equivalence of the betas.

Table 2. Coefficients from the multilevel regression of acres in farms: Kansas farm households in 25 townships, 1875-1930.

Predictor variable	Model 1			Model 2			Model 3			Model 4		
FIXED EFFECTS	Coeff.	Std. Err.		Coeff.	Std. Err.		Coeff.	Std. Err.		Coeff.	Std. Err.	
Head's Lifecourse												
Head's age	9.638	1.440	***	10.796	1.436	***	10.792	1.435	***	6.111	1.641	***
Head's age squared	-0.090	0.016	***	-0.106	0.016	***	-0.106	0.016	***	-0.067	0.018	***
Year												
1875				-95.369	12.816	***	-94.195	12.814	***	-104.254	12.689	***
1885				-89.424	11.769	***	-89.148	11.766	***	-110.716	11.716	***
1895				-78.001	11.477	***	-77.688	11.477	***	-91.835	11.394	***
1905				7.909	10.870		8.012	10.870		-6.204	10.789	
1915				-23.387	10.523	*	-23.417	10.523	*	-30.335	10.438	**
1920				23.193	10.506	*	23.044	10.506	*	17.508	10.431	
1925 (1930 omitted category)				-19.894	10.145		-19.951	10.145	*	-18.332	10.074	
Regional Land-use Zones												
Corn Belt							-317.854	53.349	***	-320.063	53.820	***
Mixed Farming							-319.214	58.987	***	-319.644	59.517	***
Bluestem Pastures							-255.244	58.975	***	-258.321	59.506	***
Central Wheat Belt							-215.066	47.016	***	-214.496	47.421	***
Wheat, Cattle, Sorghum (omitted category)												
Household Lifecycle and Labor												
Household size										12.553	2.150	***
Children (0-10)										-13.241	8.424	
Children (11-17)										-2.645	7.521	
Daughters (18 - 22)										-6.487	10.282	
Daughters (23 - 29)										15.572	16.453	
Other w omen (18 - 22)										15.855	18.227	
Other w omen (23 - 29)										-22.745	20.633	
Sons (18 - 22)										37.400	8.952	***
Sons (23 - 29)										51.406	12.296	***
Other men (18 - 22)										115.313	13.786	***
Other men (23 - 29)										119.943	14.786	***
Sons (30+)										65.921	21.686	**
Other men (30+)										62.002	11.027	***
Intercept	78.14376	45.601		89.482	45.086	*	261.522	43.765	***	319.555	46.188	***
RANDOM EFFECTS												
Tow nship-level intercept	26220.950			23860.710			5931.977			6053.946		
Household-level head's age slope	14.070			14.409			14.327			13.228		
Household-level intercept	8315.023			7258.411			7435.787			6994.905		
Residual	99385.010			98196.350			98179.220			97046.100		

Table 3. Coefficients from the multilevel regression of acres in crops: Kansas farm households in 25 townships, 1875-1930.

Predictor variable	Model 1			Model 2			Model 3			Model 4		
FIXED EFFECTS	Coeff.	Std. Err.		Coeff.	Std. Err.		Coeff.	Std. Err.	***	Coeff.	Std. Err.	
Head's Lifecourse												
Head's age	4.134	0.386	***	4.849	0.372	***	4.850	0.372	***	1.531	0.419	***
Head's age squared	-0.040	0.004	***	-0.054	0.004	***	-0.054	0.004	***	-0.024	0.005	***
Year												
1875				-96.023	3.371	***	-95.872	3.371	***	-99.333	3.286	***
1885				-91.906	3.079	***	-91.840	3.079	***	-99.352	3.015	***
1895				-56.133	2.984	***	-56.068	2.984	***	-61.535	2.912	***
1905				-49.140	2.804	***	-49.072	2.804	***	-54.365	2.737	***
1915				-29.901	2.672	***	-29.896	2.672	***	-32.844	2.610	***
1920				-14.031	2.631	***	-14.041	2.631	***	-16.534	2.574	***
1925 (1930 omitted category)				-11.398	2.513	***	-11.401	2.513	***	-10.899	2.459	***
Regional Land-use Zones												
Corn Belt							-88.655	24.373	***	-89.291	24.385	***
Mixed Farming							-101.371	27.005	***	-101.641	27.020	***
Bluestem Pastures							-98.996	27.003	***	-100.131	27.018	***
Central Wheat Belt							-7.695	21.413		-6.989	21.422	
Wheat, Cattle, Sorghum (omitted category)												
Household Lifecycle and Labor												
Household size										3.953	0.576	***
Children (0-10)										2.158	2.152	
Female children (11-17)										2.599	1.889	
Male children (11-17)										7.941	1.862	***
Daughters (18 - 22)										2.386	2.578	
Daughters (23 - 29)										4.372	4.129	
Other w omen (18 - 22)										8.601	4.593	
Other w omen (23 - 29)										6.405	5.196	
Sons (18 - 22)										29.172	2.251	***
Sons (23 - 29)										28.354	3.106	***
Other men (18 - 22)										25.263	3.484	***
Other men (23 - 29)										39.313	3.744	***
Sons (30+)										31.542	5.537	***
Other men (30+)										20.793	2.813	***
Intercept	34.660	15.356	*	70.957	14.480	***	111.045	15.871	***	163.573	16.230	***
RANDOM EFFECTS												
Tow nship-level intercept	3945.914			3375.983			1285.742			1288.979		
Household-level head's age slope	1.264			1.603			1.603			1.249		
Household-level intercept	2082.948			845.882			845.710			1117.034		
Residual	6036.879			5703.871			5703.736			5474.317		