Producer Dynamics in Agriculture: Empirical Evidence

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ABSTRACT

The usual aggregate industry statistics for agriculture mask considerable dynamics as captured by exit, entry, and changes in farm size. We describe the dynamic changes in the sector using the Census of Agriculture Longitudinal File for 1978-97 which is a panel data set. High rates of farm entry, exit, and volatility have occurred during this period. We find more turnover among small farms than other farms, that continuing farms are larger on average than either entering or exiting farms, and in some subperiods, exiting farms are larger than entering farms. The majority of continuing farms change size during the subperiods, either expanding or contracting. Mobility in output is significantly greater than mobility in acres of farmland; mobility in output varies more than mobility in acres over time. A high rate of turnover can contribute to the farming industry's aggregate productivity growth. Unfortunately, the Census of Agriculture does not allow for a meaningful measure of total factor productivity. Hence, in order to further understand the relationships among turnovers, structural reallocation, and productivity for agriculture, we estimate a 5-equation model for the period to measure the impacts using micro and state aggregated data sets. We find the farm exit rate is positively related to total factor productivity, findings that are consistent with results for other industries using micro-level measures of productivity.

EL Categories: D24, L1, O12, O47, Q12, Q16

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Introduction

The U.S. farm sector is characterized by a great deal of heterogeneity. This heterogeneity has been well-documented through Censuses of Agriculture (beginning in 1840) and a variety of surveys (such as the annual USDA farm household surveys, initiated in 1984[2]). A major indicator of the heterogeneity within the farm sector is the size distribution of farms. One reason for the heterogeneity in farm sizes is the multiple objectives of producers, in addition to profit making, such as a high-quality rural lifestyle. More than three-quarters of farms have gross farm sales less than $50,000 and, on average, lose money farming. Other common indicators which exhibit extensive heterogeneity in the structure of the industry include the type of commodity specialization, the extent of commodity diversification, and various farm household characteristics, such as major occupation of the farm operator.

While the traditional aggregate indicators capture the heterogeneity of agriculture, they also provide a picture of relative stability over time. According to the most recent Census of Agriculture (2002), there were about 2.1 million farms in the U.S. (USDA, 2004a). That count is only 8 percent less than 30 years ago, and, in fact, there has been a slight increase in farm numbers in the last decade. Similarly, the average acres in a farm in 1978 were 449, compared to 441 in 2002. However, this relative stability in the number of farms and average size in acres masks a great deal of dynamics of entry and exit of farms, as well as changing of farm size for the new and continuing farms.

Unlike the cross-sectional heterogeneity and the aggregate changes in farm characteristics over time, relatively little has been known about the dynamics of the changing U.S. farm sector. As

[2] Since 1996, the survey is the Agricultural Resource Management Survey. Previously, it was the Farm Costs and Returns Survey (USDA, 2004b).

is true for other industries in the economy until recently, this is largely because of the lack of access to a panel data set. The annual USDA farmer surveys and the Censuses of Agriculture were not designed to be panel data sets. However, in this study we use the Longitudinal Census of Agriculture file that was constructed by linking individual farm record data for the 5 censuses between 1978 and 1997 to document the extent of exit, entry, and growth in U.S. agriculture.[3] Our analysis parallels a number of recent studies of firm or plant turnover for manufacturing industries in the United States (e.g., Baily, Hulten, and Campbell 1992, Olley and Pakes 1996, Haltiwanger 1997). These studies of various non-agricultural U.S. industries are based on panel data built from economic censuses. In some cases, these studies use the data to construct firm or plant level measures of productivity and to consider some form of a decomposition of an industry productivity index. Foster, Haltiwanger, and Kruzan (2001) provide a recent review of the microeconomic evidence on productivity dynamics.[4] Unfortunately, the Census of Agriculture data do not permit farm-level total factor productivity measures to be constructed. To address the role of productivity in the dynamics of the agricultural industry, we will also present the results of a model designed to capture the causes of structural change at the state-level for this same time period, using the Census of Agriculture Longitudinal file (to construct exit rates) as well as other data available.

In the next section, we describe the way in which the agricultural industry is defined and important characteristics of the industry that have implications for the framework to evaluate the evolution of the industry. In the third section we summarize a model of farm-level decision making. The model recognizes the unique characteristics of farms and we contrast that model with the more general theoretical models of dynamic firm turnover. Section four of the paper

[3] An early effort by the Bureau of the Census and the Economic Research Service to link Censuses was initiated in the early 1980s. Several papers predicting the future farm structure resulted from the effort and are exemplified by the first paper by Edwards, Smith, and Peterson (1985). For more details on the file, see the Data Appendix.

summarizes farm entry, exit, and reallocation over the period among continuing farms. We use the term *turnover* to capture trends on entry and exit of farms (and their inputs and outputs) and the term *mobility* to capture the trends in the reallocation of inputs and outputs of continuing farms, including variation in their farm sizes and market shares. Section five of the paper interjects the role of productivity in the farm exit and reallocation dynamic through the use of a state-level model. Finally, the paper ends with conclusions and suggestions for future work.

Defining the Agricultural Industry

In the U.S., a farm is defined (in the Agricultural Census) as any place from which $1000 or more of agricultural product was produced and sold, or normally would have been sold, during the year (USDA, 2004a). Hence, it is a very liberal definition and one that assures a very diverse group of establishments will be counted in the farm population. It includes farms operated by households that are retired or attracted to farming for reasons not primarily related to production, such as the rural lifestyle or investment opportunities. In addition, since the definition is dollar-based, it is affected as price levels change. Although changing the definition is regularly discussed, a liberal definition of a farm is very popular with many for a variety of reasons. For example, some Federal program dollars are distributed to states in part based on the farm population in a state, e.g., extension funds.

The farm sector is a unique sector of the economy in a number of ways. The uniqueness can affect the dynamics of exit, entry, and reallocation of the farm production industry, relative to other industries in the U.S. economy. First of all, most farms are closely-held businesses that combine the production and household choices in one decision-making unit. This requires that economic analyses take into consideration the utility of the household members over the life-cycle, as well as

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[4] They also provide an original analysis of the dynamics of productivity in the service industry and explore the role of

profit-maximizing motivations. Secondly, a major input of farms, farmland, is considered fixed and immobile. This has technological, policy, and social implications. For example, the benefits of cost-reducing technologies and the massive government subsidies to the industry generally accrue to the owner of the farmland, who is not always the farm operator. The fixed supply of arable farmland is a focus of those concerned with long-term sustainability, as well. Moreover, it could be argued that the family labor is also considered as immobile. A third unique feature of agriculture is its high total factor productivity (TFP) growth relative to most other sectors of the U.S. economy, in large part because of the public investments in R&D (Ahearn, et al. 1998; Fuglie, et al. 1996).[5] While aggregate productivity growth is high, there is a great deal of heterogeneity in productivity across farms. Not unrelated to this heterogeneity is the primary importance of the farm as a residence to the majority of producers. Fourthly, agricultural commodity markets are generally characterized by instability, largely as a result of weather and low price elasticity of demand for food. And, finally, there is an unusually high level of interest in preserving the farming way of life, even by the general population. Public opinion polls have consistently revealed that the U.S. public has an interest in protecting the family farm from the vagaries of the market place, and this support has often translated into the transfer of subsidies to the agricultural sector and special treatment in the tax code. Some of the support is likely difficult to separate from the public's support of the environment and scenic vistas since approximately half of the 2 billion acres of U.S. land is in some type of agricultural use.

Federal agricultural-specific policies have long been concerned with the restructuring and reallocation of outputs and inputs across agricultural producers. Current farm policies have their roots in a time around the Great Depression when farm households were significantly worse off

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different measurement methodologies in the differences of studies.

[5] There is a relatively large literature on returns to R&D investment in agriculture. Fuglie, et al. provides one review.

than most households. This condition and its cause in low farm prices due to surpluses of commodities are commonly referred to as the "farm problem" (Gardner, 1992). A reason behind commodity surpluses is technological advances. The standard undergraduate agricultural economics models for understanding the relationship between innovation, surpluses, and reallocation of outputs and inputs are the "treadmill" and the "farmer cannibalism" models described by Cochrane (1958). Evidently, Cochrane was greatly influenced by Schumpeter's *Theory of Economic Development* (1934). The dynamic nature of Schumpeter's process of "creative destruction," in particular, was key in Cochrane's development of his models of innovation and reallocation for the farm industry, according to a recent biography (Levins, 2003, p. 28).

A Theoretical Framework of Farm Dynamics

Schumpeter's early work concerning the role of reallocation, in combination with an emerging literature that seeks to account for the heterogeneous performance across firms, forms the theoretical underpinnings of the current empirical work using micro-level firm data. The emerging theoretical models of industry dynamics are carefully reviewed in a number of sources, including Caves (1998). In his review article, Caves links the traditional industrial organization framework with new findings on exit, entry, and mobility of individual firms.

The emerging theoretical models include Jovanovic (1982), Lambson (1991), Hopenhayn (1992), and Ericson and Pakes (1995). What the models have in common is that they assume firms have heterogeneous productive efficiency and are subject to various sources of uncertainty. These assumptions allow the models to explain the divergent paths of entry, exit, and reallocation that characterize the observed firm-level data.

These common assumptions of the industry dynamics literature are very consistent with key characteristics of farm firms, as described above. Namely, micro-level analysis of farms shows extensive cross-sectional productivity and cost differences (e.g., McBride and Key, 2003) and farms are subject to numerous shocks, in particular the classic weather shocks. The industry dynamics literature also focuses on the consequences of high entry costs.[6] According to Hopenhayn, following a random productivity shock, φ, the distribution of future productivity is represented by

(1) $F(\varphi_{t+1} \mid \varphi_t)$.

Each firm knows its current productivity and the distribution of future productivity at the beginning of each time period. Each firm chooses to exit or remain in the industry. If they choose to remain, they pay a fixed cost C_f. Potential entrants into the industry can enter by paying an entry cost, C_e. The level of C_e will affect the flows of entering and exiting firms. A high C_e will raise the level of profits needed to make entry profitable and lower the minimum productivity needed for continuing firms to stay in business and avoid exiting.

High entry costs may result in lower producer exits, as well as entrants. High entry costs can play the role of helping to sustain low productivity firms, by lowering competition from potential new, and higher productivity, firms. Farming is often considered to be an industry with high entry costs because of the high cost of farmland, which may have implications for the productivity of farms. However, unlike the entry costs of most industries, i.e., their sunk costs, farmland is an investment that has generally appreciated steadily over time. This difference in the financial value of the initial farming investment is likely to play a role in the extent to which entry costs deter entry.

[6] Theoretical models of farmer choices of size, entry and exit are varied, but some emphasize the role of farm investment decisions as a function of sunk costs under risk neutrality, in particular, Chavas (1994).

What the emerging models do not adequately capture for farming is the role played by the most unique characteristic of farm firms, namely the dual residence-business objectives of the majority of farm households. As mentioned, the majority of farms are small farms that usually lose money farming when returns only consider before-tax cash costs and returns. Many of these farm households likely receive a variety of returns from farming that are not captured in their before-tax cash income. For example, farm households may simply enjoy farming as a lifestyle and in general these households would have a shadow value of family labor that is less than their opportunity cost. Farm work may even be considered as a leisure activity by these households. The single-most powerful trend in resource allocations of farm households during the past several decades is the allocation of household time to the off-farm labor market. More than 70 percent of U.S. farm households have someone in the household working off the farm. This high rate of off-farm labor participation is true, even in very rural areas of the U.S.

The unique relationship that a farm household has with the farm business means that micro decisions of farm businesses must be modeled along with micro decisions of farm households in a household production model. Farm households provide most of the labor on the farm and have a tripartite choice of time allocation (farm, off-farm, and leisure hours). The household production model is an extension of the basic labor-leisure model (e.g., Becker, 1965). The conceptual model combines the decisions of agricultural households relating to production, consumption, and labor supply into a theoretically consistent model (e.g., Strauss, 1986). The individual is assumed to allocate time to farm work, off-farm work, and leisure in such a fashion that the optimal allocation is achieved when the marginal values of time devoted to the activities are equal. Because of the dependence of farm households on off-farm income sources and the fixed supply of household labor, an important component of this literature is the empirical literature on estimating off-farm

labor participation and supply (e.g., El-Osta and Ahearn, 1996; Hallberg, et al., 1991; Mishra and Goodwin, 1997).[7]

The farm operator household is assumed to have the optimization problem:

(2) $Maximize\ U = U(C_h, T_h; H, Z), with\ \partial U/\partial\Omega > 0,\ \partial^2 U/\partial\Omega^2 < 0,\ \Omega = C_h, T_h$ [8]

subject to

(3) $\overline{T} = T_o + T_f + T_h, with\ T_o \geq 0, T_f \geq 0, T_h > 0$

(4) $P_h C_h = P_f F(T_f, X_f; H, Z) - P_x X_f + w_m T_o + V$

where

U = joint household utility,

C_h = goods and services consumed by the household,

T_h = leisure (or home time) of household members,

H = the human capital of household members,

Z = other household and local area characteristics,

$\overline{T}$ = total time endowment of household,

T_o = total time of household allocated to off-farm work,

T_f = total time of household allocated to farm work,

P_h = the price of consumption goods and services,

P_f = output price of farm commodities,

F = farm production function,

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[7] This presentation of the model presents the most basic version of the static model, which ignores many of the possible complexities of the model. For example, the model ignores the interdependence of the allocation decision between operator and spouse, the utility of others in the household, uncertainty, non-farm home production, commuting costs and other transaction costs of off-farm jobs, possible psychic income from farming, and household savings.

[8] The human capital (H) and other characteristics (Z) can also be written so as to be specific to farm work, off-farm work, or home time. For simplification, we have kept a general specification here.

X_f = inputs used in farm production, including hired labor,

P_x = input price for farm production inputs,

w_m= market wage,

V= non-labor income (including from government payments).

The model provides demands for farm household labor in farming, for leisure time (including personal maintenance time), and off-farm work. One of the possible solutions for the farm household is to provide no labor to the farm business, that is, to exit agriculture entirely. Farm households will continue in farming as long as the marginal utility per dollar earned from additional farm work is greater than the marginal utility per dollar earned from additional off-farm work. Otherwise, standard economic theory would predict that farm households will exit farming. This model can be extended to explain other dimensions of farm structure. For example, increased off-farm work may be associated with smaller farm size, as more time spent working off-farm means less time available for working on the farm. Human capital and other household characteristics may have an impact on farm level productivity, as well as the allocation of time between farm and off-farm work.

The household production model is especially useful for characterizing individual micro decisions. Households make micro choices that result in collective impacts at the state (or other aggregated) level of interest. Individual farm production choices lead to aggregate state productivity levels; allocation of time and resources to farming result in an aggregated size distribution of farms, and farm exit rates in a state; and allocation of time (including none) to off-farm work result in state off-farm labor supply.

Farm Turnovers and Mobility, 1978-97

As mentioned, the traditional indicators of farm structure are widely available and document the extensive heterogeneity in farm structure. Because they are widely-available and generally understood by those that study the farming industry, we provide only a brief description of their trends in this paper. We focus our description of farm structure on the much less widely available statistics, namely, the basic indicators of dynamic change for the 1978-97 time period--entry, exit, and survival rates of continuing farms.[9] We also describe the extent that continuing farms change size, namely, farms expanding by buying up or renting in other land, as well as the prevalence of some farms to decrease in size. In this section, we also present a summary of the small literature on the factors affecting farm exits. We begin the section with a discussion of a measurement issue relating to farm size.

Farm Size: Measurement and Aggregate Distribution. There are a variety of ways in which farm size is measured, and the topic is occasionally reevaluated in agricultural economics (e.g., see Hanson, Stanton, and Ahearn, 1989; Sumner and Wolf, 2002; and Yee and Ahearn, 2005). Two of the most common ways to measure farm size in statistical publications are in terms of farm acres, an input measure, and the dollar value of gross sales, an output measure. The advantage of the acre-based measured is that land is generally viewed as a key production input in farming and an acre is a clearly defined unit of measurement. It can be considered as the counterpart to a measure of employment in manufacturing or service industries. The relative proportion of land as a production input varies considerably by technology and the quality of an acre of land varies considerably over space. Output-based measures, such as the gross sales measure, avoid the major disadvantages of the acre-based measure. However, output-based measures can interject biases as a result of the differences across commodities in farm value-added and in the changing value of the dollar over

[9] The 2002 Census of Agriculture has not yet been added to the longitudinal data base. With the release of the 2002 Census the number of farms in 1997 has been revised upward due to an adjustment in weights based on a survey of

time, not to mention transitory output variations (Stanton, et al., 1992). In this paper, we employ more than one measure, depending on the purpose and the availability of statistics. We employ the two measures described above and used in the Census of Agriculture.

As mentioned, the average farm acreage has been quite stable in recent decades. The average acreage was 449 in 1978, compared to 441 in 2002.[10] Average farm acreage is significantly greater in Western states, than in the East, but farm sizes are highly dispersed in all regions. This is in part because of the shape of the cost curve. It is generally thought to be L-shaped, with the low-cost plateau occurring at a relatively small farm size. Again, the role of technology is important here because there are differing low-cost technologies available for farms of different sizes. The prevalence of off-farm income is another reason we observe a significant share of small farms. While small farms may be efficient from a technical viewpoint, they nevertheless usually do not generate enough cash income to support a family. Off-farm work opportunities allow many farm families to be engaged in farming and its lifestyle amenities.

Both the small farms and the very largest farms are increasing as a share of the total farms during the period 1978-97. The size distribution of farms is heavily skewed towards the small farms, while the production in agriculture is largely concentrated on the large farms. Approximately 2.4 percent of the largest farms (or 46,000 farms) accounted for half of all product in 1997[11] (**figure 1).** The increased concentration in production is only expected to continue in the future. However, it is still clear that with its more than 2 million farms, agriculture is not in danger of losing its poster child status for an industry characterized by many producer/sellers. **Figure 2** shows how farms are distributed into 3 size classes by state, when size is measured in acres.

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undercoverage. However, the revision to the 1997 Census will not be incorporated into the longitudinal file.

[10] The original 1997 census estimate was 487 acres per farm, and the revised estimate is 431 acres per farm.

[11] By the year 2002, there were 34,000 (or 1.6 percent of farms) that accounted for half of the product.

Turnover. Exit, entrant, and surviving farm rates vary by inter-census-time period **(figure 3).** Many farms go out of business and many new farms come into business. In the 1978-82 period and the 1992-97 period, the number of farms that entered the farm sector exceeded the number of farms that exited **(table 1).** In the two intervening census periods, the opposite was true. For example, in 1997 62% of the farms that existed in 1992 were still in existence, and 38% of the 1992 farms had exited. However, slightly more farms entered farming during the period as exited. Contrast those significant changes to the slight increase in the net number of total farms between the 1992 Census of Agriculture and the 1997 Census. Exit rates also vary by state as shown in **figure 4** for 1992-97. The entry and exit rates in **table 1** are reported first for multiple-year periods, either 4- or 5-year periods and then as an annual rate. When annualized, the annual rates are somewhat greater than those reported by Dunne, Roberts, and Samuelson (1988) for U.S. manufacturing industries in an earlier period. They report a 7.7 percent annual entry rate and a 7.0 percent annual exit rate for the 1963-82 period.

Another statistic used to characterize the turnover in an industry is the volatility of the industry. Volatility is defined as the sum of the entry and exit rate minus the absolute value of the net entry rate. It can be interpreted as a measure of the amount of producer turnover that is in excess of the amount needed to account for the change in industry size (Dunne and Roberts, 1991). Given both the high rates of entry and exits, the volatility rate in farming is about double the entry and exit rates. The positive correlation between entry and exit rates is consistent with the findings reported for other industries (Caves, 1998).

Turnover statistics are sometimes calculated for output or employment. For farming, it makes sense to calculate entry, exit, and volatility rates for output (value of sales) and acres of farm

land.[12] The total land in agriculture is relatively stable over time, but there is also considerable shifting of land. Land moves to and from agricultural and nonagricultural uses, for example, between agricultural and forest uses. Land also shifts among agricultural uses, such as pasture and cropland. Much of the land operated by the farms that exit agriculture is subsequently purchased or rented by existing farms to expand their operation. In general, entry, exit, and volatility rates were lower for acres than they were for farm firms during these periods. Entry rates for farmland acres exceeded the exit rates in the first two subperiods and the opposite was true for the last two Census subperiods. Only in two Census subperiods was there a positive relationship between turnover in farm firms and turnover in farm land **(table 1).** Entry rates for value of sales were similar to those rates for acres of farmland, but exit rates, and hence, volatility rates, were lower for value of sales than they were for acres of farmland. This indicates that those acres that went out of production contributed less to value of sales per acre than the acres that continued in production. At the end of each of the 4 subperiods considered, farms that had entered during the period accounted for 28-32 percent of all sales of the farming sector.

Turnover as exhibited by these data has been largely uncorrelated with market conditions. For example, the early 1980s were known as a difficult financial time for some farms, especially those specializing in rice, cotton, and certain cash grains, such as corn and soybeans. Although we did not find strong evidence of Shumpeter's creative destruction at work when we look at all farms combined, when we examine turnover and mobility by the type of commodity in which farms specialize we find some evidence that market conditions do play a role. During the 1982-87 Census subperiod, more farms exited than entered for cash grain, cotton, and rice producers, and for some

[12] This is not unlike the tracking of jobs in manufacturing industries; tracking of jobs in agriculture is problematic since much of the labor is unpaid and many workers are multiple-job holders.

of these specialties the average sales of the exitors exceeded the average sales of the continuing farms.

Turnover by Farm Size. In general, the average farm size in acres was larger for continuing farms than it was for either exiting or entering farms during the 4 subperiods **(table 2).** And, the average size of continuing farms increased over the full 1978-97 period by 33 acres, from 495 acres to 528 acres, although there was no change in the average size of farms during the last two subperiods. Exiting farms were larger in the initial subperiod and in the 1992-97 subperiod than were the entering farms. Recall that it was in these two subperiod where entry rates exceeded exit rates. That is, during the periods when more farms were entering farming than leaving farming, the average size of the entering farms was less than the average size of exiting farms. In the 1992-1997 period, the entry rate of farms exceeded the exit rate, but more total acres left agriculture than entered agricultural uses because the average farm that exited the sector was larger than the average entering farm while at the same time the average size of the continuing farm remained constant from the previous period.

Unlike the textbook explanation that holds that new firms enter at the optimal size, we find farms entering at all sizes. However, exit rates, entry rates, and survival rates vary considerably by size of farm. We provide the significant detail of transition matrices for each of the 4 census subperiods by size of farm, where size is measured in acres **(Tables 3-6).** Based on the transition matrices, we have also calculated entry and exit rates for farms and farmland for various size classes for the 4 subperiods. In **tables 7 and 8,** we measure farm size in acres. Exit and entry rates are higher for small farms and decline steadily until farms reach a mid-size range of 260 acres or more. The exit and entry rates flatten out considerably for the large size classes. In general, there are not large gaps between exit and entry rates over time. However, at the beginning of the period, entry

rates exceeded exit rates for large farms and the very smallest farms. (This was true for acres of land operated by those sizes of farms, too.) This was a time, 1978-82, of significant financial stress for U.S. agriculture, and consequent adjustment. There had been significant expansion in U.S. production prior to that period as international markets for U.S. products grew at a rapid rate, and then for a variety of reasons, including the contraction of the international demand for U.S. products, the U.S. had significant surpluses of agricultural commodities. The consequent adjustments are clear in the entry and exit rates. In the latter part of the period, 1992-1997, entry rates exceeded exit rates for the small farms. This reflects the growing demand for farms as high-quality rural residences, which continues today.

As described above, it is also useful to consider relationships by farm size when size is measured by gross sales. The general trends in exit and entry rates hold by this size measure. **Figure 5** shows survival rates by gross sales classes. By this measure, very small farms (with gross sales of less than $10,000), have the lowest survival rates. Survival rates are also low for the next size of farms ($10,000-$99,999 in gross sales), but somewhat higher than for the smallest farms. These two smallest categories of farms represent about 85 percent of all U.S. farms, but only 10 percent of farm output. Prior to 1987, the survival rates of the midsized farms ($100,000-$249,999) were on par with the largest farms in the sector, but since that time have been somewhat below the survival rates of the larger farms.

Across the U.S., since small farms are more likely to exit farming than large farms, we see the highest exit rates in those states that have large proportions of small farms. Small farms often require off-farm employment opportunities for their survival, and these are more likely to be available in or near metropolitan areas. The South and the East have the highest share of operators working off their farm full-time (200 or more days per year). In contrast, large farms require high

quality agricultural resources--land and climate--and for some commodities, are recipients of government support. Farms in metropolitan areas are more likely to change ownership than farms in more rural areas for a variety of reasons, including the higher probability that farming is a secondary occupation of the operator and that the land is in higher demand for urban conversion.

Reallocation and Mobility Patterns for Continuing Farms. Mobility of continuing farms in the shares of output (or acres of farmland) is usually measured by summing the absolute values of the differences between their output (acres) at *t* and *t + 1* and dividing by the sum of their output (acres) at *t*. **Table 9** provides this measure of mobility for the 4 Census subperiods for both output and acres of farmland. When we consider all continuing farms, the mobility in output varies from a high of 72% in the first subperiod to a low of 56% in the 1982-87 subperiod. The 1982-87 period stands out among the 4 subperiods. It had the smallest sum of (absolute value in) differences in output from the beginning to the end of the period and had the smallest share of farms that increased their sales during the period—less than half of continuing farms increased their output during this period. This is a reflection of the financial stress in agriculture during that particular period. The mobility in acres is much less than for output for each subperiod, but shows a consistent increase over the subperiods. In agriculture, we expect more variation in output over time, given the vagaries of weather and market prices, in contrast to the input of farmland. Baldwin (1995) highlighted the differences in mobility in employment by dividing Canadian manufacturing firms into those that gained and those that lost employment. In a similar fashion, we divided farms into those that had increasing value of product and those that had decreasing value of product over the subperiods. Farms that increased their output had significantly greater mobility than those that decreased their output. Again, for acres we see lower mobility and no difference by whether or not sales increased or decreased over the subperiods.

The reallocation that is occurring in agriculture is perhaps most directly exemplified by examining the number of continuing farms that change the number of acres that the farm operates, as reported from one census to the next. Over any given period, some farms expand, but other farms contract. **Figure 6** shows the distribution of changes in acres operated for the farms that survived from one census to the next. For example, during the 1992-97 period, only about 30% of the surviving farms did not expand or reduce their acres operated. And the tendency is for small farms to get smaller and large farms to get larger. This is shown in **figure 7** for the 1992-97 period, but is true for all census periods from 1978-97. This result differs for the result generally found for nonfarm industries, where the average growth rate of continuing firms generally declines with firm size. This difference for farming is likely the result of the unique dual role played by farms of both business and residence, often times with the residence being the predominant motivation for being in farming.

Much of the mobility of continuing farms represents relatively small changes that do not generally move farms into a new aggregated acreage size class. This is clear when we further examine the transition matrices of **tables 3-6.** These tables classify farms into 8 size classes. The majority of all farms stay in the same size class, i.e., are along the diagonal of the tables, during the Census subperiods. Two additional conclusions from further review of the transition tables relate to (1) the differences in stability by acreage class and (2) the overall stability in the size distribution of continuing farms that remain in their size class over time.

The smallest farms (1-49 acres) and the largest farms (2,000 acres or more) have the highest share of farms remaining in their size class for each subperiod. For the small farms, 80-81 percent of farms remain in the size class. For the large farms, 79-80 percent of farms remain in the size class. Given that this largest size class is open-ended, this large share is not too surprising. The

somewhat below average size class of 180- 259 acres, shows the most mobility across the Census subperiods, with only 52-54 percent of farms remaining in the same size class. This class represents only about 10 percent of all continuing farms. Farms in this size class are somewhat more likely to get larger than other size classes, but they are just as likely to get smaller as they are to get larger.

The stability in the size distribution (by acreage size class) of continuing farms over time is remarkable. **Figure 8** shows the stability for the 8 size classes of the transition matrices by displaying the share of farms that are along the diagonal for each of the subperiods. Given the stability in the farms along the diagonal, the size distribution (by these aggregated acreage classes) of all continuing farms has changed little over the subperiods; no class of continuing farms has increased its share of farms by more than 1 or 2 percent each subperiod. The stability of the size distribution of firms has been observed for non-agricultural industries, as well.

The downsizing of some farms and, in general, the increase in small farms is in part the result of the household and business jointness mentioned above, and because a small-farm lifestyle has many advantages, pecuniary and otherwise. For the farmers who have spent their careers being employed full-time on the farm, as they age, they may prefer to continue to live on the farm. It is, after all, their home, and it may have been their life-long home and the home of their ancestors. They may exit out of the farming business gradually by renting out or selling acres. Some new entrants to farming may prefer to operate a small farm because they are motivated mainly by investment or lifestyle choices, rather than the need to operate an efficiently-sized farm. As mentioned, small farmers lose money farming (on a cash basis) on average, but earn more than the U.S. average off their farms. As the baby boom retires from their primary careers, we may find an increase in hobby farms as boomers choose second careers as farmers.

Next, we examine the tendency of continuing farms to change size based upon the type of commodity in which they specialize. Some commodity specializations require more fixed investment than others, and hence, we would expect those specializations to exhibit more stability in farm size and turnover. This is certainly the case for farms that specialize in fruit and tree nuts and horticulture specialties in 1992-97 **(figure 9).** One might also expect relative stability in dairy operations, given the large fixed investment of that specialization (Foltz 2004). However, we see just the opposite. This is likely because of the increased economic pressure to increase dairy farm size. Restructuring of dairy production has been going on for some time, including the movement of production out of the traditional Midwestern dairy states towards southern climates. California is now the largest dairy state in the nation.[13]

The least developed area of the U.S. is the mid-region of the country; in contrast, the two coasts are the most developed. While there is significant variation in level of development within a state, the link between level of metropolitan development and farm survivability is even crudely evident at the state level. **Figure 10** shows the rate of "survivability" of farms between 1992 and 1997 by state, indicating that the lowest survivability is along the two coastlines, which have the most developed land and the greatest proportion of small farms. The more populated areas of the U.S. have both greater entry and greater exit rates than the less populated areas. The midsection of the country clearly has the greatest farm survivorship. In addition to survivorship, we have shown which states have the highest rates of farm expansion. Again, the midsection of the country has some of the highest rates of farm expansion, along with areas of the Southeast and the Southwest. The joint distribution of these two indicators of dynamics shows that in some areas, when farms exit, the farm resources are largely used to expand existing farms. This is the case for the

[13] In fact, California is the top producer for one-third of the 25 major commodity groups.

Southeast. In others areas, like the Northeast, when farms exit, entering farmers are operating farms of approximately the same size as those that exiting farmers operated. The strong farm economy of the midsection of the country is evident from this figure. Not only is survivability at high levels, but so is farm expansion. An important factor in the farm economy in this region is the high level of government farm subsidies. For example, in 2000, government farm payments were nearly $23 billion, and 7 states in the midsection of the country exceeded $1 billion. Those states were Illinois, Indiana, Iowa, Minnesota, Nebraska, North Dakota, and Texas. Combined they received half of the total subsidies in that year.

Determinants of Turnover. The above discussion highlights the role played by farm size in whether farms exit, enter, or continue to farm. But, other factors contribute to the turnover in farming. Since a farm-level panel data base has not been available until recently, early research in the U.S. on farm turnovers has relied on county-level estimates of farm exits (e.g., Goetz and Debertin 2001) and national analysis (e.g., Barkley 1990). Conclusions from this work point to the importance of work opportunities in the nonfarm labor markets in explaining turnover on the farm. Research which relies on panel data to examine turnover has focused on small geographical areas. Foltz (2004) is a recent example of such a study which focused on the analysis of a government program to support dairy producers in the state of Connecticut. Foltz found that the government subsidies did reduce farm exits and increased farm size, but he also reported that local development pressure and unemployment rates also have significant and positive effects on farm exits. Panel data for farm households have been available in Canada and Israel for some time and determinants of turnover have been compared for those two countries (Kimhi and Bollman 1999). We would expect the results for Canada to most closely resemble the results for the U.S. They found that a

major factor explaining exits in Canada was farm size; the larger the farm the less likely to exit. Other determinants of exit were off-farm work (negatively related) and age of the operator.

Two recent studies using the Census of Agriculture longitudinal file and focused on explaining the determinants of exits are Hoppe and Korb (2005) and Key and Roberts (2003). Hoppe and Korb control for farm size and operator age because they are known to be key in determining farm exits and consider the importance of other variables in a logit model of exit. They found that off-farm work, commodity specialization, race, and gender were important in explaining exiting from farming. Consistent with the results of Dunne, Klimek, and Roberts (2004) for U.S. manufacturing, they found that experience was negatively related to the probability of exit. The focus of Key and Roberts (2003) was on how government farm payments affect farm growth and survival, using the 1987-1997 longitudinal files. They found that payments had a small but statistically significant effect on both farm growth and survival. Again, age of the operator and farm size were determinants of farm survival and growth, as were the major occupation of the operator and the extent of operator ownership of assets.

The Role of Productivity in the Structural Change of U.S. Agriculture: A State-Level Analysis

The structural change process in agriculture is a highly complex one, with many interactions among the factors. In a recent review article, Chavas (2001) did not provide a single model of change but highlighted some factors influencing the evolution. The major factors included the role of technology, resource mobility, and market conditions.

Aggregate Productivity Trends. Traditional approaches to examining structural change in agriculture (e.g., Gardner and Pope, 1978) generally point to the importance of technological

advance as captured in the trends in the national productivity indexes. These are indexes developed by the USDA since as early as the 1940s (Cooper, Barton, and Brodell, 1947; USDA, 2004c). The series shows that productivity growth has been the source of output growth in agriculture. Real expenditures on inputs have actually declined at the national level during the recent periods. Between 1978 and 1996, the rate of growth in total factor productivity in agriculture was 2.71 percent on an annual average basis. Using 1996 as the base year (i.e., 1996 = 100), the 1978 index of agricultural output was 71.1. In comparison to this increase in the output index, measured aggregate inputs actually declined during that same period. The total input index in 1978 was 115.8 compared to 100 in 1996. But, some input categories increased and some decreased. The labor input for U.S. agriculture declined dramatically and steadily over the longer run period of 1948 to 1985, and then declined more slowly to 1996. In contrast to the longer run period of 1948-1996 when capital was increasing, capital actually declined during the 1978-96 period. Total intermediate inputs continued to rise during the 1978-96 period, but two component inputs of that group, energy and farm origin inputs, actually declined. Of course, these national estimates mask differences in the productivity of states and individual farms.

A major story for post-war agriculture is the exiting of agricultural labor from the sector, leading to improved productivity. Labor has exited the sector by (1) farms going out of business and the fixed land being controlled by other, larger farms and (2) labor has also exited by farm operators and family members working off the farm at nonfarm jobs. Hence, key variables which capture the farm structural change process besides farm size and productivity include farm exits and off-farm work participation of farmers.

Micro-level Measurement of Farm Productivity Issues. Unfortunately, total factor productivity cannot be estimated with the Census longitudinal data because key data items are not

collected on the Census. Outputs are carefully measured, but inputs are not. When inputs are measured (for only a sample of farms) they are measured as cash variable expenses, e.g., cash expense for fertilizer. Unpaid family labor, which accounts for two-thirds of labor in agriculture, is an example of an important input that is not collected at all on the Census of Agriculture. Hence, USDA's aggregate multi-factor productivity indexes are constructed from a variety of data sources, the Census of Agriculture is just one of those sources. There is a single farm-level data set that provides a much more complete accounting for inputs. USDA's Agriculture Resource Management Survey (ARMS) is an annual sample of farmers, although it is not a panel data set. The ARMS includes special rotating modules which collect extensive information on all inputs and outputs associated with the production of single agricultural commodity. Researchers have used these data to construct productivity measures for cross-sectional analysis (e.g., McBride and Key, 2003). Researchers have also used the annual ARMS survey to construct a pseudo-panel data set and to explore issues of changing cost structure and productivity over time (e.g. Morrison Paul, et al.), but the data are not well-suited to explore issues of turnover since it is a pseudo-panel.

State-level Analysis of the Links Between Farm Productivity and Structure. As mentioned, the Census longitudinal data set does not allow us to measure productivity. In addition, some variables known to be important in explaining total factor productivity (farm-level or aggregate-level) are aggregate inputs such as public investments in R&D and extension. Consequently, we have developed a state-level model which considers the relationship between productivity, reallocation, and farm exits. Two previous studies have considered the relationship between productivity and aspects of industry structure using state-level data (Huffman and Evenson, 2001; Ahearn, Yee, and Huffman, 2002). Huffman and Evenson considered how farm structural change and government policies affect productivity. They assumed that farm structure affected

productivity, and that the relationship was one-way, i.e., farm productivity did not affect farm structure. They used state level data from 1950 to 1982 to consider the relationship between farm structure, government policies, and productivity changes over the period. They found that farm structural change does affect productivity. They also found that public R&D affects farm structure, while agricultural policies had some small impact on structure.

Ahearn, Yee, and Huffman also examined the key relationships between productivity and farm structure for a relatively recent period in the history of agricultural structural adjustment, the period 1960-96. In contrast to Huffman and Evenson, they modeled the relationship between farm structure and productivity as a two-way relationship. Their results provided evidence that indeed supported a simultaneous relationship. They found that government investments had positive and significant impacts on productivity. This was true considering public investments in research, extension, highways, and commodity programs. They also found that government commodity payments had a negative impact on off-farm labor supply of farm households and a positive impact on farm size.

Although economic theory does not provide a single comprehensive model of the structural change process in agriculture, we provide a state-level analysis that is informed by the empirical results of the above studies and the theoretical models referenced above, namely the model of Hopenhayn and the household production model. In addition, there is an established literature on the key variables on which we base our model specifications. For productivity, for example, public investments in research and development have been found to be positively related to productivity (e.g., Yee, et al., 2002). There is also an extensive literature on the factors explaining off-farm work of farm households, including Hallberg, Findeis, and Lass (1991). Following the financial conditions of the 1980s, USDA supported several studies of farm exits. These included Bentley, et

al. (1989); Bentley and Saupe (1990); and Wu (1997). The farm size equation is informed by a vast historical, yet conflicting, literature as discussed previously. For example, see Harrington and Reinsel (1995) for a review.

The Empirical Model. We employ the following 5-equation model with feedback across the equations that we estimate with state-level data:

$$(5) \quad TFP = \alpha_1 Small + \alpha_2 Large + \alpha_3 Off + \alpha_4 Exit + \alpha_5 X_1 + u_1$$

$$(6) \quad Small = \beta_1 TFP + \beta_2 Off + \beta_3 Exit + \beta_4 X_2 + u_2$$

$$(7) \quad Large = \gamma_1 TFP + \gamma_2 Off + \gamma_3 Exit + \gamma_4 X_3 + u_3$$

$$(8) \quad Off = \delta_1 TFP + \delta_2 Small + \delta_3 Large + \delta_4 Exit + \delta_5 X_4 + u_4$$

$$(9) \quad Exit = \varepsilon_1 TFP + \varepsilon_2 Small + \varepsilon_3 Large + \varepsilon_4 Off + \varepsilon_5 X_5 + u_5$$

The five equations are for productivity (*TFP*), the share of farms less than 50 acres (*Small*), the share of farms more than 1,000 acres (*Large*), the odds that farm operators work off-farm at least 200 days per year (*Off*), and the odds that a farm exits the sector (*Exit*).

Table 9 and the Appendix provide more detail on the definition of our variables and our data sources, respectively. The set of exogenous variables (X_1) included in the *TFP* equation are public agricultural research stocks (from originating state and spill-ins), public extension, infrastructure in highways, government agricultural programs (commodity payments, dairy production, and set asides), private research, share of insured acres, specialization, contracting, ratio of capital rental-to-hired farm wage, weather, and geographic region. The set of exogenous variables (X_2) included in the *Small* equation are public agricultural research stocks (from originating state and spill-ins), public extension, private research, ratio of capital rental-to-hired farm wage, share of insured acres, commodity payments, specialization, contracting, share of

college educated operators, share of young operators, share of old operators, share of land acres in a state that is classified as non-metro, and geographic region. The set of exogenous variables (X_3) included in the *Large* equation is the same as X_2. The set of exogenous variables (X_4) included in the *Off* equation are infrastructure in highways, specialization, contracting, commodity payments, share of insured acres, ratio of manufacturing wage-to-hired farm wage, dairy production, share of college educated operators, share of young operators, share of old operators, share of a state's population living in non-metro areas, population density in non-metro areas, and geographic region. The set of exogenous variables (X_5) included in the *Exit* equation are ratio of manufacturing wage-to-hired farm wage, share of insured acres, specialization, contracting, commodity payments, share of college educated operators, share of young operators, share of old operators, land value per acre, share of a state's population living in non-metro areas, population density in non-metro areas, and geographic region.

The structural coefficients indicate the relationships among the endogenous variables. The impact of an exogenous variable on an endogenous variable is, however, given by the reduced form coefficient. For example, government payments appear in every structural equation and other endogenous variables appear on the right-hand-side of each structural equation, so we must examine the reduced form coefficients, which take into account both the direct and indirect effects of government payments on each endogenous variable. We can write our system of structural equations in period t in matrix form as

(10) $\mathrm{B}y_t + \Gamma x_t = u_t$.

The system of reduced form equations can be written as

(11) $y_t = \Pi x_t + v_t$.

The relation between the structural coefficients and the reduced form coefficients can be derived by solving equation (10) for y_t

(12) $y_t = -\mathrm{B}^{-1}\Gamma x_t + \mathrm{B}^{-1}u_t$.

Comparing this with the reduced form equation (11), we see that we can derive the reduced form coefficients from the structural coefficients as

(13) $\Pi = -\mathrm{B}^{-1}\Gamma$.

Empirical Results. We estimate the model by three-stage-least squares, incorporating cross-equation correlation of disturbances. We employ a panel data set constructed from five Censuses of Agriculture: 1978, 1982, 1987, 1992, and 1997. The estimated coefficients for the structural model are reported in Table 10. A large share of the estimated coefficients is significantly different from zero and the share of the variation explained is good. Given the log-log specifications of the structural equations, the coefficients can be interpreted as elasticities. Hence, the magnitude of the coefficient provides an indication of the importance of the variable. In general, we believe that the results underscore the importance of modeling the relationships simultaneously.

We turn first to the relationships among the endogenous variables. Of special interest is the relationship between productivity and farm exits. An increase in the exit rate has a positive and significant effect on productivity. In fact, the variable affecting productivity with the highest elasticity is the exit rate (elasticity of 0.7). This would be consistent with the hypothesis that the majority of farms that exit have low productivity. Aw, Chen, and Roberts (2001) found this to be the case in their study of exiting firms in Taiwanese manufacturing using firm-level data. Aw, Chung, and Roberts (2002) compared this relationship for two countries with very distinct market

structures, Taiwan and Korea, and concluded that in Taiwan, where turnover was greater, there were a smaller percent of plants operating at low productivity levels.

An increase in the share of small farms increases productivity, while an increase in the share of large farms decreases productivity.[14] While this result may seem surprising, recall that there are many ways in which to measure farm size and our farm size measures in this model are acres-based. Many areas of the U.S. with large-acreage farms are in parts of the country where soil productivity is quite low. Recall the state map of figure 2 which showed the share of farms by farm size class. States in the Plains, like Texas, had a large share of farms that had more than 1,000 acres, compared to major growing states, like California, that had a high share of farms with less than 50 acres.

We next consider the farm size measures. An increase in off-farm work increases the share of small farms and decreases the share of large farms. More time spent working off-farm means less time available for working on the farm. An increase in the exit rate decreases the share of small farms and increases the share of large farms. This would be consistent with the exit rates described earlier by size of farm. Again, we find an inverse relationship between productivity and farm size.

The most variables affecting off-farm work with the highest elasticity are productivity (elasticity of 0.6) and the share of small farms (elasticity of 0.3). A decrease in productivity increases off-farm work. It is possible that low productivity operators may be more likely to work off-farm out of necessity. An increase in farm size is associated with lower off-farm work as the farmer has more work to do on the farm, as the size of the operation increases.

[14] Recall that our farm size measures are acres based. Yee and Ahearn (2005) estimated a farm size equation using five different farm size measures: acres operated per farm, real land and building value per farm, real cash receipts per farm, real cash receipts plus government payments per farm, and an imputed measure of the real capital service flow per farm. The acres size measure was the only one negatively related to TFP. Huffman and Evenson (2001) also found that farm size reduced crop TFP.

Finally, we turn to the exit rate equation. The most variables affecting the exit rate with the highest elasticity are off-farm work (elasticity of 0.6) and the share of small farms (elasticity of 0.6). Small farms are more likely to exit than large farms, consistent with the results in the farm size equations. An increase in off-farm work decreases the exit rate. Off-farm work lessens the dependence of farm households on farm income. A decrease in productivity increases the exit rate. This is consistent with the result in the productivity equation.

To analyze the impact of an exogenous variable on an endogenous variable, we look at the reduced form coefficients. The derived reduced form coefficients are reported in **Table 11**. Again, the coefficients can be interpreted as elasticities.

We will focus on a few relationships of interest. A state's own research and extension both increase TFP. This is consistent with past studies that have stressed the importance of public research and extension (e.g., Huffman and Evenson 1993; and Yee, et al. 2002). In contrast, we find private research to have no impact on TFP. This implies that firms may be able to appropriate most of the benefits of their research by increasing the prices of their products. Specialization (computed as a Herfindahl index, based on 10 commodity categories) increases TFP. Contracting increases productivity. This result lends support for the argument that contracting increases the efficiency of production.

Increased commodity payments have a positive effect on productivity. Farmers may use part of the commodity payments to purchase newer and more efficient farm machinery, which increases productivity. A decrease in the ratio of farm machinery price to hired farm labor wage (kw) leads to an increase in productivity, as farmers substitute relatively cheaper farm machinery for farm labor. No direct payments are made under the dairy program, and the price of milk is maintained artificially high by the government price support program through purchased

manufactured dairy products. Having significant dairy production is found to reduce agricultural productivity. Our weather variables have adverse effects on TFP, with drought having a far greater impact than flood. Overall, the exogenous variables affecting productivity with the greatest elasticity are the state's own research (elasticity of 0.3) and kw (elasticity of 0.3).

Specialization decreases the share of small farms and increases the share of large farms. An increase in the share of acres in non-metro areas decreases the share of small farms and increases the share of large farms. This indicates that, with less competition for land for urban uses, farm sizes are larger. This finding is also consistent with the hypothesis that a major motivation for farm households to expand their farm size is to increase household income, for example, when off-farm work opportunities are not available.

An increase in commodity payments decreases the share of small farms and increases the share of large farms. Farmers may use part of the commodity payments to expand their farm size. A mid-sized farm may use the payments to buy the land of a smaller neighbor and move up to the large farm size category. An increase in the proportion of farm operators with a 4-year college education or more decreases the share of small farms and increases the share of large farms. The share of young operators (elasticity of 0.3) and the share of old operators (elasticity of 0.6) are important in explaining the share of farms that are small, while the share of college educated operators (elasticity of 0.9) is important in explaining the share of farms that are large.

Specialization decreases off-farm work and decreases the exit rate. An increase in the manufacturing wage-hired farm labor wage ratio increases both off-farm work and the exit rate, indicating that operators are responsive to off-farm wages. An increase in the share of college educated operators increases off-farm work and decreases the exit rate. A higher level of education expands the opportunities for off-farm work.

An increase in the share of a state's population living in non-metro areas decreases off-farm work, while an increase in population density in non-metro areas increases off-farm work, reflecting off-farm work opportunities. Commodity payments had a negative effect on off-farm work. This result has been very robust in previous studies, both using aggregate and household-level data. Commodity payments increase the value of the farmer's time working on the farm, relative to the off-farm wage rate. Contracting increases off-farm work, perhaps due to substitution of contractor's information for farmer-initiated information searches. This could free up more time for other things, including off-farm work. The exogenous variables affecting off-farm work with the greatest elasticity are the share of college educated operators (elasticity of 0.3), the share of young operators (elasticity of 0.3), and specialization (elasticity of 0.2).

An increase in real land and building value per acre decreases the exit rate of farms. Land value can be considered a proxy for the state of the agricultural economy. The higher the land value, the stronger is the farm economy. Farm households are under greater financial stress in bad economic times, and are more likely to exit. In addition, land and building value per acre is also a good indicator of the costs of entry into farming. Theoretical models of firm turnover sometimes emphasize the role of the cost of entry (e.g., Hopenhayn). If the costs of entry are high, the model would predict that entry is lower. Moreover, exits would be lower, as was the case in our results, because there is less competitive pressure (i.e., market selection forces) on continuing firms. As is commonly found, age of the operator is one of the important variables in explaining farm exits (elasticity of 0.3). Commodity payments increase the exit rate. While recipient farms are likely to have their chance of surviving and growing increased as a result of government payments, only about one-third of farms receive payments. Hence, we found government payments increased the exit rate for all farms because the farms who received payments have the opportunity to expand

their farm size by buying out the farmland of non-recipients. A major source of land for farm expansions, especially in specific regions, must generally come from farms exiting. In fact, supporting statistics from the Census longitudinal file show that farms that exited were less likely to receive government payments. Other exogenous variables affecting the exit rate, besides the share of old operators, are the manufacturing wage-hired farm labor wage ratio (elasticity of 0.4) and land and building value per acre (elasticity of 0.2).

Summary and Conclusions

This paper draws on a unique panel data set, the longitudinal Census of Agriculture data for 1978-97 to examine turnovers and reallocation in U.S. agriculture. The data are widely used in their published aggregate form for individual censuses, but only recently used in a panel file. The micro-analysis of turnovers shows considerable structural change underlying the traditional aggregate indicators of farm structure. For example, the data show that in 1997, 62% of the farms that existed in 1992 were still in existence, and 38% of the 1992 farms exited. In contrast, the net change reflected in the aggregate statistics reported a net change of 1 percent.

This analysis for agriculture is in the same vein as work that has occurred for other industries in the U.S. and elsewhere, often focused on manufacturing. For example, Caves (1998) has provided a review of these studies and more recently Foster, Haltiwanger, and Krizan (2000). The stylized facts that have emerged from the literature synthesized by these reviews are relevant to our findings for agriculture. First, there is large scale reallocation of outputs and inputs in agriculture. Secondly, the rate of entry, exit and farm expansion varies somewhat over time. Thirdly, the entry and exit of farms are involved in the growth-farm size relationships. In particular, entry and exit are more likely to occur among small farms.

Unlike for agriculture, the panel data set in manufacturing allows for an analysis of total factor productivity and the role turnover and reallocation of output and inputs plays in the level of an industry's aggregate total factor productivity. Although we were not able to decompose agricultural productivity at the micro-level, we did gain insight into the relationships through a state-level analysis using data for the 5 Census years and 48 U.S. states. Consistent with the analysis for nonagricultural industries, we found that exit rates contribute to productivity growth. In addition, we found that exits are affected by the costs of adjustment, as reflected in average farmland values. High land values were found to reduce farm exits. The results on farms size point to the importance of considering the size distribution of farms, and not just average farm sizes, when examining the structural implications of policies. This point is perhaps more relevant for agricultural than other industries because of the unique role that the farm business plays in the farm family life cycle. The model also provides us with a deeper understanding of the ways in which labor has exited agriculture and the implications of that for the productivity of the sector.

In spite of a strong interest in the structure of the farming industry, there is not a clear view regarding the most dominant factors in the structural change process. Our description of farm structural change underlying the traditional aggregate indicators, that is, the turnover and reallocation indicators, underscores the challenge in drawing simple generalizations about the process. The dearth of empirical applications of models is likely a result of the complexity of factors that are related to structural change, and the importance of identifying their separate roles. The structural change process is a macro event that occurs rather slowly over time, as a result of micro-level decisions. Hence, it is important to empirically consider both micro-level paths of firms and to measure the body of interactions over time to gain insight into the key determinants of productivity growth and change.

Although agriculture accounts for less than 2 percent of the GDP, the sector has special policy significance. One of those interests is the structure of the farming industry. Public investments in R&D were shown, once again, to have a strong positive influence on total factor productivity. Public investments in agricultural farm subsidies, in contrast, did not significantly affect productivity. Farm payments did, however, influence farm structure. Payments were found to increase farm exits. Payments also decreased the share of farms that are small and increased the share of farms that are large.

In order to understand the sources of structural change the relationships must be considered over time because of the lengthy lags of their impacts, policy and otherwise. In addition, structural change must be considered in the context of the whole farm sector because of the extensive linkages in the marketplace for land, inputs, and outputs, agricultural and otherwise. Our results support the view that the structural change process is a complex one, involving the interplay among technological change, market forces, and public policies. Consequently, policies designed to impact a single target, such as productivity or family farm survivability, will likely have reverberating structural implications, perhaps even counterintuitive or unwanted affects.

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Appendix: Data and Variables

Total Factor Productivity (TFP). Total factor productivity (TFP) is the ratio of total outputs to total inputs. Data on TFP by state are available from the ERS homepage at: http://usda.mannlib.cornell.edu/data-sets/inputs/98003. The TFP numbers for each state are spatially adjusted so that they are comparable across states.

Farm output consists of all crop and livestock products. Farm inputs include capital (durable equipment and real estate), labor, and intermediate inputs. Intermediate inputs consist of fertilizer, pesticides, energy, feed, seed, and intermediate livestock inputs.

Some inputs, such as agricultural pesticides, have changed significantly over time. The current approach to dealing with variable input quality is to account for the quality changes in key inputs, where data availability permit, through a process of measuring the component characteristics of the input that are relevant to the observed quality changes. To properly account for changes in characteristics or quality of chemicals, price indexes of fertilizers and pesticides were constructed using the hedonic regression technique.

While the number of workers employed in agriculture and total hours worked have declined, the quality per hour worked has increased. For example, in 1964, only about one-third of all farmers had completed high school, compared with more than three-quarters of farmers by 1990. The labor measure accounts for both change in hours worked and change in the quality (e.g., based on age and education) of those labor hours. This is why age and education appear as variables in the farm size, off-farm work, and exit equations, but not in the productivity equation.

Off-farm work (off). The Census of Agriculture provides data on the number of total farm operators in a state and the number of farm operators in a state that work off the farm for 200 or more days per year. From these data we calculate the share of operators working off the farm for 200 or more days, or *off*. Off-farm work, or *off*, is specified in the model as the odds of the farm operator working off the farm for 200 or more days per year, or odds [*off*/(1-*off*)].

Share of farms small (small). The share of farms in a state that are less than 50 acres in size. Data from the Census of Agriculture.

Share of farms large (large). The share of farms in a state that are 1000 acres of more in size. Data from the Census of Agriculture.

Farm Exits (exit). The annual share of farms that exit is measured by interpolating the multiple-year exit rate from the 5 agricultural censuses that were conducted from 1978-1997. An exit is defined to occur between two subsequent Censuses when a farm business' unique Census File Number (CFN) is in the earlier Census file and not in the next Census file. See the description below for more detail on the data source, the longitudinal file of the Census of Agriculture. We use the odds [exit/(1-exit)] of the exit rate in our empirical model.

R&D Stock (ownrd, spillin). Data on public agricultural research expenditures to enhance and maintain agricultural productivity up to 1995 are an enhanced version of the series provided in Huffman and Evenson (1993). The annual nominal agricultural research expenditures by state are converted to real (1984 = 1.00) expenditures using Huffman and Evenson's agricultural research price index.

Research expenditures in a given year are expected to have an impact on productivity for many years. However, including a large number of lagged research expenditures in the productivity equation uses up a large number of degrees of freedom. Also, the lagged values of the research expenditures tend to be highly correlated. Consequently, we constructed a research stock variable as a weighted sum of current and past research expenditures.

Most studies of the impact of research, especially private research in manufacturing, construct the stock of research capital from research expenditures using the perpetual inventory method and assuming geometric decay. While geometric decay may be a reasonable assumption for physical capital, it is not plausible for research capital. We constructed a research stock variable as a weighted sum of current and past research expenditures using the Huffman and Evenson (1993) trapezoidal-timing-weights over 33 years. The plot of the cumulative summation of these weights over time gives a sigmoid *S-shaped* pattern.

Two public research stock variables are used in this paper, an own-state and a spillin/spillover. For example, some of the public agricultural research discoveries in Iowa may spillover to one or more of the surrounding states or Iowa may benefit from public agricultural research conducted in surrounding states. We impose the simplifying assumption that benefits are regionally confined. For a given state in a region, the spillover (or spill-in) stock is defined as the total public agricultural research stock of all states in the region less the state's own public agricultural research stock.

Extension Stock (ext). Data on professional extension full-time equivalents (FTE's) by state and major program areas. Over most of the period, extension was organized into four program areas: agriculture and natural resources (ANR), community resource development (CRD), 4-H youth (4-H), and home economics (HE). This paper only considers the ANR program area, which includes crop production and management, livestock production and management, farm business management, agricultural marketing and supply, and natural resources. An extension capital stock for each state is obtained as a weighted sum of current and past FTE's with declining weights and dividing by the number of farms.

Private R&D (privrd). Private research stock. For a description see Huffman and Evenson, 2002.

Highway Stock (hiway). Data are available for 1931-1992 on capital stock from capital outlay and capital stock from maintenance (both in 1987 dollars) from the U.S. Department of Transportation, State Transportation Economic Division. In this data set, the standard perpetual inventory technique was used to generate the highway capital stock from expenditure data. We regressed highway stock on a constant, time, time squared, and time cubed and used the fitted equation to predict highway stock after 1992.

Weather (flood, drought). Extreme weather conditions (droughts and floods) affect agricultural productivity. We employed the USDA's precipitation data weighted by harvested crop acreage (available from the ERS homepage as an ERS data product) to create a variable (pre-plant) equal to cumulative February to July rainfall. We then created a drought dummy variable (drought) equal to 1 if pre-plant is less than 1 standard deviation below normal (and 0 otherwise) and a flood dummy variable (flood) equal to 1 if pre-plant is more than 1 standard deviation above normal (and 0 otherwise).

Specialization (spec). Specialization is computed as a Herfindahl index based on cash receipts of 10 commodity categories. Cash receipts are the value of agricultural production sold in a particular calendar year. As such, it would include the value of product produced in previous years, stored and sold in the current year. It would exclude the value of product produced in the current year and stored for later sale. It would also exclude the value of product from current year, which is used on the farm from which it was produced, usually as livestock feed. Cash receipts are largely computed from annual USDA probability-based surveys of prices and quantities. In some cases, when a commodity is heavily concentrated in a few states or represents a small share of production, state-level agricultural statisticians provide the estimates of cash receipts of the commodity. Data are largely from http://www.ers.usda.gov/Briefing/FarmIncome, or a part of USDA's historical farm income data bases developed as part of the project to estimate farm income and maintained by ERS, USDA.

Dairy Share of Total Cash Receipts (dairy). The data for all state cash receipts and dairy cash receipts of a state are available from the same source used to develop the *specialization* variable described above.

Commodity Payments (compay). Commodity payments are direct payments made to farm operators and others who own farmland and are eligible to receive subsidies under the continuing legislation of the so-called farm bill. The exact nature of the programs and eligibility of the programs has changed many times since the first Depression-era program. The payments are made largely by the Federal government, although some state program subsidies are included. The data are annual administrative records information on payments made for the agricultural programs that are associated with agricultural production. The GDP deflator was used, with a base year of 1996.

Diverted acres (setaside). Diverted acres are those acres that were required to be set-aside as part of voluntary Federal farm programs in exchange for direct payments for the production of seven program crops. Acres that were diverted varied on an annual basis, as announced by the Secretary of Agriculture. In some years, additional acreage could be diverted under the Paid Land Diversion program. The source of the data are administrative records.

Crop insurance (insureacre). The share of acres in a state that are enrolled in the subsidized Federal Crop Insurance program. Data from USDA's Risk Management Agency.

Contracting (contract). Production contracts are the number of farms in a state that had any production contracts to produce any agricultural commodity. Under a production contract, an operator-grower contracts with a processor-integrator to produce and make available for delivery a specified product, sometimes with specified quality attributes for a specified time. The contractor

takes possession of the commodity and pays the grower a fee. Terms of contracts vary widely. The Census of Agriculture, taken of farms every 4 or 5 years, provided us with the actual number of production contracts for the census years.

Input Prices (kw, mw). Where published government statistics existed we utilized those. However, for some years, state-level data were not available and so we estimated state-level data from regional data and/or interpolated between known benchmark data. Manufacturing wage rates came from the Current Population Survey, BLS, Dept. of Labor, various years. Farm wage rates came from NASS, USDA. Farm machinery price is a national price from the ERS homepage.

Value of farmland (valueacre). The real land and building value per acre of farmland in a state. The GDP deflator was used, with a base year of 1996. Data from http://www.ers.usda.gov/Briefing/FarmIncome.

Educational Attainment (college). Operator educational attainment as a categorical variable is collected occasionally on the Census of Agriculture, for example, 1964. For the most recent year of our data series, 1996, we used an average of three years (1995-97) from USDA's Agricultural Resource Management Survey.

Age of Operator (young, old). We construct two age variables, old and young. Young is the share of operators that are less than 35 years old. Another age variable, old, is the share of operators that are 65 years or older. Operator age is available from the Census of Agriculture.

Non-metro area (areanm). The share of acres in a state that are classified as non-metro. The land area non-metro designation is changed based on each decennial Census of Population from the Bureau of the Census.

Non-metro population (popnm). The share of a state's population living in non-metro areas. The land area non-metro designation is changed based on each decennial census of population. Population estimates are made annually by the Bureau of the Census, based on the annual Current Population Survey.

Non-metro population density (popden). The population density in non-metro areas, measured as population per square mile. The population estimate of persons living in non-metro areas is provided annually by the Bureau of the Census, based on the Current Population Survey. The square miles in non-metro areas are provided by the Bureau of the Census about once per decade based on the decennial Census of Population.

The Census of Agriculture Longitudinal File

The Census of Agriculture has been conducted for over 150 years. In the early 1980s, a joint effort by the Bureau of the Census and the Economic Research Service resulted in the linking of 2 Censuses of Agriculture. In later years, this was expanded. An example of this early work relating to the future farm structure is Edwards, Smith, and Peterson (1985). In 1997, responsibility was transferred from the Bureau of the Census to National Agricultural Statistics Service. The Census of Agriculture Longitudinal file is currently a subset of the Census files; developed by combining individual farm operator records for five censuses (1978, 1982, 1987, 1992, and 1997)

into one continuous record. Each record represents one individual farm operator's responses about a farm operation to all and/or any censuses. Thus, farms can be followed for a 20 year period. The file contains 4.5 million observations (records) and 85 analysis variables.

The longitudinal file attempts to follow farm operations which are tied to the farm land rather than follow individual farm operators. This is done using the Census File Number (CFN). The CFN identifies a farm operation for a particular census, and may follow a farm operation through subsequent censuses (up to five on the longitudinal file). If the farm continues from one census to the next, and the farm operator responds to the census using the same CFN, the information reported by that farm for that census period is appended to the longitudinal file using the same CFN. If the operation changes hands, either through sale or inheritance, the CFN may continue, it may change, or it may be terminated. A farm is defined as going out of business when either the questionnaire is returned with the indication that it is no longer operating as a farm, or there is no response to repeated requests for information. The absence of a farm in a particular census year is represented in the longitudinal file by zeros for all the variables for that observation for that year. We consider a farm to be out of business (an exit) when zeroes in the CFN field indicate that the farm has been discontinued. Likewise a farm operation with a CFN that is not matched or linked to a previous longitudinal record would be considered a new business and added to the longitudinal file as a new record. This is an entry. A farm which has a CFN for both a beginning and an ending census time period in its record is considered to be a survivor.

While the CFN is unique to a single farm operation the opposite is not necessarily true. A single farm does not necessarily have one unique CFN. A CFN must only be unique to a farm operation for a given Census time period. Therefore a single farm operation could have as many as 5 CFNs on the longitudinal file, one for each census. While a farm operation's CFN may extend to subsequent censuses, this may not be the case if a farm changes hands. If a farm operation changes hands, the CFN may or may not change. If the operation is taken over by a family member it would likely continue with the old number, however if it is sold it would probably receive a new number. In this case the new number and the old number would be linked together. This linking would require matching farm operations either manually or by computer. Matching new CFNs to old CFNs would be performed by the data collection agency, either the Census Bureau or NASS. Linking allows data for the new CFN, to be added to longitudinal data from the previous census under the old CFN, thereby extending the longitudinal record. If the farm is sold and no link established, (there is no evidence that this farm is continuing), then zeroes are recorded in the longitudinal CFN field and other data fields for that record for that census period. Farms that are split up may have a portion of their operation continue under the old number and the rest under a new number/s, or all parcels of the operation may receive new numbers.

Most observations on the longitudinal file represent only themselves and are assigned a non response weight of one. Some farms have a weight of 2 meaning they represent themselves and another farm that did not respond to the Census. This means that the one which did respond was assumed to be similar to one which did not and is therefore counted twice in the statistics. If the non-responding operation was a large farm, as defined by value of production or acreage, or a unique farm operation, intensive telephone or personal follow-up was conducted during census processing to obtain a response. If these attempts failed, either the NASS survey database, the census historic database, or other more current sources were used to impute data for the operation. As a result, all large farms are assigned a nonresponse weight of 1.

Table 1. Entry, exit, and volatility rates for farms, acres of farmland, and value of sales, for Census subperiods.

	Entry rate		Exit rate		Volatility	
	Subperiod	Annual	Subperiod	Annual	Subperiod	Annual
Farms						
1978-1982	37%	11%	33%	10%	66%	20%
1982-1987	33%	9%	40%	10%	66%	18%
1987-1992	32%	8%	38%	10%	63%	17%
1992-1997	39%	10%	37%	9%	74%	19%
Acres						
1978-1982	28%	8%	26%	8%	53%	15%
1982-1987	34%	8%	30%	7%	61%	14%
1987-1992	26%	6%	30%	7%	51%	12%
1992-1997	30%	7%	32%	8%	60%	15%
Value of sales						
1978-82	31%	8%	20%	5%	39%	11%
1982-1987	32%	8%	33%	8%	63%	15%
1987-1992	29%	6%	24%	5%	47%	11%
1992-1997	35%	8%	24%	6%	49%	11%

Table 2. Average farm size in acres of entering, exiting, and continuing farms, 1978-97

	Entrants	Exits	Continuing
1978-82	344	359	495
1982-87	391	355	498
1987-92	373	357	528
1992-97	380	428	528

Table 7. Exit rates by farm size (measured in acres) for farm firms and farm land.

	1978-82	1982-87	1987-92	1992-97
Acre class		Exit rate for farms		
1-49	42%	51%	49%	47%
50-99	35%	41%	40%	38%
100-179	32%	38%	37%	36%
180-259	29%	35%	34%	33%
260-499	27%	34%	32%	31%
500-999	26%	33%	30%	30%
1000-1999	26%	31%	27%	28%
2000 plus	26%	31%	27%	30%
Acre class		Exit rate for acres of land		
1-49	38%	47%	45%	43%
50-99	35%	41%	40%	38%
100-179	32%	38%	37%	35%
180-259	29%	35%	34%	33%
260-499	27%	34%	32%	31%
500-999	26%	32%	30%	29%
1000-1999	26%	31%	27%	28%
2000 plus	25%	31%	28%	34%

Table 8. Entry rates by farm size (measured in acres) for farm firms and farm land.

	1978-82	1982-87	1987-92	1992-97
Acre class		Entry rate for farms		
1-49	51%	48%	46%	49%
50-99	35%	34%	34%	41%
100-179	31%	32%	31%	36%
180-259	28%	29%	28%	32%
260-499	27%	28%	27%	29%
500-999	27%	29%	25%	27%
1000-1999	27%	30%	25%	27%
2000 plus	28%	31%	27%	29%
Acre class		Entry rate for farm land		
1-49	45%	42%	42%	47%
50-99	35%	34%	34%	41%
100-179	31%	31%	31%	36%
180-259	28%	29%	28%	32%
260-499	26%	28%	26%	29%
500-999	27%	29%	25%	27%
1000-1999	27%	30%	25%	27%
2000 plus	28%	31%	26%	32%

Table 9. Mobility indicators for output and acres of farmland for continuing farms, by Census subperiod.

All Continuing Farms	Value of Product[b]	Acres	Farms
1978-82	72%	26%	100%
1982-87	51%	31%	100%
1987-92	68%	35%	100%
1992-97	68%	37%	100%
Value of product increased[a]			
1978-82	87%	26%	67%
1982-87	68%	36%	47%
1987-92	84%	36%	63%
1992-97	86%	39%	59%
Value of product decreased[a]			
1978-82	41%	29%	33%
1982-87	41%	28%	53%
1987-92	43%	34%	37%
1992-97	43%	36%	41%

[a] Excludes less than 1 percent of farms that had no value of sales in either period.
[b] Value of product is the total value of sales or the value of product removed under contract in 1997 dollars.

Table 10. Variable Definitions

Variable	Definition
TFP	Level of total factor productivity (relative to Alabama in 1987)
small	Share of farms in state less than 50 acres
large	Share of farms in state more than 1,000 acres
off	Proportion of farm operators who worked 200 or more days off farm
exit	Exit rate per year
ownrd	Own research stock
spillin	Spill-in research stock
ext	Extension stock per farm
hiway	Highway stock
privrd	Private research stock
spec	Specialization computed as a herfindahl index, based on 10 commodity categories
contract	Proportion of farms with production contracts
compay	Real commodity payments per farm
setaside	Diverted acres per farm
insureacre	Share of acres enrolled in crop insurance
valueacre	Real land and building value per acre
college	Proportion of farm operators with a 4-year college education or more
young	Proportion of farm operators under 35 years old
old	Proportion of farm operators 65 years old and over
kw	Farm machinery price-hired farm labor wage ratio (lagged one year)
mw	Manufacturing wage-hired farm labor wage ratio (lagged one year)
areanm	Share of acres in state classified as non-metro
popnm	Proportion of a state's population living in non-metro areas
popden	Population density in non-metro areas
drought	Drought dummy
flood	Flood dummy
dairy	Dummy variable equal to 1 if dairy is greater than 20% of total cash receipts

Notes: "ℓ" in front of a variable denotes taking the log (e.g., ℓTFP). Regional dummy variables are included in each equation. The regions considered in this paper are:

1. Northeast (NE): CT, DE, ME, MD, MA, NH, NJ, NY, PA, RI, VT
2. Southeast (SE): AL, FL, GA, KY, NC, SC, TN, VA, WV
3. Central (CENT): IN, IL, IA, MI, MO, MN, OH, WI
4. Northern Plains (NP): KS, NE, ND, SD
5. Southern Plains (SP): AR, LA, MS, OK, TX
6. Mountain (MOUNT): AZ, CO, ID, MT, NV, NM, UT, WY
7. Pacific (PAC): CA, OR, WA

Table 11. Three stage least squares estimates of productivity and structure equations, 1978, 1982, 1987, 1992, and 1996 (n=240)

Variables	ℓtfp	ℓsmall	ℓlarge	ℓ[off/(1-off)]	ℓ[exit/(1-exit)]
Endogenous variables					
ℓtfp		1.190*	-1.776*	-0.597*	-0.024
ℓsmall	0.105			0.302*	0.583*
ℓlarge	-0.108*			-0.108	-0.282*
ℓ[off/(1-off)]	-0.112	1.773*	-2.135*		-0.624*
ℓ[exit/(1-exit)]	0.701*	-0.203	0.716	0.035	
Exogenous variables					
ℓownrd	0.183*	-0.012	0.088		
ℓspillin	-0.020	0.031	0.223*		
ℓext	-0.028	0.150*	0.170		
ℓhiway	-0.112*			-0.002	
ℓspec	0.080*	0.101	-0.224	-0.114*	-0.006
ℓcontract	0.015	-0.041*	0.164*	0.039*	0.044*
ℓcompay	0.013	0.025	0.040	-0.007	0.059*
setaside	0.001				
insureacre	0.001*	-0.0004	0.001*	0.0002	0.0001
ℓvalueacre					-0.194*
ℓareanm		-0.032*	0.039		
ℓpopnm				-0.023	0.017
ℓpopden				0.007	-0.080*
ℓprivrd	0.0001	0.0001	-0.00006		
ℓkw	-0.179*	-0.16	-0.434		
ℓmw				0.066	0.072
ℓcollege		-0.338*	1.222*	0.276*	0.350*
ℓyoung		-0.158	0.81*	0.202*	0.093
ℓold		-0.572*	0.96*	0.441*	0.163
drought	-0.068*				
flood	-0.004				
dairy	-0.065			-0.021	
Regions					
SE	-0.108	-0.546*	1.341*	0.456*	0.382*
CENT	-0.040	-0.489*	0.898*	0.346*	0.311*
NP	0.062	-0.135	1.872*	0.221	0.487*
SP	-0.165*	-0.584*	1.870*	0.524*	0.527*
MOUNT	-0.064	0.131	2.307*	0.286*	0.211*
PAC	-0.039	0.174	1.667*	0.233	-0.064
Intercept	2.151*	1.794	-9.253*	-2.276*	-2.646*
R^2	0.637	0.657	0.850	0.770	0.269

* Denotes significant at the 5% level.

Table 12. Derived Reduced Form Coefficients

Variables	ℓtfp	ℓsmall	ℓlarge	ℓ[off/(1-off)]	ℓ[exit/(1-exit)]
Exogenous variables					
ℓownrd	0.271	0.019	0.004	-0.153	0.099
ℓspillin	-0.183	-0.076	0.337	0.044	-0.163
ℓext	0.093	0.295	0.030	0.035	0.139
ℓhiway	-0.240	-0.083	0.117	0.099	-0.137
ℓspec	0.001	-0.270	0.185	-0.219	-0.080
ℓcontract	0.015	0.023	0.089	0.028	0.014
ℓcompay	0.040	-0.016	0.098	-0.044	0.049
setaside	0.001	0.0003	-0.001	-0.001	0.001
insureacre	0.001	0.0001	0.0004	-0.0004	0.0003
ℓvalueacre	-0.106	0.077	-0.135	0.095	-0.168
ℓareanm	-0.102	-0.118	0.126	0.008	-0.107
ℓpopnm	-0.108	-0.163	0.183	-0.032	-0.107
ℓpopden	-0.007	0.081	-0.110	0.047	-0.031
ℓprivrd	0.0003	0.0003	-0.0003	-0.0001	0.0003
ℓkw	-0.291	-0.264	-0.274	0.119	-0.143
ℓmw	0.371	0.412	-0.432	0.030	0.406
ℓcollege	-0.235	-0.084	0.933	0.286	-0.134
ℓyoung	-0.002	0.313	0.262	0.271	0.033
ℓold	0.246	0.595	-0.391	0.525	0.286
drought	-0.140	-0.042	0.062	0.061	-0.077
flood	-0.008	-0.002	0.004	0.004	-0.005
dairy	-0.238	-0.178	0.211	0.038	-0.182
Regions					
SE	-0.072	0.364	0.338	0.577	0.141
CENT	-0.004	0.157	0.176	0.381	0.116
NP	-0.487	-0.324	2.084	0.176	-0.388
SP	-0.333	0.256	0.963	0.695	-0.021
MOUNT	-0.431	0.595	1.774	0.521	-0.257
PAC	-0.120	0.921	0.783	0.495	-0.054
Intercept	3.713	-1.445	-6.239	-4.225	0.816

Table 3. Transition matrix for farms and acres, by acreage size class, 1978-82

		1982 acre class									
	Exits 1978-82	1-49 acres	50-99 acres	100-179 acres	180-259 acres	260-499 acres	500-999 acres	1000-1999 acres	2000 plus acres	Subtotal	1978 farms
1978 Acre class						***Number of farms***					
Entrants, 1978-82		312,771	117,343	111,648	58,896	82,144	52,032	24,868	17,264	776,966	
1-49	220,649	253,920	27,081	12,498	4,335	4,119	1,552	559	378	304,442	525,091
50-99	114,746	29,594	149,438	24,135	6,080	4,362	1,303	340	109	215,361	330,107
100-179	117,835	13,659	26,835	167,569	21,260	13,309	3,225	732	238	246,827	364,662
180-259	61,147	4,765	6,330	22,011	86,738	23,527	4,060	623	178	148,232	209,379
260-499	84,213	4,336	4,193	12,814	22,210	152,272	27,347	2,937	591	226,700	310,913
500-999	49,179	1,710	1,157	2,685	3,220	20,891	96,884	14,866	1,478	142,891	192,070
1000-1999	22,848	551	260	569	489	2,123	10,231	45,516	6,459	66,198	89,046
2000 plus	15,991	369	110	235	171	529	1,193	4,715	37,583	44,905	60,896
Subtotal	686,608	308,904	215,404	242,516	144,503	221,132	145,795	70,288	47,014	1,395,556	2,082,164
1982 farms		621,675	332,747	354,164	203,399	303,276	197,827	95,156	64,278	2,172,522	

		1982 acre class									
	Exits 1978-82	1-49 acres	50-99 acres	100-179 acres	180-259 acres	260-499 acres	500-999 acres	1000-1999 acres	2000 plus acres	Subtotal	1978 Acres
1978 Acre class						***Total acreage***					
Entrants, 1978-82		5,568,698	8,376,334	15,067,195	12,699,461	29,357,421	35,848,964	33,825,855	126,145,567	266,889,495	
1-49	4,270,693	5,562,813	776,354	296,501	93,242	78,258	25,537	7,127	3,801	11,114,326	11,114,326
50-99	8,286,524	2,009,179	10,885,854	1,865,117	461,451	328,891	96,577	24,973	7,981	23,966,547	23,966,547
100-179	15,999,537	1,797,561	3,419,660	22,838,614	3,082,642	1,910,671	461,072	104,165	33,647	49,647,569	49,647,569
180-259	13,193,091	1,017,184	1,344,534	4,624,788	18,761,759	5,258,299	898,293	136,228	38,522	45,272,698	45,272,698
260-499	29,998,805	1,513,767	1,426,386	4,308,269	7,328,519	54,592,005	10,931,421	1,137,844	222,527	111,459,543	111,459,543
500-999	33,848,602	1,147,383	765,045	1,756,773	2,053,056	13,038,766	66,696,888	11,723,597	1,120,256	132,150,366	132,150,366
1000-1999	31,061,100	738,489	341,216	743,336	628,445	2,710,706	12,648,026	62,048,058	10,109,522	121,028,898	121,028,898
2000 plus	110,023,384	1,771,926	560,339	1,056,431	800,146	2,238,216	4,547,165	14,447,613	307,114,673	442,559,893	442,559,893
Subtotal	246,681,736	15,558,302	19,519,388	37,489,829	33,209,260	80,155,812	96,304,979	89,629,605	318,650,929	937,199,840	937,199,840
1982 acres		21,127,000	27,895,722	52,557,024	45,908,721	109,513,233	132,153,943	123,455,460	444,796,496	957,407,599	

Table 4. Transition matrix for farms and acres, by acreage size class, 1982-87

		1987 acre class									
	Exits 1982-87	1-49 acres	50-99 acres	100-179 acres	180-259 acres	260-499 acres	500-999 acres	1000-1999 acres	2000 plus acres	Subtotal	1982 Farms
1982 Acre class						***Number of farms***					
Entrants, 1982-87		281,975	105,999	104,685	56,715	82,481	57,037	28,934	20,339	738,165	
1-49	326,005	251,252	30,334	14,958	5,613	5,223	2,229	787	516	310,912	636,917
50-99	142,101	28,719	132,586	25,575	6,980	5,448	1,730	457	179	201,674	343,775
100-179	140,298	14,261	24,413	146,615	21,611	15,000	4,326	1,035	318	227,579	367,877
180-259	74,990	5,412	6,265	20,510	74,334	23,580	5,243	899	252	136,495	211,485
260-499	106,428	5,614	4,779	13,050	20,182	129,940	30,184	4,018	830	208,597	315,025
500-999	66,308	2,352	1,448	3,325	3,631	19,995	87,494	17,377	1,995	137,617	203,925
1000-1999	30,206	867	417	844	736	2,538	10,537	43,877	7,373	67,189	97,395
2000 plus	19,765	506	171	320	260	726	1,638	5,498	35,693	44,812	64,577
Subtotal	906,101	308,983	200,413	225,197	133,347	202,450	143,381	73,948	47,156	1,334,875	2,240,976
1987 farms		590,958	306,412	329,882	190,062	284,931	200,418	102,882	67,495	2,073,040	

		1987 acre class									
	Exits 1982-87	1-49 acres	50-99 acres	100-179 acres	180-259 acres	260-499 acres	500-999 acres	1000-1999 acres	2000 plus acres	Subtotal	1982 Acres
1982 Acre class						***Total acreage***					
Entrants, 1982-87		4,924,094	7,581,473	14,172,076	12,237,215	29,552,301	39,493,662	39,322,290	141,316,045	288,599,156	
1-49	6,063,496	5,292,040	841,977	356,142	118,797	99,565	35,931	10,417	5,291	6,760,160	12,823,656
50-99	10,202,917	1,954,611	9,613,971	1,959,241	525,554	406,993	127,779	33,530	12,687	14,634,366	24,837,283
100-179	18,986,606	1,879,789	3,108,560	19,908,586	3,101,811	2,145,813	612,279	146,520	44,717	30,948,075	49,934,681
180-259	16,195,650	1,159,740	1,336,852	4,315,833	16,048,479	5,247,692	1,159,803	198,259	55,345	29,522,003	45,717,653
260-499	38,052,306	1,959,272	1,642,201	4,430,003	6,716,720	46,484,463	11,925,420	1,551,937	311,560	75,021,576	113,073,882
500-999	45,628,415	1,576,171	949,059	2,195,314	2,346,773	12,652,720	60,128,054	13,531,655	1,497,108	94,876,854	140,505,269
1000-1999	41,089,951	1,149,999	534,733	1,093,163	971,255	3,278,539	13,226,764	59,701,262	11,394,470	91,350,185	132,440,136
2000 plus	145,786,903	2,930,305	799,660	1,572,586	1,167,285	3,103,560	6,371,607	17,449,142	288,282,971	321,677,116	467,464,019
Subtotal	322,006,244	17,901,927	18,827,013	35,830,868	30,996,674	73,419,345	93,587,637	92,622,722	301,604,149	664,790,335	986,796,579
1987 acres		22,826,021	26,408,486	50,002,944	43,233,889	102,971,646	133,081,299	131,945,012	442,920,194	953,389,491	

Table 5. Transition matrix for farms and acres, by acreage size class, 1987-92

						1992 acre class					
	Exits 1987-92	1-49 acres	50-99 acres	100-179 acres	180-259 acres	260-499 acres	500-999 acres	1000-1999 acres	2000 plus acres	Subtotal	1987 Farms
1987 Acre class						***Number of farms***					
Entrants, 1987-92		257,924	98,212	94,638	50,216	70,739	47,484	24,673	18,114	662,000	
1-49	292,008	242,583	29,913	15,631	5,748	5,502	2,447	1,026	836	303,686	595,694
50-99	123,826	26,116	121,510	24,979	6,891	5,092	1,732	523	198	187,041	310,867
100-179	124,654	13,084	22,483	132,767	21,182	14,160	4,164	1,069	419	209,328	333,982
180-259	65,776	5,105	5,770	19,194	67,168	22,596	5,097	1,053	329	126,312	192,088
260-499	91,628	5,322	4,515	12,157	19,235	119,619	28,410	4,309	1,011	194,578	286,206
500-999	59,335	2,258	1,536	3,261	3,604	20,329	87,828	19,207	2,700	140,723	200,058
1000-1999	27,800	849	421	901	744	2,713	11,974	46,758	9,918	74,278	102,078
2000 plus	18,325	522	158	331	252	779	1,658	5,915	38,846	48,461	66,786
Subtotal	803,352	295,839	186,306	209,221	124,824	190,790	143,310	79,860	54,257	1,284,407	2,087,759
1992 farms		553,763	284,518	303,859	175,040	261,529	190,794	104,533	72,371	1,946,407	

						1992 acre class					
	Exits 1987-92	1-49 acres	50-99 acres	100-179 acres	180-259 acres	260-499 acres	500-999 acres	1000-1999 acres	2000 plus acres	Subtotal	1987 Acres
1987 Acre class						***Total acreage***					
Entrants, 1987-92		4,651,147	7,013,507	12,751,607	10,825,624	25,233,184	32,829,091	33,644,901	120,092,666	247,041,727	
1-49	5,276,476	5,003,818	814,117	361,530	119,372	98,879	38,309	13,357	8,662	6,458,044	11,734,520
50-99	8,901,760	1,769,308	8,797,758	1,911,370	520,482	378,506	128,646	38,667	14,367	13,559,104	22,460,864
100-179	16,898,969	1,722,143	2,859,448	18,002,682	3,039,287	2,014,520	586,813	150,467	58,881	28,434,241	45,333,210
180-259	14,190,285	1,093,397	1,227,754	4,037,479	14,501,790	5,027,420	1,122,901	231,196	71,526	27,313,463	41,503,748
260-499	32,750,387	1,851,332	1,558,556	4,129,635	6,386,884	42,957,297	11,247,305	1,655,900	379,434	70,166,343	102,916,730
500-999	40,939,225	1,531,401	1,030,396	2,168,220	2,323,919	12,852,431	60,640,790	15,029,912	2,024,377	97,601,446	138,540,671
1000-1999	37,795,354	1,137,842	565,502	1,180,480	958,076	3,517,827	14,866,372	63,463,665	15,324,436	101,014,200	138,809,554
2000 plus	129,857,918	2,768,614	713,863	1,611,714	1,248,427	3,208,873	6,419,454	18,177,817	299,164,648	333,313,410	463,171,328
Subtotal	286,610,374	16,877,855	17,567,394	33,403,110	29,098,237	70,055,753	95,050,590	98,760,981	317,046,331	677,860,251	964,470,625
1992 acres		21,529,002	24,580,901	46,154,717	39,923,861	95,288,937	127,879,681	132,405,882	437,138,997	924,901,978	

Table 6. Transition matrix for farms and acres, by acreage size class, 1992-97

		1997 acre class									
	Exits 1992-97	1-49 acres	50-99 acres	100-179 acres	180-259 acres	260-499 acres	500-999 acres	1000-1999 acres	2000 plus acres	Subtotal	1992 Farms
1992 Acre class						***Number of farms***					
Entrants, 1992-97		286,763	124,434	110,648	54,747	71,979	48,893	26,825	20,556	744,845	
1-49	260,546	237,618	28,045	14,361	5,141	4,882	2,143	913	558	293,661	554,207
50-99	107,398	25,709	113,432	22,939	6,485	4,904	1,720	521	247	175,957	283,355
100-179	106,899	12,582	22,962	121,417	19,045	12,588	3,722	1,154	422	193,892	300,791
180-259	56,899	4,809	6,005	19,327	59,990	19,560	4,211	1,000	389	115,291	172,190
260-499	80,404	4,645	4,709	12,250	18,801	106,329	23,711	3,632	977	175,054	255,458
500-999	55,162	2,089	1,605	3,317	3,690	19,988	80,505	17,474	2,557	131,225	186,387
1000-1999	28,761	818	502	1,040	858	2,991	11,825	45,452	9,676	73,162	101,923
2000 plus	21,063	469	218	419	309	856	1,895	6,477	39,283	49,926	70,989
Subtotal	717,132	288,739	177,478	195,070	114,319	172,098	129,732	76,623	54,109	1,208,168	1,925,300
1997 farms		575,502	301,912	305,718	169,066	244,077	178,625	103,448	74,665	1,953,013	

		1997 acre class									
	Exits 1992-97	1-49 acres	50-99 acres	100-179 acres	180-259 acres	260-499 acres	500-999 acres	1000-1999 acres	2000 plus acres	Subtotal	1992 Acres
1992 Acre class						***Total acreage***					
Entrants, 1992-97		5,636,978	8,886,947	14,855,209	11,763,215	25,659,989	33,750,602	36,544,530	146,050,175	283,147,645	
1-49	4,707,530	4,885,197	782,995	346,175	117,707	98,603	39,529	15,142	8,202	6,293,550	11,001,080
50-99	7,698,815	1,737,065	8,202,499	1,754,010	487,385	364,857	126,473	38,070	17,067	12,727,426	20,426,241
100-179	14,425,964	1,648,545	2,932,440	16,446,835	2,727,880	1,791,193	523,477	160,644	58,462	26,289,476	40,715,440
180-259	12,254,362	1,028,842	1,276,829	4,064,372	12,961,236	4,350,428	930,736	217,916	84,906	24,915,265	37,169,627
260-499	28,761,318	1,621,237	1,622,132	4,166,940	6,253,416	38,112,245	9,405,513	1,399,532	368,829	62,949,844	91,711,162
500-999	38,092,699	1,415,213	1,073,963	2,206,619	2,390,964	12,650,713	55,818,364	13,695,843	1,920,581	91,172,260	129,264,959
1000-1999	39,105,704	1,097,848	666,347	1,369,710	1,134,485	3,885,693	14,714,327	62,026,081	14,984,290	99,878,781	138,984,485
2000 plus	162,185,015	2,553,294	1,147,169	2,308,234	1,421,201	3,673,335	8,363,802	20,295,566	274,310,896	314,073,497	476,258,512
Subtotal	307,231,407	15,987,241	17,704,374	32,662,895	27,494,274	64,927,067	89,922,221	97,848,794	291,753,233	638,300,099	945,531,506
1997 acres		21,624,219	26,591,321	47,518,104	39,257,489	90,587,056	123,672,823	134,393,324	437,803,408	921,447,744	