Agricultural Structural Adjustment to Government Policies: Empirical Evidence

by

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Summary: Economic theory alone cannot predict the impacts of government payments on farm structure. We estimate a 5-equation model for the 1978-96 period to measure the impacts using state micro and macro data sets. We found that government payments were positively associated with farm size and farm exits, but negatively associated with the extent of consolidation in farm production and the off-farm work of operators.

Keywords: government payments, productivity, farm size, farm exits, off-farm work, consolidation

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In 2002, approximately 40 percent of U.S. farms received government payments, and this share has been increasing somewhat over time, largely as a result of new agri-environmental programs (e.g., the Environmental Quality Incentives Program, EQIP). Although the majority of farms do not receive payments, payments affect the farm sector at large through their capitalization into land values and because of their magnitude (accounting for nearly 30% of net farm income for the whole sector during the last decade).

In his classic book, *The Development of American Agriculture: A Historical Analysis*, Cochrane describes the "cannibalism" effect of technology and government agricultural commodity programs, in which payments allow the large farms, often times the early adopters of new technology, to buy out their smaller neighbors largely through the effects of increases in productivity. But, more recently others have made similar observations regarding the effects of payments encouraging farms to get larger, including such widely differing sources as the agricultural policy watchdog, the Environmental Working Group, and the USDA's Chief Economist (Collins, 2001; EWG, 2003).

Alternative conceptual models posit that payments do just the opposite. That is, some arguments conclude that payments act to keep small and medium-sized farms in business, slowing down the technological forces that tend to increase farm size. Unfortunately, economic theory does not offer clear direction on the critical relationships. Leathers (1992) has shown formally how the impact of alternative agricultural programs on the structure of agriculture cannot be predicted by theory alone.

Government programs that distribute payments to participants have a variety of goals. However, none of the explicit goals of the programs is to increase farm size. In fact, an oft-stated public policy concern is that the share of the sector that could be classified as family farms is shrinking. This concern arises because there is some belief that family farms have a public good nature to them and are important to preserve. Any evidence that would show that payments have an unintended consequence of increasing farm size would likely be of interest to policy makers. Therefore, there is an interest in understanding how past government policies have affected the structure of agriculture and how future policies could be designed to achieve preferred social outcomes. For example, there is an interest in understanding how government policies can be designed so as to strengthen the survivability of family farms, or at least not to contribute to their demise while accomplishing other goals.

In spite of this policy interest in understanding how payments affect farm structure, there is a lack of definitive empirical results. This is likely a result of the complexity of factors that are related to structural change, and the importance of identifying their separate roles. A major factor contributing to farm consolidation is economies of scale. Economies of scale allow more agricultural product to be produced at lower per unit costs. Lower per unit costs may also result from increases in productivity. Therefore, it is important to account for this underlying technical change that occurs over time in explaining structural change impacts of government payments. The structural change process is a macro event that occurs rather slowly over time, as a result of micro-level decisions. Hence, empirical applications require extensive panel data. Without definitive empirical applications to provide direction, the variety of conflicting conceptual models of the causal relationship between government payments and farm structure have endured.

Huffman and Evenson (2001) made a recent empirical contribution to the literature in relating 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.

More recently, Ahearn, Yee, and Huffman (2002) examined the key relationships between productivity and farm size 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.

Undoubtedly, some of the expansion in average farm size observed in these two studies as a result of payments came from the consolidation of farms that exited the sector. Key and Roberts (2003) considered what effect payments had on the size and survival of a subset of farms that receive commodity payments between 1987 and 1997, ignoring the role of productivity. Key and Roberts concluded that payments had a positive, but small, effect on farm size for the subset of farms. This is consistent with the results of the other two studies cited for the total farm sector, not just those farms that participated in government programs. Unlike the other studies, Key and

Roberts also considered the influence of payments on farm survivability, and found that payments had a significant influence on farm survivability of those farms that participated in programs.

The purpose of this paper is to build on the previous empirical studies (Huffman and Evenson and Ahearn, Yee, and Huffman) that examined government payments, productivity, and farm structure variables. In this paper, we ask not only how have payments affected the links among productivity, off-farm work, and farm consolidation, but how have payments affected the exiting of farms out of agriculture altogether? Note that we are interested in examining how payments have affected all farms, not just those that received payments. We are able to do this by taking advantage of a rich data base which links individual farms across recent agricultural censuses, in conjunction with state level aggregate data. The individual farm data base is available for 1978 forward and is further described in the appendix. Before we present our model, data, and results, we first provide a brief description of the changing structure of U.S. agriculture, focusing largely on our study period, 1978-96.

Structural change in U.S. agriculture

Major changes in the organization of U.S. agriculture are captured by examining trends in total factor productivity (TFP), the size distribution of farms, entry and exit of farms, and farm household labor allocations.

Productivity. Over the past century, productivity has been the major force behind the changes in U.S. agricultural output. Between 1978 and 1996, the rate of growth in total factor productivity in agriculture was 2.71 percent on an annual average basis (http://www.ers.usda.gov/Data/AgProductivity/#data). 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.

Farm size distribution. The size distribution of U.S. farms is very skewed, hence, it is useful to consider both changes in average farm sizes and the concentration of production in the sector. Concentration of production, or consolidation, brings a variety of potential social concerns. Concentration *can* lead to market power and reduced competition, reduced innovation, lack of market transparency, and adverse impacts in some communities. Because there is no clear consensus on what level of concentration is dangerously high, there is a general interest in monitoring consolidation in agriculture.

The aggregate amount of agricultural land has been relatively fixed during the 20th century, and so the change in the number of farms is closely correlated with the change in the size of farms, which has generally been increasing until recent years. Since 1978, the total number of farms has remained about 2 million. The number of large farms (>1,000 acres) and smallest farms (<50 acres) has increased, but the number of mid-sized farms has declined. Two distinct forces drive the evolving structural changes of the U.S. farm sector. First, the pressures to minimize costs and consumer prices and to provide products with attributes that are more tailored to the specific demands of consumers drives the concentration in production. Secondly, the fact that most farm households earn cash income from off-farm sources is a primary driver of the resource allocation choices they make. Half of all agricultural product is produced by 2% of U.S. farms (approximately 46,000) (Figure 1).

The overriding characteristic of the U.S. farm sector is its diversity. Size is the most obvious example of that diversity, and hence is a leading structural indicator. Table 1 provides recent statistics (for 2002) on the diversity of farm households by a gross value of product size concept. More than three-quarters of farms have gross farm sales less than $50,000 and, on average, lose money farming. However, their off-farm income is above the U.S. average income for all households. The farm households with gross farm sales of $50,000 to $500,000 have similar farm characteristics in terms of the number and types of commodities produced and the participation in government programs. The largest farms, those with sales over $500,000 have a different farm profile. The largest farms are more likely to use contracts and to produce high value crops and livestock, other than dairy. Hence, given the focus of government farm direct payment programs on cash grains and cotton, the largest farms are less likely than the mid-sized farms to receive payments, although large farms that receive payments average a higher payment than other farms.

There is a great deal of dynamics underlying the statistics on average farm size. Over any given period, some farms expand, but other farms contract. Figure 2 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.

Entry-Exit. The relatively slow rate of decline in the number of farms over time masks significant exit and entry. Exits, entrants, 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. 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, roughly the same number of farms entered farming during the period as exited. Hence, little change in the number of total farms between the 1992 Census of Agriculture and the 1997 Census occurred. The high rate of entry into agriculture is an indicator that anti-competitive barriers to entry likely do not exist. The total land in agriculture is more stable over time than the number of farms, 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.

Farm Household Labor Allocations. The majority of workers on U.S. farms are the operators and their families, contributing at least two-thirds of the labor hours worked. By definition, all operators work on the farm, but also 40 percent of spouses, primarily female, work on the farm. In addition, most farm families (72% in 2002, table 1) have at least one family member working in a non-farm occupation and in about half of those families both the operator and spouse work off the farm (USDA, 2001). Operators are more likely than spouses to work off the farm, 56 percent compared to 46 percent (USDA, 2001). Over all only about 5 percent of total farm household income is from farm sources (table 1). Also, as has been the case for some time, off-farm income has played a major role in closing the income gap between farm and non-farm households and in reducing income inequality among farm operator households (Ahearn, Strickland, and Johnson, 1985; Mishra, et al., 2002).

The Theoretical Model

As mentioned previously, economic theory does not provide a clear prediction of the final impact of government payments on farm structure. However, economic theory does provide a model of the micro decisions of the farm household affected by payments. Because nearly all U.S. farms (more than 90%) are family businesses, the household production model is a useful theoretical model for examining resource allocation choices that result in structural change over time. 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).[2]

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

$$Maximize\ U = U(C_h, T_h; H, Z), with\ \partial U / \partial \Omega > 0,\ \partial^2 U / \partial \Omega^2 < 0,\ \Omega = C_h, T_h$$ [3]

subject to

[2] 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.

[3] 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.

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

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

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,
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 utility function and the production function are assumed to be concave, continuous, and twice differentiable. The first-order conditions for the above model provide many useful results, including the demand functions for farm household labor in farming, the demand for hired farm labor, the demand for household home time (or leisure), and the off-farm labor supply of the farm household. The derivation of these labor-related functions depends on the assumption to be made about the decision process of the household and the relative completeness of the markets, e.g., the off-farm labor market or the labor market for hired farmworkers.

The decision process is either simultaneous or recursive. In the first case, the model is said to be nonseparable and in the latter, separable. In the nonseparable model, price-related constraints are provided by an internal shadow price determination. In the separable model, price-related constraints are provided by assuming perfect markets and fixing prices exogenously (Taylor and

Adelman, 2003). In the separable model with complete labor markets, the price of home time, or leisure, becomes the market wage rate. The model provides demands for farm household labor in farming, for leisure time (including 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, while useful for characterizing individual micro decisions, does not directly translate into direction of farm sector structural change, especially because of the vast diversity among farm households. For policy purposes, structural change is of interest at some collective level. 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 state average farm size, measures of concentration of production in the state, and farm exit rates in a state; and allocation of time (including none) to off-farm work result in state off-farm labor supply. We now turn to our empirical model using state-level data.

The Empirical Model

We employ the following 5-equation model with feedback across the equations that we estimate with state-level data for 1978-96:

(1) $$TFP = \alpha_1 Size + \alpha_2 Conc + \alpha_3 Exit + \alpha_4 Off + \alpha_5 X_1 + \varepsilon_1$$

(2) $$Size = \beta_1 TFP + \beta_2 Conc + \beta_3 Exit + \beta_4 Off + \beta_5 X_2 + \varepsilon_2$$

(3) $$Conc = \gamma_1 TFP + \gamma_2 Size + \gamma_3 Exit + \gamma_4 Off + \gamma_5 X_3 + \varepsilon_3$$

(4) $$Exit = \delta_1 TFP + \delta_2 Size + \delta_3 Conc + \delta_4 Off + \delta_5 X_4 + \varepsilon_4$$

(5) $$Off = \lambda_1 TFP + \lambda_2 Size + \lambda_3 Exit + \lambda_4 Conc + \lambda_5 X_5 + \varepsilon_5$$

The five equations are for productivity (*TFP*), average farm size (*Size*), an indicator of the concentration in farm production (*Conc*), the odds that a farm exits the sector (*Exit*), and the odds that farm operators work off-farm at least 200 days per year (*Off*). The *Conc* indicator of the farm size distribution is specified as the share of farms that produce 50 percent of the total product. So, the larger the *Conc* indicator, the less the concentration in the sector. The earlier work using state-level data has measured farm size as the average for the state. In this paper we prefer to use the traditional measure (i.e., the average farm size) and this additional measure of the size distribution (i.e., *Conc*) that captures information about the extent of the skewness of the distribution. All states have a size distribution dominated by many small farms, but vary in the extent of concentration of production by the largest farms. This indicator allows us to capture the variation in size masked by a state average, although we acknowledge that any single indicator of farm size has advantages and disadvantages.

There is an established literature on the key variables for all of our equations 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, ERS supported several studies of farm exits. These included Bentley, et al. (1989); Bentley and Saupe (1990); and Wu (1997). Although the focus of this body of the literature was not on structural implications of policy, it does provide some guidance on the exit model specification. Barkley (1990) examined the role played by government payments in the decline in the use of labor, as a production input, over time. 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.

Table 2 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), specialization, contracting, ratio of capital rental-to-hired farm wage, weather, and geographic region. The set of exogenous variables (X_2) included in the *Size* equation are public agricultural research stocks (from originating state and spill-ins), public extension, ratio of capital rental-to-hired farm wage, commodity payments, specialization, contracting, share of operators aged, and geographic region. The set of exogenous variables (X_3) included in the *Conc* equation are public agricultural research stocks (from originating state and spill-ins), public extension, ratio of capital rental-to-hired farm wage, commodity payments, specialization, contracting, land value per acre, and geographic region. The set of exogenous variables (X_4) included in the *Exit* equation are ratio of manufacturing wage-to-hired farm wage, specialization, contracting, commodity payments, share of college educated operators, share of operators aged, population density in non-metro areas, land value per acre, and geographic region. The set of exogenous variables (X_5) included in the *Off* equation are infrastructure in highways, specialization, contracting, commodity payments, conservation payments, ratio of manufacturing wage-to-hired farm wage, dairy production, share of college educated operators, share of young operators, share of a state's population living in non-metro areas, population density in non-metro areas, and geographic region.

Hypotheses

Because of the complex interactions among the variables thought to affect structure, we are especially interested in the relationships between our endogenous variables. But, the most important set of relationships of interest are those that capture the role of government policies. Hence, to highlight these relationships, we formalize our expectations about these relationships in the following hypotheses:

Hypothesis I: An increase in government agricultural payments has no effect on farm productivity; with the alternative being a positive effect;

Hypothesis II: An increase in government agricultural payments has no effect on the average size of farms; with the alternative being an increase in average farm size.

Hypothesis III: An increase in government agricultural payments has no effect on the size distribution of farms; with the alternative being an increase in the concentration of production.

Hypothesis IV: An increase in government agricultural payments has no effect on the exiting of all farms; with the alternative being a positive effect; and

Hypothesis V: An increase in government agricultural payments (both commodity and conservation) has no effect on off-farm work of farm operators; with the alternative being a negative effect.

Results

We estimate the model by three-stage-least squares, incorporating cross-equation correlation of disturbances. We choose to limit our analysis to the 1978 to 1996 time period in large part because the uniqueness of this application is the addition of the dynamic structural variables, which are only available to us from 1978 forward. The estimated coefficients for the structural model are reported in Table 3. A large share of the estimated coefficients is significantly different from zero and the share of the variation explained is good.

Table 3 presents the full set of econometrics results. Our description here will focus on the results pertaining to the endogenous relationships and the hypotheses stated above. For all 5 equations, the majority of the relationships among the endogenous variables were significant, indicating the importance of estimating the relationships simultaneously.[4] The directions of the significant relationships were consistent with prior econometric results (where they existed in the literature) and with reasonable expectations. The exception to this is the relationships between *Off* and *Size*. We expected an increase in the off-farm work choice of operators to be negatively related to farm size and the farm size choice to be negatively related to the off-farm work choice. This expectation is based on our observation of the simple correlations between the variables, given the fixed time available in the household. While we did find farm size to have a negative effect on the off-farm work choice, we also found that an increase in off-farm work of the operator had a positive effect on farm size. Perhaps this indicates that when all other factors are controlled for, off-farm sources of income allow the operators to expand their farm size.

[4] The relationships which were not significant are the following: *Exit* was not significantly related to *TFP*, and *TFP* was not significant in the *Exit* equation. *TFP* was not significant in the *Off* equation, either, although the reverse was not true. *Conc* was not significant in the *Size* equation. *Off* was not significant in the *Exit* equation.

Hypothesis I cannot be rejected. We did not find that government commodity payments had a significant effect on productivity of the sector. This was not consistent with the result found by previous work for the 1950-82 time period and the 1960-96 time period which found a small positive effect of payments on productivity. Agricultural policies change, usually about every 5 years, and of course are designed to change as economic conditions change for the sector on an annual basis. Hence, we should not necessarily expect the results to be consistent for all time periods.

Hypotheses II and III relating to the effects of payments on the farm size distribution can be rejected, since we found significant effects of payments on these two indicators of the farm size distribution. For the average farm size measure, we found that payments had a positive effect, consistent with the past results for the 1950-1982 period (Huffman and Evenson) and the 1960-1996 period (Ahearn, Yee, and Huffman). However, we also found that the alternative hypothesis III is rejected, as well, because we found that payments had a positive effect on increasing the share of farms that account for 50% of production. In other words, payments tend to lessen consolidation in the sector.

Hypothesis IV relating to farm exits can also be rejected. We found that payments tended to increase the share of farms that exit the sector. This is seemingly not consistent with the result found by Key and Roberts when they considered the impact of payments on the exiting of the subset of farms that received payments. But, the differing populations involved must be considered, and then the two sets of results are in fact complementary. In other words, payments increase the survivability of those minority of farms in the sector that receive payments, but decrease the survivability of all farms taken as a whole.

Hypothesis V relating to off-farm work can also be rejected. We found that payments had a negative impact on the off-farm work participation of farm operators. This result has been very robust in previous studies, both using aggregate and household-level data, whether payments are coupled or decoupled from production levels.

Discussion

We found that government payments increased the average farm size and increased farm exits in a state. This can be explained by the farms who participated in programs expanding their farm size by buying out the farmland of non-participants. Farmland is relatively fixed and the aggregate land used in agriculture has remained fairly stable over this period. 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. For example, 25 percent of farms that exited between 1992 and 1997 received payments compared to 40 percent that survived during this period. Similarly, figure 4 shows that cash grain and dairy farms, that are supported at a relatively high level compared to other U.S. farms, were the most likely to expand their farm size. Figure 4 shows this relationship for the 1992-97 period, but it is consistent for the other census time periods between 1978 and 1992.

At the same time that payments led to increased average farm size, they increased the share of farms that accounted for 50 percent of the production, i.e., they reduced the concentration of production. This is likely because cash grain and cotton production is not as common among the very largest farms as it is among the mid-sized farms (see table 1), and payments help to keep the cash grain and cotton producers in business. These results, on average farm size and production concentration, point to the importance of considering the size distribution of farms, and not just average farm sizes, when examining the structural implications of policies. While our results were not intended to address the issue of anti-competitive market power as a result of trends in industrialization, they do suggest that consolidation has led to increased productivity in the sector. As the share of the largest farms that account for 50% of agricultural production decreases, i.e., concentration increases, productivity also increases.

Payments were also found to have a negative impact on the probability that an operator would work off the farm full-time. This result is logically consistent with the results on farm size. If payments help to keep mid-sized family farms in agriculture and slow down the trend for production to be concentrated on an increasingly small share of farms, then farm operators must work full-time on their farms. In contrast, the majority of farm operators operate small farms, accounting for a small share of agricultural product, and working full-time off their farm. We found this same result, regardless if the payments were commodity payments or conservation payments. This period 1978-96 is an interesting one for considering conservation payments because of the introduction of the Conservation Reserve Program (CRP) with the 1985 farm bill. Large amounts of acreage were enrolled in the CRP by 1987, and continued to be enrolled in 10- or 15-year contracts through the period.

Concluding Remarks

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.

We find that while government payments may have led to increasing average farm size and exits from agriculture, it has also reduced the concentration of production. This pair of results have not been jointly considered in previous studies. By doing so, we have helped explain the opposing views provided by experts who conjecture on the impacts of farm policies on farm structure without the benefit of the empirical analysis. Payments have also had a significant impact on the decisions of farm operators to allocate their labor to the farm, rather than pursue off-farm work opportunities.

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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 of those labor hours.

Off-farm work (off). Off-farm work is measured as the odds of the farm operator working off the farm for 200 or more days per year.

Farm Size (size). Farm size is measured as the real average agricultural use value of farms in a state. The average use value per farm is calculated as the product of the average acres of land in a farm and the market rental rate per acre for land rented. Note that this assumes that the rental rate is a good rental measure for all land, whether rented or owned. The use value is deflated by the prices received index.

Farm concentration (conc). The distribution of farm product is measured as the share of the farms in a state that account for 50% of production. This size indicator better communicates information about the concentration of the product of farms in a state than does an average farm size. See the description below for more detail on the data source, the longitudinal file of 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. See the description below for more detail on the data source, the longitudinal file of the Census of Agriculture.

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 spillin) 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.

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.

Dairy Share of Total Cash Receipts (dairy). 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.

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.

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.

Conservation Payments (conpay). A variety of conservation programs have been established during our study period. The largest program during the period is the Conservation Reserve Program, established in 1985. Conservation payments are for conservation programs: CRP, WRP, WHIP, EQIP, currently and different ones historically.

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. We interpolated for intercensal years using a straight-line approach.

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.

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. We interpolated in between benchmarks.

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. We interpolated in between Census benchmarks.

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.

Non-metro population density (popden). The population density in non-metro areas, measured as population per square mile.

The Census of Agriculture Longitudinal File

The Census of Agriculture has been conducted for over 150 years. In 1997, responsibility was transferred from the Bureau of the Census to National Agricultural Statistics Service. The Census of Agriculture Longitudinal file is 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 – Farm operator household characteristics, by sales classes, 2002

Item	Sales classes					48-State total
	< $50,000	$50,000-$99,999	$100,000-$250,000	$250,000-$499,999	>=$500,000	
	Number					
Total operator households	1,624,109	165,488	181,643	83,930	59,654	2,114,824
	Percent					
Distribution of farms by specialization						
Cash grains	8.4	35.9	39.5	35.3	14.9	14.5
High value crops	4.6	9.4	8.4	11.8	19.1	6.0
Other crops	25.7	14.4	10.3	11.6	10.5	22.5
Beef, hogs and poultry	39.8	26.0	22.1	26.2	41.4	36.7
Dairy	0.6	10.8	17.5	12.7	11.6	3.6
Other livestock	20.8	na	2.2	*2.5	*2.4	16.6
Distribution of commodities produced						
One commodity	76.6	22.9	18.9	24.1	27.3	64.0
Two commodities	17.4	37.6	34.5	27.0	28.9	21.1
Three commodities	4.2	20.9	23.6	23.2	20.9	8.4
Four or more commodities	1.8	18.6	23.0	25.7	22.9	6.5
Share of farms with contracts	3.5	23.3	33.6	46.0	64.8	11.0
	Dollars per household					
Household income	62,654	53,338	69,173	72,632	164,643	65,757
Farm earnings	-4,776	*7,269	20,449	33,517	123,561	*3,473
Off-farm income	67,430	46,069	48,724	39,115	41,082	62,285
Earned	50,233	34,975	38,169	28,782	27,893	46,521
Unearned	17,197	11,094	10,555	10,332	13,189	15,764
Government payments						
All households	1,244	6,516	12,932	19,495	21,663	3,961
Reporting households	3,641	8,717	16,456	25,460	34,008	9,069
	Percent					
Share of farms with government payments	34.2	74.7	78.6	76.6	63.7	43.7
Share of farms with off-farm earned income	74.4	69.6	63.6	61.1	52.8	72.0
Share of land rented in	30.9	49.1	53.9	58.4	55.5	46.5
Share of farms with more than one operator	30.0	30.9	39.9	45.3	55.1	32.2
Share of farms providing income to multiple households	6.9	11.8	15.9	23.3	35.3	9.5
	Percent of households					
Households with						
Positive household income and-						
Loss from farming	67.9	31.0	18.4	10.0	9.7	56.9
Gain from farming	28.0	58.1	68.6	70.2	71.1	36.7
Negative household income	4.1	10.9	13.0	19.8	19.2	6.4
	Dollars per household					
Farm household assets	503,033	804,652	948,586	1,197,073	1,854,893	630,581
Farm assets	348,648	697,449	828,054	1,056,588	1,674,426	482,611
Non-farm assets	154,385	107,203	120,532	140,485	180,466	147,970
Farm household debt	59,500	106,882	142,023	227,503	462,597	88,333
Farm debt	23,596	83,130	116,468	199,759	409,500	54,109

Non-farm debt	35,903	23,751	25,555	27,744	53,097	34,225
Farm household net worth	443,534	697,770	806,563	969,569	1,392,296	542,248
Farm net worth	325,052	614,318	711,586	856,829	1,264,927	428,503
Non-farm net worth	118,482	83,452	94,977	112,740	127,369	113,745

Source: 2002 USDA Agricultural Resource Management Survey.
Based on 11,926 observations.(11,926 Households). Expansion factor=vallwt0. Versions=1 and 2.
All 48 contiguous States were included in the sample.
Coefficient of **V**ariation = (Standard Error/Estimate)*100. * indicates that CV is greater than 25 and less than or equal to 50.
na indicates value is not available due to no observations, an undefined statistic, or reliability concerns.
Rounded percents may not add precisely to 100.

Table 2. Variable Definitions

Variable	Definition
TFP	Level of total factor productivity (relative to Alabama in 1987)
size	Real land rental per farm
conc	Share of farms in state accounting for 50% of total production
exit	Exit rate per year
off	Proportion of farm operators who worked 200 or more days off farm
ownrd	Own research stock
spillin	Spillin research stock
ext	Extension stock per farm
hiway	Highway 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
conpay	Real conservation payments per farm
setaside	Diverted acres per farm
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)
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).

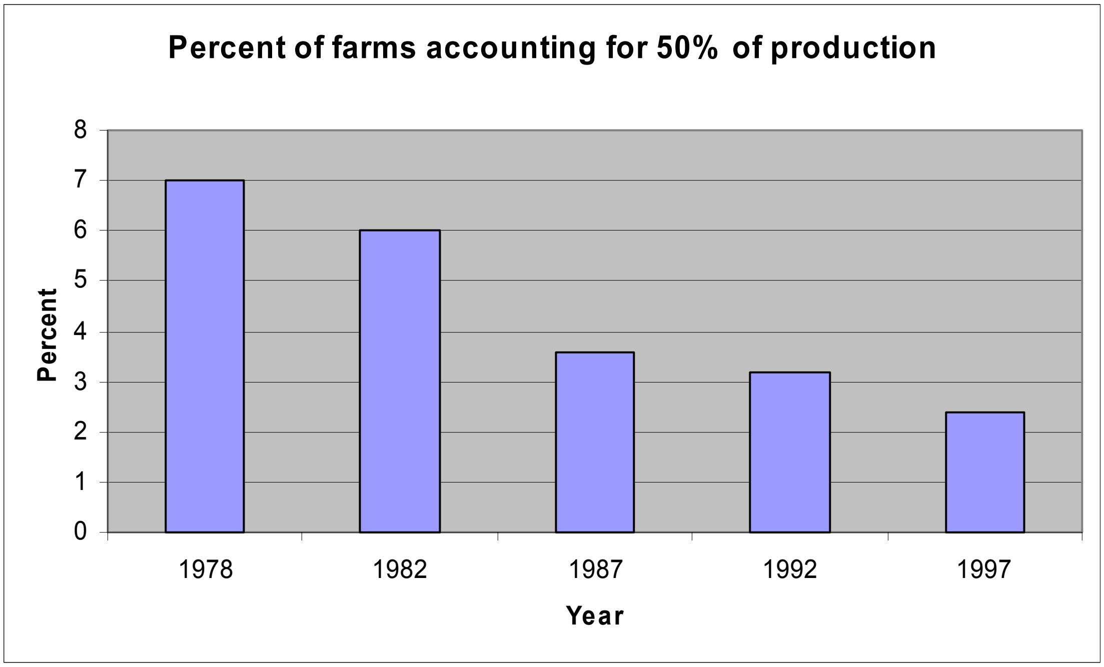
Regional dummy variables are included in each equation. The regions considered in this paper are:
1. Northeast (NE): CT, DE, ME, MD, MA, NH, NJ, NY, PA, RI, VT
2. Southeast (SE): AL, FL, GA, KY, NC, SC, TN, VA, WV
3. Central (CENT): IN, IL, IA, MI, MO, MN, OH, WI
4. Northern Plains (NP): KS, NE, ND, 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 3. Three stage least squares estimates of productivity and structural equations, 1978-96 (n = 912)

Variables	ℓtfp	ℓsize	ℓconc	ℓ[exit/(1-exit)]	ℓ[off/(1-off)]
Endogenous variables					
ℓtfp		2.075*	-1.141*	0.017	0.058
ℓsize	0.273*		0.860*	0.144*	-0.243*
ℓconc	-0.293*	0.039		-0.120*	-0.164*
ℓ[exit/(1-exit)]	0.142	-1.900*	-3.009*		0.623*
ℓ[off/(1-off)]	-0.568*	0.874*	-1.433*	-0.040	
Exogenous variables					
ℓownrd	0.112*	-0.040	-0.022		
ℓspillin	0.100*	0.060	0.178*		
ℓext	-0.042	0.258*	-0.059		
ℓhiway	-0.114*				0.035*
ℓspec	-0.098*	0.164*	-0.469*	-0.074*	-0.198*
ℓcontract	-0.018*	0.035*	-0.060*	-0.016*	0.012
ℓcompay	0.003	0.156*	0.082*	0.042*	-0.070*
ℓconpay					-0.032*
setaside	-0.001*				
ℓvalueacre			-0.195*	-0.076*	
ℓpopnm					0.008
ℓpopden				0.033*	0.003
ℓkw	-0.067	0.418*	0.329		
ℓmw				0.011	0.402*
ℓcollege				-0.035	0.366*
ℓyoung					0.288*
ℓold		-0.817*		0.047	
drought	-0.012				
flood	0.008				
dairy	-0.028				-0.166*
Regions					
SE	-0.334*	0.389*	-0.811*	-0.162*	0.430*
CENT	-0.442*	0.927*	-1.459*	-0.320*	0.434*
NP	-1.004*	1.743*	-3.401*	-0.584*	0.096
SP	-0.776*	1.263*	-2.020*	-0.329*	0.343*
MOUNT	-0.984*	1.868*	-2.816*	-0.409*	0.342*
PAC	-0.616*	1.126*	-1.884*	-0.315*	0.202*
Intercept	-2.429	-3.982	-17.478*	-3.138*	-0.240
R^2	0.275	0.654	0.393	0.448	0.729

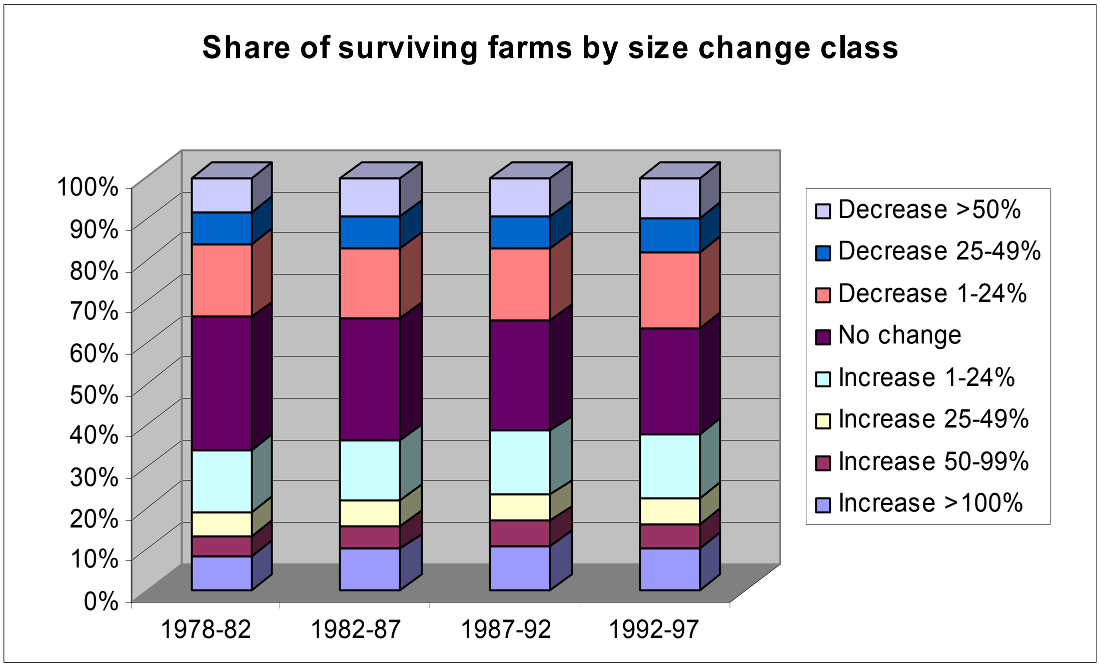
* Denotes significant at the 5% level.

Figure 1.



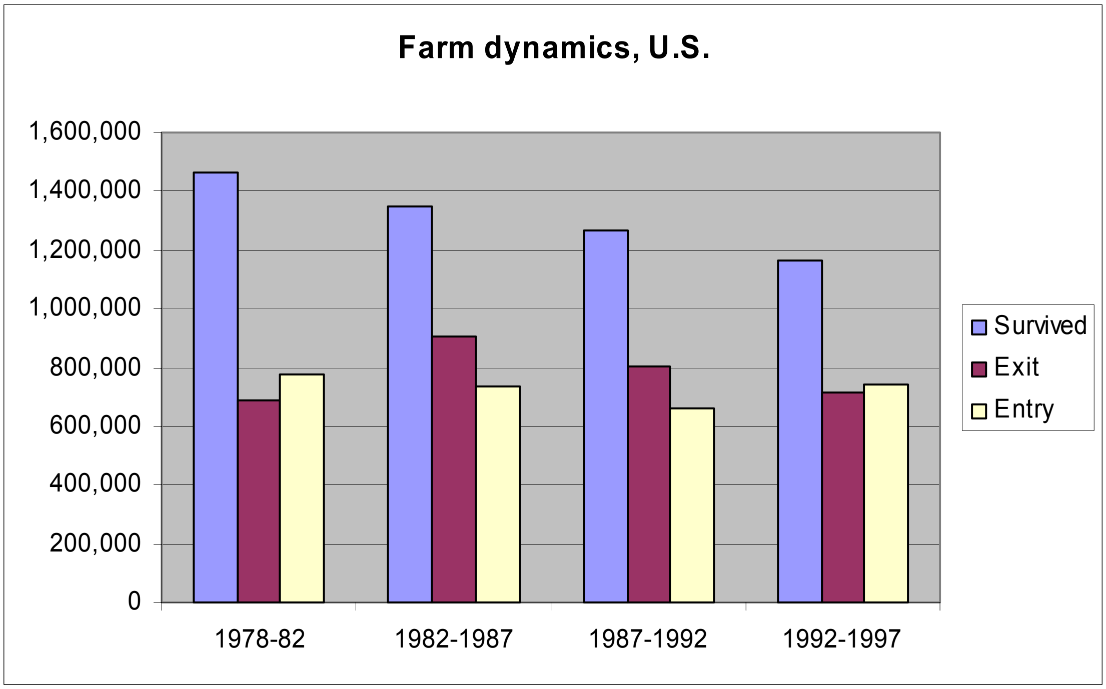
Source: Censuses of Agriculture, various years.

Figure 2.



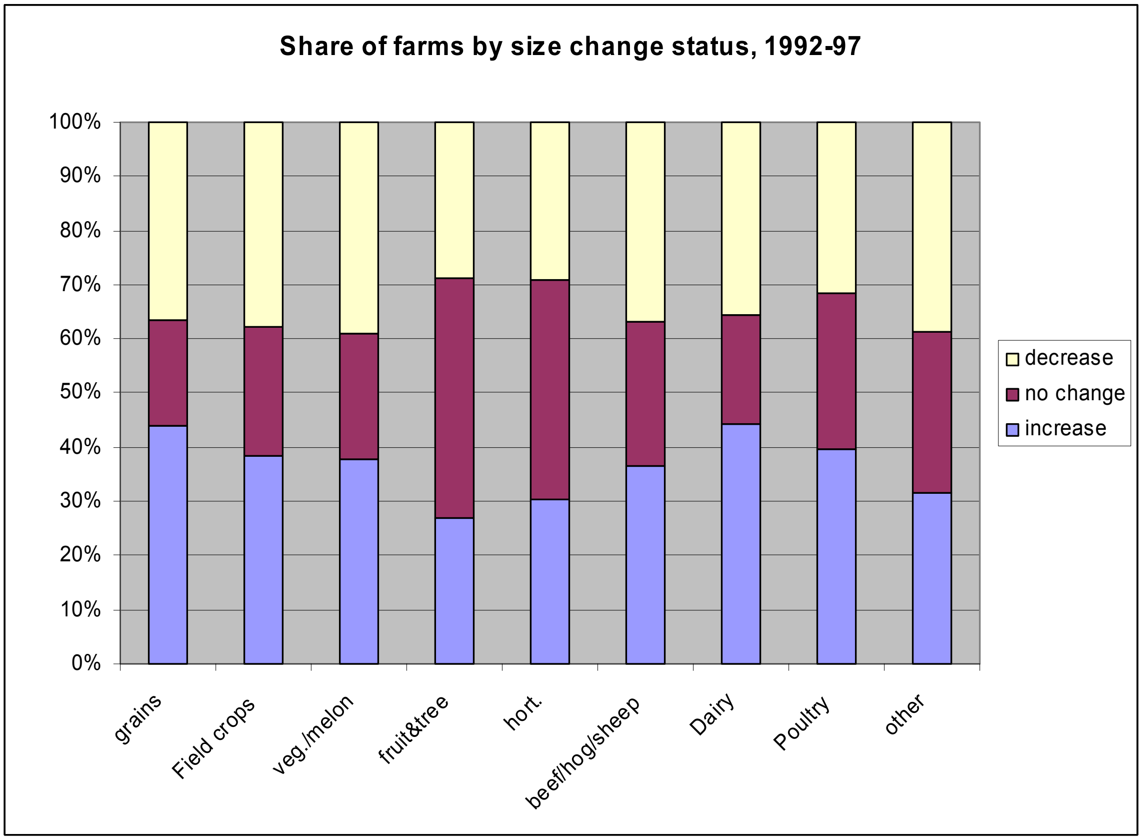
Source: Censuses of Agriculture, various years.

Figure 3.



Source: Censuses of Agriculture, various years.

Figure 4.



Source: Census of Agriculture.