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Government Payments and Farmland Concentration

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Abstract. Over the last twenty five years commodity crop farms have steadily declined in number and grown in average size, and production has shifted to larger operations. During the same period, the share of agricultural payments going to large farms has increased, in large part because payments are tied to actual or historical crop production. This study evaluates whether payments from federal farm programs may have contributed to the concentration of farmland. Using zip code-level data constructed from the micro files of the 1987-2002 Agriculture Censuses the study estimates the association between government payments per acre and subsequent growth in weighted median farmland area. A semi-parametric generalized additive model controls for location and initial concentration levels, and narrows comparisons to nearby zip codes with similar average farm sizes. Findings indicate, both with and without spatial controls, that government payments are strongly associated with subsequent concentration growth.

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1. Introduction

Over the last twenty five years the production of field crops has become increasingly concentrated on larger farms, as measured by acres. In major program crop producing counties, farms with 1,000 to 10,000 acres increased in number by 50 percent between 1978 and 2002, and the total farmland controlled by these large operations increased by almost 48 percent.[1] In contrast, over this period farms with less than 1,000 acres declined in number and amount of farmland controlled. The increasing concentration of agricultural production has resulted in an increasing share of government payments going to large farms: between 1978 and 2002 the share of all payments going to farms with between 1,000 and 10,000 acres increased by 46 percent.

In recent years some have expressed concern that payments unfairly advantage large operations. Some interest groups, politicians, and newspaper editorials have argued that government payments are a key factor contributing to the steady growth in average farm size and concentration of production (e.g., Becker, 2001; Nelson, 2002; Williams-Derry and Cook, 2000). Concerns about the link between agricultural payments and farm size growth have helped motivate congressional efforts to tighten payment caps on large-scale producers (USDA, 2003).[2]

Claims that government payments unfairly advantage large farms are usually supported with statistics that show the steady growth in farm size and the strong association between farm size and payment levels. However, while government payments and production have both become increasingly concentrated, this concurrence of trends does not prove a causal relationship between payments and farm size. The design of government programs that give rise to payments are such that payment levels are tied to the amount of land being farmed or to the production history of the land. Consequently, the association between increasing concentration of farm size and farm payments is caused, at least in part, by expanding farm size, which could

[1] The source and construction of the statistics cited in this paragraph are described in detail in the third section.
[2] In 2002, a Senate amendment to cap payments at $275,000 per farm was dropped in conference with the House. Efforts to limit payments continued in 2003, when the Grassley-Dorgan payment limits bill that would have limited annual farm subsidy payments to $250,000 ($500,000 for a couple) was introduced (and later dropped). In 2005, President Bush proposed payment caps legislation similar in scope to Grassley-Dorgan bill.

be driven by factors other than the distribution of government payments (MacDonald, Hoppe and Banker, 2005).

To what extent are government agricultural programs and their associated payments contributing to the concentration of production? Most studies that have attempted to explain changes in the size and survival of individual farms based on characteristics of the farm operator or farm have not considered the role of government payments (Sumner and Leiby, 1987; Hallam, 1993; Zepeda, 1995; Weiss, 1999; Kimhi and Bollman, 1999). An exception is a recent study by Key and Roberts (2006) that found that the level of government payments has a significant positive effect on the survival rate and duration of individual farm businesses. However, their study, and more generally any study analyzing the effects of payments on the growth or survival of individual farms, cannot predict the effects of an increase in payments on aggregate farm structure (e.g. average farm size) because these studies cannot account for the influence of payments on farms entering production. In other words, these studies can test how existing farms respond to payments, but not how potential farmers respond.

Some past studies have estimated the effect of agricultural payments on aggregate measures of farm structure, including the national agricultural bankruptcy rate (Shepard and Collins, 1982), the total number of farms (Tweeten, 1993), and average farm size (Huffman and Evenson, 2001). While taking very different approaches, these studies have treated government payments as exogenous and have used current payments to explain current indicators of farm structure. A problem with this approach is that it is difficult to attribute a causal mechanism to an observed cross-sectional association between payments and farm concentration. To do so requires confidence that factors other than agricultural payments that affect farm structure are adequately controlled for. A particular concern is the great heterogeneity of land and farms across regions in the U.S. For example, if one finds larger farms in areas with higher payments, the association might be due to government programs targeting particular field crops that require more land to be profitably farmed. Moreover, causation might go in the opposite direction:

larger farms might have higher rates of participation in government programs and therefore receive higher payment levels.

This study compares payment levels to subsequent percentage *changes* in land concentration at the zip code level. That is, we examine whether concentration *growth rate* is higher in zip codes with higher historical payment levels relative to zip codes with lower payment levels. Even if programs happen to target farms that are larger due to the nature of the crops they grow, there is no obvious reason to expect programs to target farms inclined to subsequently grow faster over time. In other words, a correlation between payments and the subsequent change in land concentration is unlikely to result from reverse causality.

The study also uses a semi-parametric generalized additive model to control for location (using a two-dimensional non-parametrically estimated spatial surface) and beginning concentration levels (using one-dimensional non-parametric surface). The spatial regression analysis narrows the comparisons to nearby locations that are likely to be similar in many respects besides payments, including land quality, climate, distance to markets, etc. Local variation in payment levels stem in part from a longer history of participation and planting decisions, which likely varied depending on heterogeneous expectations and participation costs of past farm operators.

Land concentration is measured at the zip code level. Farmland concentration is defined as the acre-*weighted median farm size*: the farm size such that half the farmland within each zip code resides on larger farms and half resides on smaller farms. The analysis uses micro data from the 1987, 1992, 1997, and 2002 Agricultural Censuses and includes all U.S. zip codes with at least three farms.[3] The zip code analysis improves upon national, state, or county level analyses by providing more observations and more variation across observations in concentration and

[3] More precisely, every zip code where at least three farm operators responded to the Census in each of the four Census years. To protect the confidentiality of farmers' responses, the data were analyzed on site at the USDA's National Agricultural Statistical Service (NASS), the agency that administers the Agricultural Census. More information about the Census of Agriculture can be found at: http://www.nass.usda.gov/census/.

payment levels. Sufficient variation at a local level is important when using an empirical technique that controls for factors that vary geographically, as is clearly the case for agriculture.

The paper is organized as follows. The next section reviews the theoretical links between farm business growth and survival and between government payments and farm structure. We then use data from the Census of Agriculture to provide an overview of farm structure changes using data from 1978 to 2002. The section illustrates how average farm size and concentration has changed over time for commodity crop producers historically targeted by government agricultural programs, discusses alternative statistical measures of farm concentration, and argues that the "weighted median" farm size is superior to the mean or median farm size for the purpose of characterizing concentration of agricultural production. The remaining sections discuss the empirical approach, data, results, and conclusions.

2. Determinants of Concentration: Farm Size and Survival

Because the amount of U.S. farmland has remained relatively stable over time, changes in land concentration are ultimately linked to farm size and survival (Vesterby et al., 2006). The literature on firm size and survival therefore provides some insight into the determinants of farm structure. In this literature, the relationship between firm size and survival is often modeled as a dynamic process wherein firms (or entrepreneurs) are uncertain about their own competitiveness at startup (Jovanovic, 1982; Ericson and Pakes, 1992; and Pakes and Ericson, 1998). In these models, firms gradually learn about their abilities over time and the longer they operate, the more they learn about their competitiveness. As managers revise their perceptions of their firm's ability upward, they tend to expand, while those revising downward tend to contract or exit. Thus, the longer a firm has existed, the bigger it will become and the less likely it will be to fail. Empirical studies generally confirm these theoretical predictions (Dunne, Roberts and Samuelson, 1988; Baldwin and Gorecki, 1991; Audretsch, 1992; Audretsch and Mahmood, 1995; among others).

In general, theory does not provide unambiguous predictions as to how a change in government payments would influence farm growth and survival. Consider, for example, a model of a representative farm where the quantity of agricultural land is fixed, but labor and capital are mobile between agricultural and non-agricultural sectors (Kislev and Peterson, 1983). In this model, farm size is ultimately linked to the ratio of wages to the cost of capital. Thus, an increase in government payments increases returns to farming, but these additional profits are capitalized into the price of land. Hence, a change in government payments has no clear direct effect on the cost of labor relative to capital, and therefore has no effect on farm size.

In more complex economic models that allow for transaction costs and a range of farm sizes, there arises a variety of mechanisms through which payments could influence farm structure. For example, if *per-acre* payments are unequally distributed across farms of different sizes then an increase in payments could alter farm structure. Such a pattern may arise if there are fixed transactions costs associated with participation, so that larger farms have a stronger incentive to participate than smaller farms do. Higher payments per-acre for a particular farm size group would allow this group to expand and bid up the prices of fixed resources – especially land –and cause other size farms to shrink or exit.

An unequal distribution of *total* payments might also influence farm size and survival through capital or labor market mechanisms. Borrowing constraints could cause a farm's cost of capital to depend on its net worth: farms with greater net worth face lower borrowing costs because they have more resources with which to secure a loan (e.g., Hubbard, 1998). If this were the case, an increase in income from government payments would raise the net worth of a farm, making it less costly for a farmer to obtain financing to increase farm size. If large farms are credit constrained and small farms are not then an increase in payments causes large farms to expand and increase in number, which bids up land prices and causes small farms to shrink and decline in number (Key and Roberts, 2005). If both large and small farms are credit constrained, then the effect of an increase in government payments on farm size and survival is ambiguous.

Total payments may also influence farm size and survival by altering farm operator labor-leisure decisions through a wealth effect combined with transactions costs. Payments could encourage the farmers receiving them to work less; and if there are transaction costs associated with hiring labor or finding employment, higher payments may cause a reduction in the supply of farm labor (Lopez, 1984; Strauss, 1986). Less farm labor could mean less production and a smaller farm. However, under certain conditions, a higher shadow wage for farm labor could mean greater capital utilization and thus an increase in farm size, as in Kislev and Peterson.[4]

3. Trends in Concentration and Government Payments

This section provides an overview of farm structural changes over the past quarter century and argues that the "weighted median" farm size is superior to the mean or median farm size for the purpose of characterizing concentration of agricultural production.

Table 1 illustrates structural change from 1978 to 2002 in agricultural areas in counties where land harvested in the major program commodities represented most cropland harvested.[5] Restricting the Census information in this way limits the total number of counties to 765, and between 655,482 and 882,546 farms (about half of all those reporting), depending on the year. The table shows a marked increase in the prevalence of farms with between 1,000 and 10,000 acres. Between 1978 and 2002, these large farms increased from 4.6 to 9.3 percent of all farms and increased their share of total farmland from 28.6 to 46.5 percent. The growth in the number of these large farms came mainly at the expense of farms with between 50 and 500 acres, which shrank as a share of farmland and farms. Farms with less than 50 acres represented a larger share of all farms (24.2 percent) in 2002 than they did in 1978 (21.0 percent), though they

[4] Kislev and Peterson held total labor supply fixed to obtain the result that farm size was linked only to the relative costs of labor and capital.

[5] Specifically, we include those counties where land harvested in barley, corn (grain), cotton, hay, oats, rice, sorghum (grain), soybean, and wheat as measured by NASS represented between 90 and 110 percent of the total land harvested in the county as measured by the census in 1987, 1992 and 1997. The reported land harvested in the commodity crops from NASS occasionally exceeded that recorded in the Census. This could have resulted from doublecropping - two crops being planted in one field per year.

decreased in number and share of land farmed over this period. Farms with more than 10,000 acres of farmland, declined slightly, though their share of all farmland increased slightly.

Table 2 presents four measures of the representative farm size from 1978 to 2002 for all farms, and for farms with fewer than 10,000 acres. For all farms, mean farm size increased by one-third from 336 acres in 1978 to 449 acres in 2002. However, median farm size actually declined by 8 percent over this period: falling from 160 to 147 acres. The decline in median farm size reflects the relative increase in the number of very small farms that was discussed above.[6]

The *acre-weighted mean* and the *acre-weighted median* are alternative indicators of land concentration. The weighted mean farm size effectively averages farm sizes over acres rather than over farms. The acre-weighted median is the size of a farm such that half of all farmland is controlled by larger farms and half by smaller farms. The weighted mean and weighted median are much larger than the unweighted averages, reflecting the fact that large farms control most of the farmland. Table 2 shows that for all farms, the weighted mean declines slightly between 1978 and 2002, but the weighted median almost doubles. The weighted median indicates that in 1978 half of all farmland was controlled by farms larger than 690 acres. By 2002, half of all farmland was controlled by farms having at least 1360 acres.

Comparing all farms to farms with less than 10,000 acres (bottom of table 2), we find similar patterns over time for the mean, median, and weighted median (the levels are smaller but the changes over time are similar). However, the weighted mean, which is more sensitive to outliers, displays a different trend: excluding the very large farms, the weighted mean farm size increased by 44 percent from 1313 acres in 1978 to 1887 acres in 2002.

The analysis of changing land concentration in the next section uses the weighted median as the measure of land concentration because it tracks concentration better than the mean and median when the farm size distribution is highly skewed and because it is less sensitive to

[6] The decline in median farm size, despite the increasing concentration of farmland on large operations, might be explained in part by the USDA's definition of a farm as: "Any place from which $1,000 or more of agricultural products (crops and livestock) were sold or normally would have been sold during the year under consideration." The $1,000 figure has remained unchanged since the 1974 Census. If adjusted for inflation using the CPI, the comparable number for 2002 would be $3800.

outliers than the weighted mean.[7] The weighted median is also a standard measure of concentration within the industrial organization literature (e.g., Hart and Clarke p. 43).

Government Payments

Table 3 illustrates trends in the level of government payments by farm size category beginning in 1987, when payments data are first available from the Census of Agriculture. Government payments are defined as total payments received for participation in Federal farm programs net of payments received for participation in the Conservation Reserve Program and the Wetlands Reserve Program.[8] The level of government payments is closely associated with farm size in all observed periods. Mean government payments per farm increases with farm size up to 10,000 acres. In 2002, farms with 1,000-10,000 acres, received a median payment of $14,809 – more than double the median payment received by farms with 500-1,000 acres, and about ten times the median payment received by farms with 150 to 500 acres. While the nature and level of farm payments has changed over time, the level of payments received by large farms continues to represent a sizeable contribution to farm household income. However, over half of all farms with less than 150 acres receive no government payments – a fact that has not changed since 1987.

As large farms produced an increasing portion of total output, they also received an increasing share of government payments. The share of total payments going to farms with between 1,000 and 10,000 acres rose from 30.6 percent of all payments in 1987 to 44.9 percent in 2002. In contrast, farms with between 150 and 1,000 acres received a smaller share of total payments over the same period. Reflecting an increase in the number of small farms, farms with fewer than 150 acres received an increasing share of government payments (increasing from 4.7

[7] Using the weighted mean in the analysis in the next section yielded similar results to the weighted median.

[8] The 1987, 1992, and 1997 censuses asked respondents for the "total amount received for participation in Federal farm programs (not including CCC loans)." Respondents were also asked to provide "how much was received for participation in the Conservation reserve program and Wetlands Reserve Program (CRP and WRP)?" The latter was subtracted from the former to obtain the measure of payments used in this study. In 2002, the amount received for participation in Federal farm programs other than CCC loans, CRP or WRP was asked directly.

percent of the total in 1987 to 8.4 percent in 2002). The share of payments received by farms with more than 10,000 acres also increased.

4. Empirical Methods

This study compares the changes between census periods of the farmland concentration in zip codes with different levels of government payments per acre. Zip codes are assigned to six discrete categories based on payments-per-acre of farmland. Discretely categorizing zip codes by payment levels allows for possible non-linear associations between payments and concentration growth, and mitigates the statistical influence of any single observation or group of observations, making estimates more robust.

We first estimate the simple relationship between concentration growth and the payments-per-acre category:

$$(1) \qquad \Delta c_i = \mathbf{X}_i\boldsymbol{\beta} + \varepsilon_i$$

where subscript i (omitted below to simplify notation) indexes zip codes, Δc is the percentage change in concentration between censuses ($(c_1 - c_0)/ \frac{1}{2}(c_1 + c_0)$), c_0 denotes concentration in the beginning year, $\mathbf{X}$ is a matrix of indicator variables detonating payment-per-acre categories (one element of each row equals 1 and the other elements equal 0), $\boldsymbol{\beta}$ is a vector of payment-category effects and ε is a random error.

Growth in concentration is expressed as a percentage change in order to scale the growth measure relative to initial concentration levels. Differencing controls for time-invariant heterogeneity and, for the two-year panels used here (described below), this is equivalent to using a fixed effect for each zip code area.[9]

[9] The model in levels would be $c_{it} = a_i + \mathbf{X}_{it}\boldsymbol{\beta} + \nu_{it}$, where t indexes the two time periods (0,1) and a_i is zipcode i's fixed effect (time-invariant idiosyncratic variation). Differencing over time gives equation 1, with $\varepsilon_i = \nu_{i1} - \nu_{i0}$. The fixed effect, which is constant over the time periods, drops out.

Although comparison of *changes* in land concentration controls for time-invariant factors that might lead to non-causal associations between farm size and payments, the approach is not infallible. It could be that corn, wheat, and cotton and other crop farms traditionally targeted by programs have coincidently experienced greater growth in concentration for reasons other than government programs. For example, there may have been more technological change in cultivation of these crops as compared to non-program crops. To address this concern, we use a semi-parametric regression, called a *generalized additive model*, to control for zip code location and initial concentration (Hastie and Tibshirani, 1990; Hastie, 1992). This model has been used in a similar fashion by Gibbons (2004) to estimate the costs of urban property crime and by Pope et.al (2002) to estimate health effects of long-term exposure to fine particulate air pollution, among many other applications. To our knowledge there have been no applications of this model in agricultural economics.

With controls, the model has the form:

$$(2) \qquad \Delta c_i = \mathbf{X}_i\boldsymbol{\beta} + f(x_i, y_i) + g(c_{0i}) + \varepsilon_i$$

where $f(x,y)$ is a smooth function of zip code centroids (x, y), $g(c_0)$ is a smooth function of c_0. One may think of the smooth surface $f(x, y)$ as 'smoothed' location fixed effects. Using state fixed effects would create false discontinuities at zip codes near state borders, which could create bias. The smooth non-parametric surface eliminates sharp discontinuities in fixed effects between adjacent zip codes. Similarly, we estimate a smooth function of beginning concentration levels $g(c_0)$.

The smooth functions were estimated using "loess", short for "local polynomial regression," which fits the smooth functions by estimating polynomial functions using points local to each fitted point, with local points weighted more heavily than further points. The smooth functions are estimated jointly with β using a Gauss-Seidel backfitting method, as described and implemented by Hastie. See this reference for more details about the procedure.[10]

The key modeling decision concerns the share of points considered local to each fitted point on the smooth functions. For our models, each point on the smooth spatial surface was estimated using 5 percent of the zip codes, which is the smallest share that was computationally feasible for the two-dimensional spatial surface. For consistency, we used the same share for the one-dimensional concentration function. The software package used was the public domain package 'R' with the 'gam' package by Hastie (see www.r-project.org).

With respect to the control variables (location and initial concentration) the generalized additive model is very flexible. A potential shortcoming to using such a flexible model is that it can use so many degrees of freedom that it is not possible to identify the model. This is not a problem in our application because we have many observations (21,922 zip codes in each panel). A second possible shortcoming is the lack of parametric structure, which can make reporting tangible results difficult. For this application, this feature is a strength rather than a weaknesses. The purpose of using these non-parametric controls is to check the robustness of our estimates to specification of the controls, so making the controls as flexible as possible lends greater credibility to the estimated effects of payments.

There are likely two principle sources of the variation in payments per-acre across zip codes that allow us to identify the effect of payments on concentration growth. One source is broad regional differences in crop mix and yields – some crops have higher associated payments than others and areas with historically higher yields receive higher payments. The non-parametric functions of location and initial farm size likely remove most variation in payment levels caused by differences in crop mix and yield. The second source of variation, much of which remains after controls for location and farm size, is differences in historical patterns of

[10] Briefly, the backfitting algorithm first fits the parametric components of the model and then uses the residuals to estimate the first additively separable non-parametric function; the residuals from non-parametric estimates are then used to estimate the second non-parametric function; the parametric components are then re-estimated by subtracting the fitted values of the two non-parametric function from the dependent variables; and so on, iterating until estimated values on successive iterations converge.

participation in government programs. In the late 1980's, program participation came with many restrictions: it required farmers to limit their plantings to a share of acres historically planted and required a certain portion to be set-aside (left fallow). Farmers with environmentally fragile land (e.g., highly erodible) were required to follow certain management practices to limit environmental damages stemming from their cropping activities.[11] These costly participation restrictions limited participation somewhat. Some farmers may have strategically chosen not to participate in order to build 'base' (payment-qualifying) acres in anticipation of higher future payments. Because payments are tied to historical plantings, and participation required farmers to limit plantings, some may have chosen not to participate in order to expand acreage and expected future payments. Because payments in future years were tied to historical plantings and participation, and historical participation varied somewhat across producers, so do payments.[12] The second source of identification differs markedly from the first source and does not have obvious links to non-payment drivers of growth. By estimating the relationship between payments and concentration growth with and without the controls, we are able to consider two sources of identification.

5. Data

Measures of land concentration and government payments are constructed at the zip code level using individual farm-level data from the Census of Agriculture. The zip code is used as the unit of analysis because it is the smallest geographic area that can be associated with individual farms. The data include all zip codes recorded in the Census of Agriculture that had at least three farms in each of the four census years examined (1987, 1992, 1997, and 2002). The analysis begins in 1987 because that is the first year farm-specific data on government payments are available.

[11] See Claasen et al. for a description of these cross compliance provisions.
[12] See Young et. al for a description of government programs and how they have evolved over the last twenty years.

An important consideration when using zip code regions as observational units is that zip codes can change over time (Blodgett, 2005). Most zip code changes have occurred in relatively urban areas that have experienced rapid population growth and where agriculture is less prevalent, which mitigates the importance of the issue somewhat for our analysis. Zip codes usually change by splitting into two or more zip codes, with one of the new areas retaining the old code and the other(s) assigned a new code. Because we restrict our analysis to zip codes appearing in all four censuses, farms in areas where zip codes changed are omitted. Some farms in our analysis may be in zip codes that were split, and therefore decreased in size, between 1987 and 2002. These changes, however, should not be systematically related to payments per acre or the land concentration measure, which do not depend on the size of the zip code region.

The Census of Agriculture reported farms in 32,959 zip codes in 1987, 34,202 in 1992, 34,408 in 1997, and 33,548 in 2002. These counts compare to a nationwide total of about 43,000 zip codes currently in the U.S. Our sample includes 21,922 zip codes for the analysis of farmland concentration. Although our sample drops about one third of all zip codes, it drops a much smaller share of the total number of farms. Our sample includes 1,719,392, 1,527,210, 1,543,905, and 1,343,807 farms in the four sequential Census years, compared to 1,799,926, 1,621,263 1,653,098 and 1,486,895 farms in the raw Census files.

For each zip code, we measure "concentration" as the acre-weighted median farmland - the farm size at the midpoint of the farmland acreage array such that half the acres in the zip code reside on larger farms and half resides on smaller farms. Figure 1 shows zip code frequency distributions of farmland (and cropland) concentration for each of the Census years from 1987 to 2002. The horizontal axis is the natural logarithm of the weighted median farmland and the vertical axis is the estimated density.[13] We use the logarithm of land size because the size distribution of farms is highly skewed and the logarithm is more closely bell-

[13] The distributions were estimated with a kernel density estimator using the software program 'R'(http://r-project.org/). The estimates use the default bandwidth of the function "density," which is 0.9 times the minimum of the standard deviation and the interquartile range divided by 1.34 times the sample size to the negative one-fifth power.

shaped and therefore easier to discern changes at higher end of the distribution. Over time, the distributions shift markedly to the right, particularly above 5 (equivalent to about 150 acres), illustrating the shift in farming to larger operations. For relatively small farm sizes, the distribution changes little. These farms are mainly "residential lifestyle" farms with little production and little or no government payments.

For each zip code, the measure of the potential influence of government programs is total payments divided by total farmland area. Defining the payment level on a per-acre basis creates a standardized measure that is not sensitive to zip code size – which varies widely across the U.S.

We organize the data into three five-year panels corresponding to the time between censuses (1987-1992, 1992-1997, and 1997-2002). We also construct a "long panel" by averaging the values of all three panels (1987-2002). Zip codes are sorted into six groups according to payment per acre in the initial year of the two-period panels (1987, 1992, and 1997). The first group includes those zip codes with zero government payments; the remaining zip codes are sorted into five equal-sized quintiles. For the long panel, zip codes are sorted into similar groups, except according to the three-period average of initial payments.[14] Table 4 reports the portion of zip codes, farms and land in each of the payment groups.

6. Results

Table 5 illustrates how initial government payments per acre are associated with subsequent changes in farmland concentration for the three panel periods. For example, the first row shows how farmland concentration changed between 1987 and 1992 according to 1987 payments per-acre category. The table also illustrates the long run relationship between payments and land concentration by comparing average payments per acre for each zip code in 1987, 1992 and 1997 with average percentage growth in concentration from 1987-1992, 1992-1997, and 1997-2002.

[14] Before averaging payments, they were put into constant dollars using the consumer price index. Using nominal dollars or dollars deflated by the producer price index has little influence on the results.

All the panels generally indicate increasing concentration growth for higher payment levels, and the relationship is strongest and clearest in the fifteen-year panels. In the long panels, zip codes are more likely to be classified into their appropriate payment group (since payments can vary from year to year and in the long panel payments are averaged over three years rather than a single year). Consequently, the long panels might provide the most reliable information about the relationship between payments and concentration.

Table 6 reports estimated concentration growth rates for the same panels and groups as table 5, except the estimates include controls for beginning-year concentration levels and location using the generalized additive model. As compared to table 5, these estimates restrict comparisons between proximate zip codes that have similar initial concentration rates. The addition of controls changes the estimates somewhat, but a similar pattern remains. For farmland, the estimated difference in concentration between the first and fifth quintiles decreases from 33.2 to 27.2 percentage points.

A summary of the fitted model is reported in table 7, excluding the parametric components, which are reported in table 5. The F-values indicate that the null hypothesis that the smoothed functions should not be included in the model is strongly rejected.[15]

Assuming we can interpret the association between payments and concentration growth as causal, how much of the observed concentration change would be attributed to payments from agricultural programs? Answering requires an estimate of how much concentration would have grown without payments. Results from table 6 imply that if there were no payments, farmland concentration would have declined by about 8 percentage points between 1987 and 2002. This estimate may be misleading, however, because there are relatively few zip codes with no payments, and these zip codes are likely quite different from those with positive payments –

[15] The F-tests use "nonparametric degrees of freedom" which may be interpreted as the equivalent number of parameters required for the estimated smooth function. More formally, the smooth function can be formulated as a linear combination of the observed responses so that for some matrix *A*, $\hat{\Delta} c = A\Delta c$. Because the matrix *A* serves the same role the projection matrix in linear regression, nonparametric degrees of freedom for the model are defined as the trace of *A*.

which would explain the sharp difference in concentration growth between the zero payment group and the first quintile. An alternative way to predict concentration growth in the absence of payments is to extrapolate using information about farms receiving payments. Rather than breaking farms into discrete groups, this approach assumes that the effect of payments on concentration varies linearly with payments. The linearity assumption seems reasonable given the proportionately increasing effect of payments across payment quintiles. To this end, we estimate the model:

$$(3) \qquad \Delta c_i = \alpha + \beta p_i + f(x_i, y_i) + g(c_{0i}) + \varepsilon_i \,,$$

where p_i indicates payments per acre in zip code i, β is the average marginal effect of payments on concentration growth, and the rest of the model is as specified as in (2). To predict concentration in the absence of payments, we multiply the estimate of β by the average value of p_i and subtract this amount from the average predicted concentration growth.

The linear extrapolation implies that, in the absence of payments, average farmland concentration would have increased by 7.9 percent in the absence of payments as compared to an observed growth of 17.4 percent, so payments explain more than half the growth.[16]

7. Conclusions

Agricultural structural change over the last few decades can be characterized, in part, by crop production shifting to larger operations. The share of total farmland controlled by large-scale operations has steadily increased, while the share controlled by medium-scale operations has

[16] The zip code farmland concentration growth (17.4 %) is considerably smaller than the concentration growth reported in table 2 (63.9 % between 1987 and 2002). One reason for the apparent discrepancy is that the statistics reported in table 2 are only for farms in counties where a considerable portion of the land is in commodity crops historically targeted by government programs, whereas the zip code analysis includes all of the U.S. As we have shown, the targeted areas have experienced far more concentration growth than other agricultural areas. A second reason for the discrepancy is that the weighted median is estimated for all farms in table 2, whereas it is averaged over zip codes in the regression analysis.

declined. Though many factors likely contribute to the increased concentration of land, including changes in technology and factor prices, concerns have been expressed that government payments to farmers have contributed to this phenomenon.

This study is the first to examine the effect of agricultural payments on subsequent changes in farm size using fine-scale regional (zip code) panel data. The analysis considers two plausibly exogenous sources of variation in government payments: 1) broad regional variation crop types and yields caused by soil and climate variation, and 2) local variation resulting from differences in 'base acreage' (program participation). The very large data set – the sample of all agricultural zip codes with three or more farms - permits comparisons across very similar regions using a semi-parametric spatial regression analysis that controls for location and initial land concentration. By examining how payments affect subsequent concentration change, the approach controls for time-invariant factors that might be correlated with government payments and structural change. While payments could be correlated with farm size for a number of reasons, it is less likely that payments would be spuriously correlated with farm size growth, especially after controlling for location and initial farm size. However, it is not possible to know with certainty whether there remain factors that have not been controlled for. This is a standard caveat to measuring program effects when program participation is not randomly assigned.

Findings indicate that both broadly and locally, there is a strong positive association between government payments and the subsequent change in farm concentration (as measured by the acre-weighted median farmland). The evidence is striking, particularly because the marginal association between payments and concentration growth remains even when comparing nearby zip codes having similar initial concentration measures.   The study also finds that government payments explain about half of the observed growth in farmland concentration.

Because the relationship between payments and concentration growth is maintained after including flexible non-parametric controls, it is not clear what omitted variables could confound a causal interpretation of these results. However, it is equally difficult to pin down the fundamental economic forces that appear to create a link between payments and concentration growth. One possibility is that there are significant increasing returns to scale in agricultural production and that government payments, which provide cash and perhaps also a means to leverage greater resources from lending institutions, relieve liquidity constraints and allow some farms to transition more quickly to an efficient scale. This explanation would be consistent with studies finding increasing returns to scale (e.g., Morrison Paul and Nehring, 2005; Morrison et al., 2004) and liquidity constraints in agriculture (e.g., Bierlen and Featherstone, 1998; Hubbard and Kashyap, 1992; Barry, Bierlen and Sotomayor, 2000; Roberts and Key, 2002).

Because this is the first study to examine the relationship between payments and subsequent concentration growth, it is prudent to consider alternative explanations for these findings. For example, some of the local variation in payments may be due to local variation in program "base yields," which were fixed in 1985. Areas with higher base yields probably also have better land quality (flatter, more fertile soil, etc.). If scale-enhancing technological change favored higher quality land relative to lower quality land for same crop, this may provide an alternative explanation for our findings at the local level. However, technological change would also have to favor higher-valued field crops relative to lower-valued crops (e.g., cotton over corn over wheat) to explain the observed association at a broader level. A technological effect of this kind would seem coincidental, but given magnitude and novelty of these findings, this and other explanations are worth exploring.

If the findings are not spurious—that is, if there is indeed a causal effect of payments on concentration growth—they suggest that a cap on total payments may reduce the rate of land concentration with a commensurate reduction in the growth of farm sizes. The normative implications of such a policy remain unclear, however. For example, if liquidity constraints coupled with increasing returns to scale provide the fundamental explanation for these findings (one of several possible explanations), this suggests a payment cap would reduce production efficiency. A complete assessment of such a policy would need to balance the loss in efficiency against any perceived social benefits resulting from a reduction in concentration growth.

Although our findings may indicate the magnitudes of the potential tradeoffs, they do not measure the social benefits of such a policy.

The change in concentration from one period to the next depends on the size of farms that survive, how much they grow if they survive, and on the sizes of new, entering farms. Future work could try to develop a better understanding of how payments might be leading to higher concentration levels by examining how payments affect the probability of individual farm survival, the expected size of the farm if it does survives (how much it grows over time), the probability that potential farmers begin farming, and the scale of new farms. These farm-level analyses would complement the findings of the zip code-level analysis and provide further insight into how payments alter farm structure.

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Table 1. Farmland and Number of Farms by Farm Size Category, 1978-2002

Farmland Categories	1978	1982	1987	1992	1997	2002	Pct. Change 1978-2002
0-50 Acres							
Farmland (m. ac.)	3.540	3.505	3.115	2.932	3.091	2.984	-15.7
(Percent of total)	(1.4)	(1.5)	(1.3)	(1.3)	(1.3)	(1.3)	-7.1
Farms	184,964	208,751	195,166	185,833	177,248	158,590	-14.3
(Percent of total)	(21.0)	(25.3)	(23.7)	(24.5)	(24.5)	(24.2)	15.4
50-150 Acres							
Farmland (m. ac.)	19.224	16.980	15.386	13.770	13.826	12.230	-36.4
(Percent of total)	(7.4)	(7.1)	(6.4)	(5.9)	(5.9)	(5.2)	-29.9
Farms	233,477	220,530	208,745	192,031	188,831	165,998	-28.9
(Percent of total)	(26.5)	(26.8)	(25.3)	(25.4)	(26.1)	(25.3)	-4.3
150-500 Acres							
Farmland (m. ac.)	80.933	70.563	62.777	54.118	48.904	41.773	-48.4
(Percent of total)	(31.0)	(29.5)	(26.2)	(23.2)	(21.0)	(17.6)	-43.1
Farms	335,455	304,701	288,292	250,943	226,091	195,104	-41.8
(Percent of total)	(38.0)	(37.0)	(35.0)	(33.1)	(31.3)	(29.8)	-21.7
500-1,000 Acres							
Farmland (m. ac.)	51.318	48.798	50.607	47.585	44.788	39.874	-22.3
(Percent of total)	(19.7)	(20.4)	(21.2)	(20.4)	(19.2)	(16.8)	-14.4
Farms	86,472	80,192	88,233	82,321	79,409	73,170	-15.4
(Percent of total)	(9.8)	(9.7)	(10.7)	(10.9)	(11.0)	(11.2)	13.9
1,000-10,000 Acres							
Farmland (m. ac.)	74.573	73.224	78.441	85.404	93.573	109.984	47.5
(Percent of total)	(28.6)	(30.6)	(32.8)	(36.6)	(40.2)	(46.5)	62.5
Farms	40,789	37,840	42,409	45,071	50,337	61,218	50.1
(Percent of total)	(4.6)	(4.6)	(5.1)	(6.0)	(7.0)	(9.3)	102.1
10,000+ Acres							
Farmland (m. ac.)	31.166	29.204	28.862	29.704	28.753	29.863	-4.2
(Percent of total)	(12.0)	(12.2)	(12.1)	(12.7)	(12.3)	(12.6)	5.6
Farms	1,389	1,144	1,175	1,282	1,221	1,402	1.0
(Percent of total)	(0.16)	(0.14)	(0.14)	(0.17)	(0.17)	(0.21)	35.9
Total farmland (m.ac.)	260.754	242.273	239.187	233.514	232.935	236.709	-9.2
Total farms	882,546	853,158	824,020	757,481	723,137	655,482	-25.7

Source: Census of Agriculture. Sample includes farms located program crop producing counties (see text for details).

Table 2. Representative Farm Size, Various Measures, 1978-2002

	1978	1982	1987	1992	1997	2002	Pct. Change 1978-2002
All farms							
Mean	336.0	338.3	361.9	389.9	401.0	449.0	33.7
Median	160	153	158	157	148	147	-8.1
Weighted Mean	9588.4	9498.4	9573.5	9703.1	9909.0	9148.7	-4.6
Weighted Median	690	743	830	968	1080	1360	97.1
Farms < 10,000 Ac.							
Mean	296.8	298.6	319.5	342.2	353.1	394.9	33.1
Median	160	153	157	156	147	146	-8.8
Weighted Mean	1313.3	1344.4	1393.9	1529.9	1632.3	1887.2	43.7
Weighted Median	567	609	685	790	880	1100	94.0

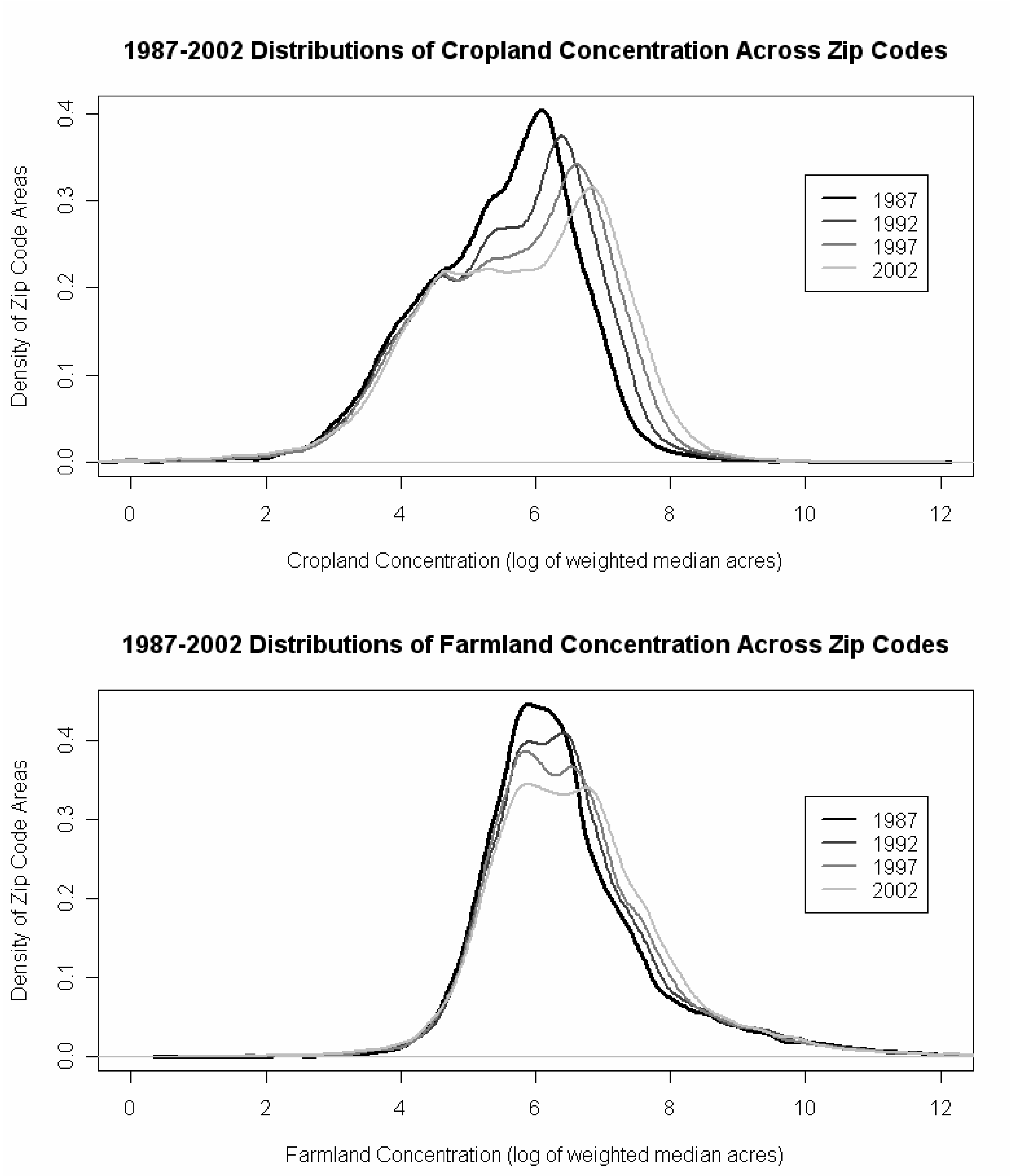
Source: Census of Agriculture. Sample includes farms located program crop producing counties (see text for details).

Table 3. Government Payments by Farm Size Category, 1987-2002

Farmland Categories	1987	1992	1997	2002	Pct. Change 1987-2002
0-50 Acres					
Mean ($)	190.1	113.9	309.4	383.0	101.5
Median ($)	0	0	0	0	0.0
Sum (m. $)	29.3	16.2	43.8	50.3	71.6
(Percent of total)	(0.7)	(0.8)	(2.1)	(2.0)	201.5
50-150 Acres					
Mean ($)	1067.7	525.7	926.0	1198.0	12.2
Median ($)	0	0	0	0	0.0
Sum (m. $)	176.0	77.8	138.7	159.6	-9.3
(Percent of total)	(4.0)	(3.9)	(6.5)	(6.4)	59.4
150-500 Acres					
Mean ($)	6140.1	2593.0	3084.8	3794.9	-38.2
Median ($)	3100	650	1553	1454	-53.1
Sum (m. $)	1394.8	507.2	548.6	577.7	-58.6
(Percent of total)	(31.6)	(25.6)	(25.9)	(23.0)	-27.2
500-1,000 Acres					
Mean ($)	19346.7	8147.4	8678.0	9611.4	-50.3
Median ($)	15435	6475	7100	6736	-56.4
Sum (m. $)	1429.1	563.0	561.1	548.7	-61.6
(Percent of total)	(32.4)	(28.4)	(26.5)	(21.9)	-32.5
1,000-10,000 Acres					
Mean ($)	34302.5	18500.0	17521.7	21727.1	-36.7
Median ($)	27000	13620	14000	14809	-45.2
Sum (m. $)	1350.9	787.8	804.4	1125.5	-16.7
(Percent of total)	(30.6)	(39.8)	(38.0)	(44.9)	46.4
10,000+ Acres					
Mean ($)	23753.8	21532.6	16806.0	34057.6	43.4
Median ($)	0	1500	1800	11406	-
Sum (m. $)	27.9	27.6	20.5	46.6	66.9
(Percent of total)	(0.6)	(1.4)	(1.0)	(1.9)	193.3
Total payments (m. $)	4408.0	1979.6	2117.1	2508.5	-43.1

Source: Census of Agriculture. Sample includes farms located program crop producing counties (see text for details).

Figure 1. Probability distributions of average zipcode farm size (weighted-median cropland and farmland)



Source: Census of Agriculture. Sample includes all zip codes with at least three operations reporting in every year.

Table 4. Distribution of Zip Codes, Farms, and Farmland by Payments-Per-Acre Category

Panel Years	Payments per Acre of Farmland in Beginning Year					
	No Payments	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
1987-1992						
Payments per acre	0	0.01-1.06	1.07-4.18	4.19-10.90	10.91-22.41	>22.41
% of zip codes	9.4	18.1	18.1	18.1	18.1	18.1
% of farms	2.3	15.8	19.7	20.0	21.1	21.1
% of farmland	3.5	21.7	17.7	19.5	20.2	17.4
1992-1997						
Payments per acre	0	0.01-0.65	0.66-2.12	2.13-4.87	4.88-9.29	>9.29
% of zip codes	10.7	17.9	17.9	17.9	17.9	17.9
% of farms	2.8	18.1	20.4	19.5	20.6	18.7
% of farmland	2.1	22.6	18.4	18.6	20.0	18.3
1997-2002						
Payments per acre	0	0.01-0.58	0.59-1.98	1.99-4.69	4.70-9.11	>9.11
% of zip codes	9.8	18.0	18.0	18.0	18.0	18.0
% of farms	2.5	16.5	20.2	20.1	21.1	19.7
% of farmland	2.7	24.1	17.5	19.4	19.3	17.0
Long panel						
Payments per acre	0	0.01-0.82	0.83-2.71	2.72-6.73	6.74-13.92	>13.93
% of zip codes	3.0	19.4	19.4	19.4	19.4	19.4
% of farms	0.1	14.9	20.4	19.8	21.4	23.0
% of farmland	0.4	23.8	18.6	18.2	20.0	19.0

Source: Census of Agriculture. Sample includes all zip codes with at least three operations reporting in every year.
Note: Payments in 1997 dollars using the consumer price index. For the Long Panel, payments per acre are the average of 1987, 1992, and 1997 payments per acre, adjusted to 1997 dollars before averaging.

Table 5. The Percentage Change in Zip Code Farmland Concentration (Weighted-Median Farmland) by Payments Per-Acre Category without Controls

	Payments per Acre of Farmland in Beginning Year					
Panel Years	No Payments	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
1987-1992						
Concentration change (%)	5.5	-0.1	4.6	6.6	10.4	14.4
(Standard error)	(1.2)	(0.8)	(0.8)	(0.8)	(0.8)	(0.8)
1992-1997						
Concentration change (%)	1.0	-4.3	-2.7	2.4	6.0	10.3
(Standard error)	(1.1)	(0.9)	(0.9)	(0.9)	(0.8)	(0.9)
1997-2002						
Concentration change (%)	2.2	1.4	3.6	7.7	12.9	15.0
(Standard error)	(1.2)	(0.9)	(0.9)	(0.9)	(0.9)	(0.9)
Long panel (1987-2002)						
Concentration change (%)	-2.4	4.7	6.1	12.5	26.1	37.9
(Standard error)	(2.7)	(1.1)	(1.1)	(1.1)	(1.1)	(1.1)

Source: Census of Agriculture. Sample includes all zip codes with at least three operations reporting in every year.
Note: Concentration is defined as the weighted median farmland in each zip code (see text for discussion). For each zip code and panel, the percent-change in concentration is calculated as 100 times the change in concentration divided by average concentration in the two years considered. For the long panels (1987-2002), the percentage change is calculated as the sum of percentage changes for the individual panels. Payment quintiles are calculated using payments per acre of farmland in the beginning panel year for all zip codes reporting positive government payments in the beginning year. For the long panels, quintiles are calculated using the sum of payments-per-acre in 1987, 1992, and 1997. Because zip codes are sometimes classified into different payment categories in different panels, the percentage change for the long panel may not equal the sum of the individual panels.

Table 6. The Percentage Change in Zip Code Farmland Concentration (Weighted-Median Farmland) by Payments Per-Acre Category with Controls

	Payments per Acre of Farmland in Beginning Year					
Panel Years	No Payments	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
1987-1992						
Concentration change (%)	6.8	11.4	11.6	13	17.7	24.4
(Standard error)	(0.8)	(0.6)	(0.7)	(0.7)	(0.7)	(0.7)
1992-1997						
Concentration change (%)	3.6	11.3	9.9	14.7	19.9	25.6
(Standard error)	(0.7)	(0.6)	(0.7)	(0.7)	(0.7)	(0.7)
1997-2002						
Concentration change (%)	4.1	10.2	7.5	13.3	21.7	28.2
(Standard error)	(0.8)	(0.7)	(0.7)	(0.8)	(0.8)	(0.8)
Long panel (1987-2002)						
Concentration change (%)	-7.8	11.9	6.7	11	24.1	39.1
(Standard error)	(1.4)	(0.8)	(0.8)	(0.9)	(0.9)	(0.9)

Source: Census of Agriculture. Sample includes all zip codes with at least three operations reporting in every year.
Note: See the notes to Table 5 for definitions. This table reports estimated effects of payment quintiles with controls for location and concentration in the beginning year of each panel (see text for details).

Table 7. Summary of GAM Estimates

	Non-parametric Function Initial Farmland Concentration		Location (Spatial Surface)		Goodness of Fit	
	Degrees of Freedom	F-Value	Degrees of Freedom	F-Value	Adj. R^2	Est. $Var(\varepsilon)$
1987-1992	37.6	123.6	72.3	23.1	0.172	0.232
1992-1997	38.0	131.1	72.3	23.9	0.170	0.240
1997-2002	37.9	115.6	72.3	26.7	0.173	0.279
Long panel (1987-2002)	37.6	171.9	72.3	41.2	0.287	0.379

Note: Estimates and standard errors for the parametric components of the models (the payment per acre category fixed effects) are reported in Table 6.