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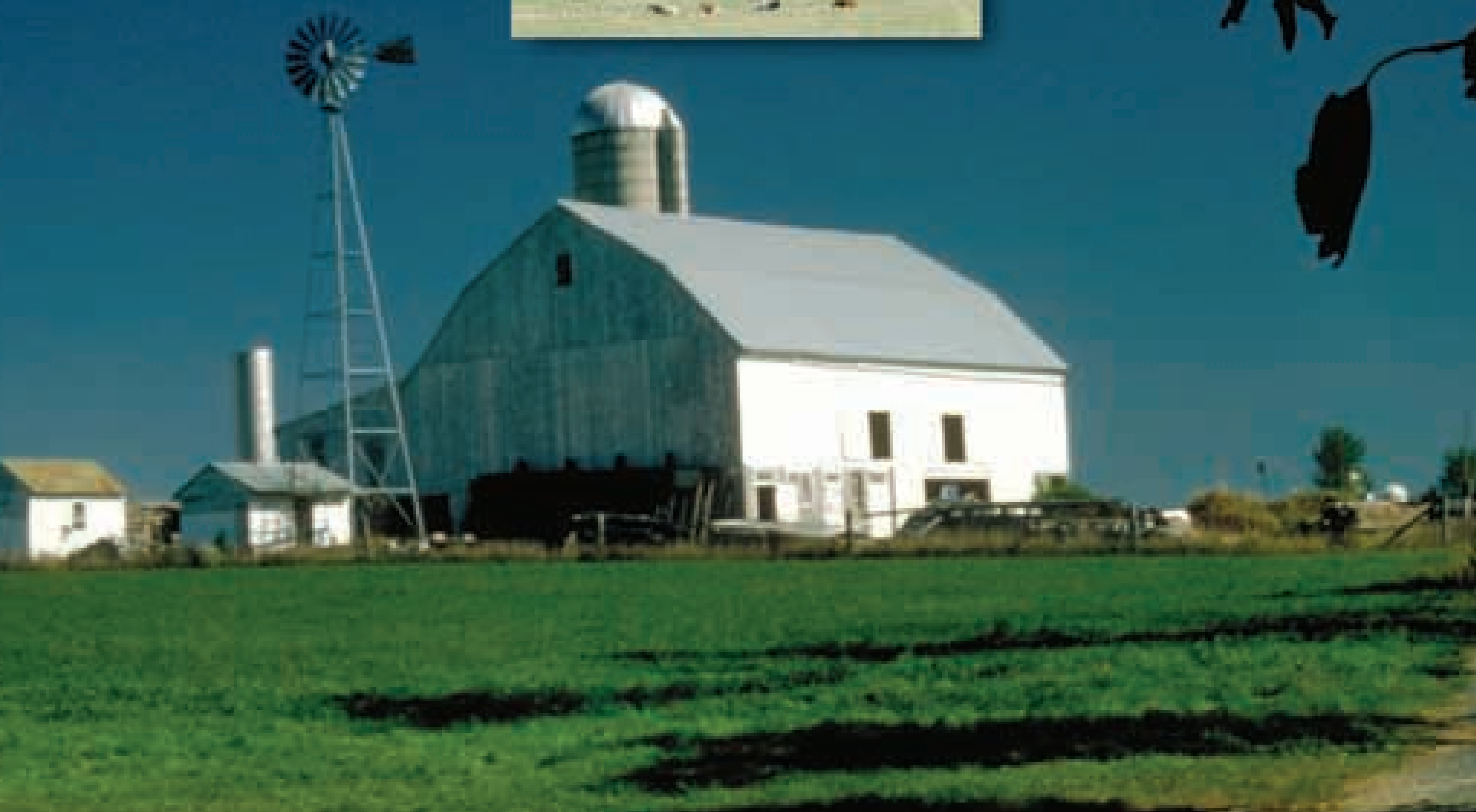

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Abstract

In the last 25 years, U.S. crop farms have steadily declined in number and grown in average size, as production has shifted to larger operations. Larger farms tend to receive more commodity program payments because most payments are tied to a farm's current or historical production, but whether payments have contributed to farm growth is uncertain. This study uses farm-level data from the census of agriculture to determine whether there is a statistical relationship between farm commodity program payments and greater concentration in production. The analysis indicates that, at the regional level, higher commodity program payments per acre are associated with subsequent farm growth. Also, higher payments per acre are associated with higher rates of farm survival and growth.

Keywords: agricultural payments, farm size, farm survival, concentration, consolidation, government payments, commodity programs.

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Contents

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Summary

What Is the Issue?

Farm structure is undergoing a complex set of changes. The census of agriculture shows increasing numbers of small farms (less than 50 acres) and large farms (1,000 acres or more), but also sharp and ongoing declines in the number of farms in the middle. Small farms, while numerous, account for less than 2 percent of all U.S. farmland, while large farms account for 67 percent. Consequently, the growth in the number of large farms has increased the concentration of crop production—that is, an increasingly large share of cropland and production is concentrated on relatively few large farms. A number of factors, including technological change or changing factor prices, could have driven the increase in concentration of production. Commodity program payments may also be contributing to the growth in concentration—allowing farms that receive more payments to grow faster than they would have without payments.

This report uses data from five agricultural censuses (1982, 1987, 1992, 1997, 2002) to determine whether there is a statistical relationship between the level of commodity program payments received and subsequent changes in farm structure. The analysis pursues four broad questions. How can changes in concentration of agricultural production be measured and how has it changed? Is there a link between concentration of agricultural production, farm size or farm survival, and commodity program payments? If so, how large and how extensive is this link? Finally, what might drive the observed links?

What Did the Study Find?

Crop production is shifting to larger farms. For example, farms with at least 1,000 acres in corn harvested 19.8 percent of all U.S. corn acres in 2002, up from 4.6 percent in 1987. Farmland has shifted to larger enterprises in most commodities and in most parts of the country, although the rate of growth varies substantially by location and across commodities.

Commodity program payments per acre displayed a strong positive association with subsequent increases in cropland concentration (weighted-median farm size). Areas with higher average payments per acre had higher rates of concentration growth over the subsequent 5-year period. In addition, areas with higher payments per acre at the beginning of this analysis (1987) had faster growth in concentration over the next 15 years. The association between payments and concentration growth was maintained after controlling for several factors that might affect concentration growth, including the initial (beginning of period) level of concentration, land characteristics such as crop sales per acre, the share of cropland in all farmland, and location.

An analysis of program crop producers finds past commodity payments as a share of sales to be positively and significantly associated with the observed lifespan of farm businesses. The 25 percent of farms with the highest payment as a share of sales had a longer lifespan than farms in the lowest quartile. After controlling for farm and operator characteristics that might be correlated with farm survival, the positive relationship between program

payments and farm survival rates persisted. Commodity program payments appear to have a larger effect (on estimated farm business lifespan) for operations with higher sales than for those with lower sales. A separate analysis of producers specializing in four major crop categories found that, conditional on survival, payments are positively associated with subsequent growth in farm size.

The apparent association between payments per acre and subsequent growth in concentration is consistent with the hypothesis that commodity program payments accelerate structural change. However, it is not possible to rule out other explanations for the association between payments and farm structure. If unobserved factors that influence concentration growth are also associated with government payments, then the association between payments and concentration may stem from the unobserved factors rather than payments. Despite efforts to account for many kinds of unobserved factors, it is impossible to know for certain how large of an issue this may be. This is a standard caveat for studies that use data collected from the observed world rather than from a carefully designed experiment.

How Was the Study Conducted?

The study relies on farm-level records from the census of agriculture, including a farm's acreage (cropland and all farmland) and commodity mix, its gross income from sales and from commodity program payments, and its location (State, county, and ZIP Code). Use of census data enables the researchers to develop measures of land concentration for local areas (as defined by ZIP Codes) and to track changes in the size of individual farms and regions over time. Concentration of production is measured using the weighted-median farm size: the farm size at which half the land in a ZIP Code is in larger farms and half is in smaller farms.

The study illustrates how cropland concentration varies across ZIP Codes, and how the distribution has changed over time. Payments per acre vary widely across ZIP Codes and reflect differences in crop mix, crop yields, and operator enrollments in commodity programs. The authors compare how cropland concentration has changed in ZIP Codes with different initial levels of farm payments per acre. The authors use statistical regression analyses to assess the robustness of the link between payments and concentration. The ZIP Code analysis is supplemented with farm-level analyses of the link between commodity program payments (expressed as a share of farm sales) and farm business survival and subsequent farm growth.

Chapter 1

Introduction

Over the last 25 years, crop production has become increasingly concentrated on large farms. Between 1982 and 2002, the number of farms with 1,000-10,000 acres increased by 14 percent, and total farmland operated by these large farms increased by 21 percent. In contrast, farms with between 50 and 1,000 acres declined in number and amount of farmland operated. While the number of farms with less than 50 acres actually increased in number and land operated, these very small operations still account for less than 2 percent of all farmland. Consequently, production increasingly occurs on farms with at least 1,000 acres.

Because large-scale operations grow a large portion of total output, they also receive a large share of commodity program payments. In 2002, farms with 1,000-10,000 acres represented 8 percent of all farms and received about half of all commodity program payments. The increasing concentration of agricultural production has resulted in an increasing share of commodity program payments going to large farms: between 1982 and 2002, the share of payments going to farms with 1,000-10,000 acres increased from 41 to 50 percent.

In recent years, some have expressed concern that payments provide an advantage to large operations. Some interest groups, politicians, and newspaper editorials have pointed toward commodity program payments as a factor contributing to the steady growth in average farm size and concentration of production. For example, the Environmental Working Group asserted:

> "Large farming operations may have used the additional profits they received from Freedom to Farm to purchase more equipment and land, or to secure more capital from the private sector to expand their operations. Such capital investments may have allowed large farms to increase their competitive advantage over smaller producers, making it that much more difficult for small and medium-sized farmers to make a profit from their farming operations."
>
> (Williams-Derry and Cook, 2000)

The steady growth in the concentration of farmland and production on large farms and the strong association between farm size and payment levels would seem to support claims that commodity program payments benefit large farms. However, farm commodity programs often tie payment levels to current production or to a farm's production history. Thus, regardless of how farms came to be larger, payments would have become increasingly concentrated with larger farms (MacDonald et al., 2005).

Expanding farm size could be driven by any number of factors other than the distribution of commodity program payments, such as technological change or changing factor prices. After all, expanding farm sizes and increasing concentration of production are observed in many areas of agriculture. Hog finishing operations today typically feed two to three times the number of hogs that they finished in the early 1990s. Broiler operations are typically twice as large as they were 20 years ago. Farms producing fruits and vegetables have also grown substantially larger in recent years. Economists see the trend toward larger farms mainly as a byproduct of the innovations that spurred vast economic growth and employment opportunities outside of agriculture, from factories a century ago to today's burgeoning service sectors. As agricultural labor has shifted to other sectors, farms have adopted bigger, faster, and more automated farm equipment; computerized information systems; and other capital inputs. By distributing the capital costs of these technological innovations over more production, farmers have been able to realize "economies of scale" in production. Technological change has encouraged farmers to operate much larger farms and allowed fewer farmers to produce more agricultural output.

This report examines a hypothesized link between commodity program payments and farm size by examining how past payments per acre correlate with (1) subsequent cropland concentration at the ZIP Code level and (2) subsequent size and survival of farms.[1] In the first case, the objective is to consider structural change on an aggregate level, to see how much of the pattern of increasing concentration might be attributed to program payments. In the second case, the objective is to see how variations in payment levels affect farm-level growth and survival.

Perspectives on the Issue

Each chapter of this report considers a different perspective of the analysis (see table 1 for an overview). Chapter 2 presents a brief overview of the literature on the determinants of farm structure and discusses some of the theoretical mechanisms through which commodity payments might affect farm size and farm business survival. Chapter 3 begins by presenting an overview of farm structure changes over the past 25 years, using several common measures of representative farm size. It then explains why the weighted-median farm size[2] is useful for measuring concentration change, particularly when the number of very small farms is large and growing and production is increasingly concentrated on relatively few large farms.

Chapter 4 presents summary statistics illustrating how cropland concentration varies across ZIP Codes, and how the distribution of concentration has shifted over time. The chapter then compares the change in cropland concentration over time for ZIP Codes with different initial levels of payments per acre. Payments per acre vary widely across ZIP Codes, and reflect differences in crop mix, crop yields, and past operator participation in government commodity programs. Statistical regression analyses are used to control for various factors—including location, initial sales per acre, and initial concentration—that might also explain changes in cropland concentration growth.

Chapter 5 examines how past payments relate to individual farm business survival and farm size growth. This chapter focuses on producers who specialize in program crops.[3] Specifically, the study compares the lifespans of farm businesses having different levels of commodity program payments expressed as a share of farm sales. The chapter also presents growth and exit rates (the chance that a business will cease operating within a year) and the survival probabilities (the chance that a farm survives a particular length of time) of farms with different levels of payments as a share of sales.

[1] Because the census of agriculture does not distinguish among all farm programs, the measure of commodity program payments equals total payments net of Conservation Reserve and Wetland Reserve Program payments. It therefore includes disaster payments and payment for other minor programs along with commodity program payments (see box, "Defining Commoedity Program Payments," p. 14, for more information).

[2] The weighted-median farm size is the size (in acres) for which half the land in a ZIP Code is operated by larger farms and half is operated by smaller farms. For example, if a ZIP Code's weighted-median farm size is 850 acres, then half of the cropland in that ZIP Code is operated by farms with more than 850 acres, and half is operated by farms with less than 850 acres.

[3] The individual farm analyses focus on those farms specializing in the production of wheat, rice, corn, soybeans, cash grains, or cotton. For some of the analyses, rice and cotton producers were excluded because there were too few observations to perform crop-specific regressions.

Table 1
Overview of empirical analyses

	Farm size/ concentration measures (Ch. 2)	Cropland concentration (Ch. 3)	Farm survival (Ch. 4)	Farm size and exit rate (Ch. 5)
Variable of analysis	Mean, median, weighted median, weighted mean, size class, and crop-specific measures	Weighted-median cropland acres	Farm business lifespan, instantaneous business survival rate, duration of farm survival	Average farmland acres
Unit of analysis	U.S.	ZIP Code	Farm business	Farm business
Commodity payments variable	(Not applicable)	Payments per cropland acre (quintiles)	Payments per dollar of sales (quartiles and continuous)	Payments per farmland acre
Sample	All U.S. farms	ZIP Codes with at least three farms reporting in all censuses	Farms with at least 10 acres of land and $10,000 in sales in 1987, and SIC codes indicating they were primarily producers of wheat, rice, corn, soybeans, cotton, or “cash grains.”	Farms with at least 10 acres of land in 1987, with SIC codes indicating they were primarily producers of wheat, corn, soybeans, or “cash grains.”
Years covered[1]	1982-2002	1987-2002	1987-1997	1987-2002
Controls	Not applicable	ZIP Code location (longitude and latitude), beginning-year cropland concentration, ratio of cropland to ZIP Code area, crop sales per acre of cropland	SIC code, year, size of operation (sales), operator age, year the farm began operating, farm’s organizational structure, debt-to-asset ratio, location (State)	SIC code, year, size of operation (farmland), operator age, farm’s organizational structure, land tenure status, location (State)
Reference			Key and Roberts (2006)	Key and Roberts (2007)

[1] All analyses of commodity payments begin in 1987 because that is the first year the Census of Agriculture collected data on commodity program payments.

Separate comparisons are made for farms producing different kinds of program crops, controlling for farm and operator characteristics that might affect farm survival and growth. The study then estimates the change in average farm size that might be expected if past commodity program payments for each farm had been lower than those historically received. Because commodity program payments might influence farm size by altering both the probability of surviving in farming and the scale of the farms that survive, both effects are considered simultaneously.

A New Approach

This study is the first to use data from five agricultural censuses (1982, 1987, 1992, 1997, and 2002) to examine the link between farm commodity program payments and structural change in agriculture. Because these data include most U.S. farms, it is possible to measure cropland concentration on a small geographic scale. The large number of observations narrows comparisons to farms or small regions that are similar in many respects besides payment levels. The data also allow the linking of operations across censuses, permitting a comparison of the survival and growth rates of similar farms having different initial levels of commodity program payments.

While the findings of this report are consistent with the hypothesis that farm commodity program payments influence structural change in agriculture, it is not possible to rule out other explanations for the observed associations. Despite efforts to control for factors that might cause spurious associations between program payments and structural change, it is impossible to know whether factors remain that have not been accounted for. This is a standard caveat to non-experimental studies that employ data observed in the natural world as opposed to data from a carefully controlled experiment.[4]

[4] In a carefully controlled experiment, government payments would be randomly assigned to some farmers in some regions and not to others in other regions (the control group). One could then attribute an association between payment levels and concentration growth as the influence of payments, because other factors affecting concentration growth would not be associated with payments, given they were randomly assigned. Such an experiment is clearly impossible in this case.

Chapter 2
Determinants of Farm Size and Survival

There has long been interest in the forces driving structural change in agriculture and how agricultural policy can or has influenced this change (USDA, 1981; Shepard and Collins, 1982; Leathers, 1992; Tweeten, 1993; Harrington and Reinsel, 1995; Atwood et al., 1996; Huffman and Evenson, 2001). Cochrane's (1958; 1979) "technology treadmill" model focused on the adoption and diffusion of technology. In this framework, technological innovations reduce production costs, thereby creating incentives for individual operators to adopt the new innovation. Early adopters benefit from a new technology. However, as an innovation diffuses among producers, industry output increases and commodity prices fall. Lower prices force out less efficient producers. According to Cochrane, larger farms are better suited to innovate and adopt new technologies, and the nature of many new technologies requires a minimum farm size to be profitably adopted. Hence, technological change and economies of scale drive farm size growth.

Kislev and Peterson (1982) articulated a simple but influential model that points to labor mobility between farm and nonfarm sectors as the driving force behind structural change. In their framework, the movement of labor out of agriculture has been driven by economywide increases in labor productivity, which caused wages to rise relative to the price of capital. As relative labor costs increased, farms substituted capital for labor in the production process, resulting in larger and more capital-intensive farms.

Neither of these models offers clear implications for how government payments affect farm structure in the absence of transaction costs or market imperfections. For example, in the Kislev and Peterson framework, an increase in commodity program payments might increase returns to farming, but would be capitalized into the price of land. But because payments would not affect costs of labor relative to capital, they would have no effect on farm size.

Transaction costs and market imperfections allow for a variety of mechanisms through which payments could affect farm structure. For example, payments might make it easier or less expensive for larger farms to finance production. Commodity program payments provide cash, some degree of insurance (due to links with commodity prices), and perhaps also a means to leverage greater resources from lending institutions, all of which may lower farmers' capital costs (Evans and Jovanovic, 1989; Holtz-Eakin et al., 1994; Bierlen and Featherstone, 1998; Hubbard and Kashyap, 1992; Barry et al., 2000; Key and Roberts, 2005; Roberts and Key, 2002). Lower capital costs may allow some farms to more quickly adopt new technologies (Cochrane model) or may provide an incentive to operate on a capital-intensive and larger scale (Kislev and Peterson model). In a context of increasing returns to scale, payments might facilitate farms' becoming larger in the short run, but not necessarily the long run (e.g., Morrison Paul and Nehring, 2005; Morrison Paul et al., 2004). Over time, business owners may accumulate sufficient wealth to finance an efficient scale of production, thereby mitigating the influence of payments as a source of liquidity.

If payments are not fully capitalized into land values, then they implicitly increase returns to nonland assets, such as labor. By increasing returns to labor, payments provide an incentive for farmers to work more onfarm and to increase their scale of production. If payments are decoupled from production, as some were after 1996, they could have the opposite effect on scale. In this case, higher income from commodity program payments could induce farmers to work less onfarm, resulting in less total labor (farmer and hired labor) and less production if there are costs associated with hiring labor or finding employment off farm (Lopez, 1984). While land rents are likely associated with payment levels, some evidence suggests that rents do not rise dollar-for-dollar with payments (Goodwin et al., 2003; Roberts et al., 2003). These findings suggest that payments influence labor/leisure decisions and/or facilitate capital acquisition.

Since the effect of payments on structure cannot be predicted from theory, this study addresses whether the level of farm payments is associated with farm size and the survival of farms using an empirical approach.

Chapter 3

Rapid Growth in Land Concentration

This chapter uses statistics from the census of agriculture to show how different land-based measures of farm size and concentration have changed over time. Taken together, the measures indicate large structural changes over the past quarter century. The weighted-median farm size is chosen as a measure of concentration because it provides a clearer indication of concentration change than median or mean farm size.[5]

Many different variables can be used to measure farm size, including farmland or cropland acreage, sales, value of production, and net returns. The focus of this study is on the effects of commodity program payments. To minimize the influence of changes in the size of noncrop enterprises, particularly livestock, the empirical analyses in this and the next chapter use farmland and cropland acreage to measure farm size. Acreage is less likely to be related to changes in past payments than are measures based on sales, value of production, and net returns, which depend on prices and yields and could be correlated with commodity program payments. For example, if payments were correlated with prices or yields, then even though past payments are exogenous to current sales, past payments would not be exogenous to past sales and this could cause a spurious correlation between past payments and the change in sales. Acreage-based measures, unlike sales-based measures, do not need to be deflated for changes in prices in order to make comparisons over time. Also, using land-based measures avoids ambiguity about how to compare prices (e.g., producer price index versus consumer price index).[6] Land-based measures of size do miss farm size growth occurring on livestock farms, some of which have grown markedly in animals managed without simultaneously increasing acreage. But since our primary focus is on farms receiving commodity payments, this actually clarifies the analysis.

This chapter provides a broad overview of structural change for all farms, so farmland is used as the variable of analysis. In the next chapter, which examines the correlation between payments and land concentration, cropland is used rather than farmland because cropland does not include pasture and rangeland and better corresponds to the land targeted by program payments.

Between 1982 and 2002, farms operating at least 1,000 acres of farmland and farms operating fewer than 50 acres increased in number, while farms operating 50 to 999 acres declined in number (table 2).[7] Most of the shifts in land were from farms operating 150-999 acres to farms operating 1,000-9,999 acres. Farms operating 1,000-9,999 acres increased their share of total farmland from 34.0 to 41.8 percent. The expansion of these large farms contrasts with farms operating 150-499 acres, whose share of total farmland declined by 4.5 percentage points, and with farms operating 500-999 acres, whose share declined by 2.5 percentage points.

Using harvested acreage instead of total farmland illustrates how production has become concentrated on large farms for seven major field crops. For every major field crop in every census year from 1987 to 2002, the share of land harvested by farms harvesting more than 1,000 acres increased (fig. 1). For example, in 1987, 4.6 percent of land harvested in corn was harvested

[5] In this study, the term concentration refers to the phenomenon of agricultural production or land shifting to fewer and larger operations—the term should not be confused with the concept of oligopoly or market power, where a few large firms are able to influence the market price. The measure of land concentration (the weighted-median land size) is distinct from the USDA-NASS (National Agricultural Statistics Service) concentration measure: the percent of farms that, when ordered from largest to smallest, cumulatively account for 50 percent of sales.

[6] Prices for agricultural inputs and commodities have not increased as much as consumer prices. The share of sales going to farmers' out-of-pocket production costs may be best deflated by producer prices, while farmers' wages (returns net of costs) may be best deflated by the consumer price index. It is difficult to determine the appropriate share of sales that should be deflated by producer versus consumer price indices. Difficulties are compounded by the fact that producer and consumer prices vary over location, time, and type of operation, and tend to be poorly measured for small geographic areas.

[7] Farmland is defined by the census as the quantity of farmland owned plus farmland rented in minus farmland rented out.

Table 2
Farmland operated and number of farms by farm size, 1982-2002

Farm size	1982	1987	1992	1997	2002	Change 1982-2002
						Percent
0-49 acres						
Farmland (million acres)	12.70	11.61	10.87	11.46	15.52	22.1
(Percent of total)	(1.33)	(1.25)	(1.19)	(1.27)	(1.66)	24.4
Farms	629,962	588,632	546,955	556,330	738,113	17.2
(Percent of total)	(28.45)	(28.57)	(28.81)	(29.54)	(34.77)	22.2
50-149 acres						
Farmland (million acres)	52.38	47.49	43.14	43.92	49.18	-6.1
(Percent of total)	(5.49)	(5.10)	(4.73)	(4.88)	(5.25)	-4.4
Farms	571,330	517,388	470,880	482,340	548,062	-4.1
(Percent of total)	(25.81)	(25.11)	(24.81)	(25.61)	(25.82)	0.0
150-499 acres						
Farmland (million acres)	179.05	162.62	144.85	136.33	133.45	-25.5
(Percent of total)	(18.78)	(17.47)	(15.88)	(15.16)	(14.26)	-24.1
Farms	656,800	595,808	530,961	502,820	498,524	-24.1
(Percent of total)	(29.67)	(28.91)	(27.97)	(26.69)	(23.48)	-20.8
500-999 acres						
Farmland (million acres)	138.12	136.15	126.99	119.93	112.38	-18.6
(Percent of total)	(14.48)	(14.63)	(13.93)	(13.34)	(12.00)	-17.1
Farms	200,601	196,705	183,207	172,660	161,450	-19.5
(Percent of total)	(9.06)	(9.55)	(9.65)	(9.17)	(7.60)	-16.1
1,000-9,999 acres						
Farmland (million acres)	324.04	335.80	349.88	365.12	390.88	20.6
(Percent of total)	(33.98)	(36.08)	(38.37)	(40.61)	(41.76)	22.9
Farms	147,615	154,535	158,492	162,223	168,730	14.3
(Percent of total)	(6.67)	(7.50)	(8.35)	(8.61)	(7.95)	19.2
10,000+ acres						
Farmland (million acres)	247.27	237.13	236.16	222.41	234.68	-5.1
(Percent of total)	(25.93)	(25.48)	(25.90)	(24.73)	(25.07)	-3.3
Farms	7,641	7,492	7,739	7,218	8,096	6.0
(Percent of total)	(0.35)	(0.36)	(0.41)	(0.38)	(0.38)	10.5
Total farmland (million acres)	953.56	930.80	911.87	899.16	936.08	-1.8
Total farms	2,213,949	2,060,560	1,898,234	1,883,591	2,122,975	-4.1

Source: Census of agriculture. Farmland is defined in the census as the quantity of land owned plus land rented in minus land rented out.

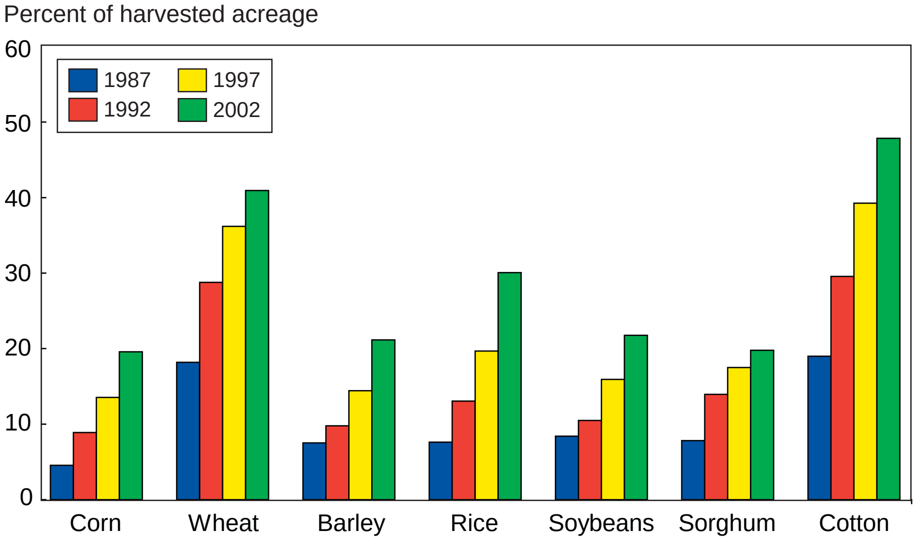
Table 3
Representative farm size, various measures, 1982-2002

Measure	1982	1987	1992	1997	2002	Change 1982-2002
			Acres			*Percent*
All farms						
Mean	430.7	451.7	480.4	477.4	440.9	2.4
Median	122	125	125	120	95	-22.1
Weighted mean	48,955	46,998	51,742	95,482	95,945	96.0
Weighted median	1,620	1,700	1,925	2,000	2,190	35.2
Farms < 10,000 acres						
Mean	321.4	339.3	359.5	362.5	333.7	3.9
Median	121	125	125	120	94	-22.3
Weighted mean	1,776.8	1,831.5	1,957.6	2,035.9	2,144.8	20.7
Weighted median	864	954	1054	1143	1225	41.8

Source: Census of agriculture.

Figure 1

Share of harvested acreage in large farms (at least 1,000 harvested acres of commodity)



by these large farms, increasing to 9.0 percent in 1992, 13.7 percent in 1997, and 19.8 percent in 2002.

Mean and median farm size can be misleading indicators of concentration when the distribution of farm size is heavily skewed. This is illustrated in table 3, which presents four measures of average farm size by farmland size category from 1982 to 2002. To illustrate the influence on the statistics of very large operations, the table presents these statistics both for all farms (top half of the table) and for farms with fewer than 10,000 acres (bottom half of table). For all farms, the mean farm size increased slightly from 430.7 acres in 1982 to 440.9 acres in 2002. However, the median farm dropped from 122 to 95 acres of farmland, reflecting an increase in the number of small farms.

To characterize land concentration, the acre-weighted mean and acre-weighted median have advantages over the mean or median (see box, "Measures of Land Concentration"). The acre-weighted mean farm size 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 operated 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 operate most of the farmland. For all farms, the weighted mean almost doubled between 1982 and 2002, while the weighted median increased by 35 percent. The weighted median indicates that in 1982, half of all farmland was operated by farms larger than 1,620 acres. By 2002, half of all farmland was operated by farms having at least 2,190 acres.

Farms with more than 10,000 acres operate about 25 percent of U.S. farmland but represent only 0.4 percent of all farms. Most land on farms with more than 10,000 acres is range, pasture, and woodland, and generally of much lower quality than land on farms with less than 10,000 acres. Separate measures for farms with less than 10,000 acres (the bottom half of table 3)

Measures of Land Concentration

Mean and median farm size can be poor indicators of agricultural concentration. To see why, consider the hypothetical example illustrated below. Suppose there are initially four medium-sized farms and two of these farms consolidate to make one farm equal in size to the two former farms. And suppose that one medium-sized farm is simultaneously split into two smaller farms. In the left panel, before the change, each of four farms cultivates 10 acres; in the right panel, the largest farm operates 20 acres and the smallest two operate 5 acres each.

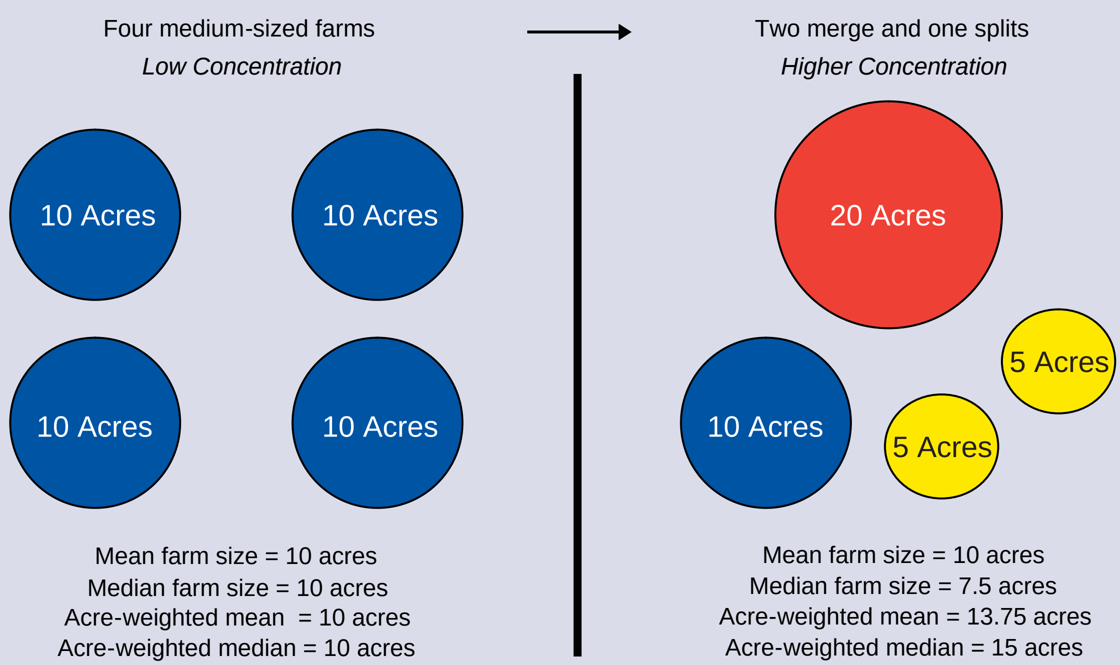
Now consider the different ways one might measure the size of a typical farm in each panel. The mean farm size is 10 acres in both panels: each has a total of 40 acres divided by 4 farms. The median farm is the farm for which half are smaller and half are larger. In the first panel, median farm size is 10 acres, because all farms are that size. In the second panel, half the farms are 10 acres or larger and half are 5 acres or smaller so the median farm is 7.5 acres. These measures seem to belie the rather large change that has taken place. One of four farms controls half the land in the second panel, whereas it is equally divided in the first panel. Land concentration, if not median or mean farm size, would seem to have increased.

Now consider the acre-weighted median. This measure is calculated by ordering farms from smallest to largest and picking the farm size at the middle acre (unlike the regular, unweighted median, which is the middle farm). In the second panel, half the acres are on a 20-acre farm and half are on farms 10 acres or less, so the acre-weighted median is the farm size in-between 10 and 20, or 15 acres. The increase in the acre-weighted median from 10 to 15 acres better reflects the increase in concentration taking place between the first and second panels of the figure than does the mean or median. The acre-weighted median is used in the ZIP Code analysis (next chapter) in this report.

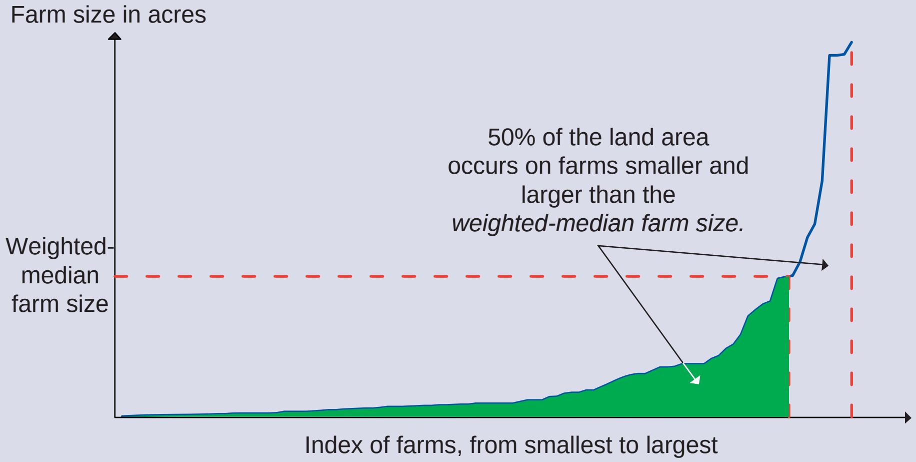
This simple example is similar to what has actually occurred in U.S. agriculture. Production has shifted to larger farms, while the relative number of small farms has increased at the same time. The observed increase in the number of small farms can be partly attributed to how a farm is defined. The definition of a farm plays an important role in determining the mean and median farm size, as well as the number of farms.

The USDA defines 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” (USDA, 1997).

Measures of land concentration



Weighted-median farm size



Note: The farms depicted are 100 farms chosen randomly from the 2002 Census of Agriculture to illustrate the acre-weighted median farm size.

This definition includes many small operations for which farming contributes only a small share of farm household income. The $1,000 figure has remained unchanged since the 1974 census, so inflation has effectively increased the number of small operations that qualify as farms. Other changes in the definition may have also increased the count of small farms.[1]

The concentration measure used in this study, the acre-weighted median, is less sensitive to how a farm is defined than is the mean or median. This is because adding or dropping a large number of very small farms changes the total number of acres by only a small amount. Hence, the farm size associated with the "middle acre" changes very little.

[1]Beginning in 1997, maple syrup and Christmas tree sales qualified as part of the $1,000 sales threshold. For details on these changes, see http://agcensus.mannlib.cornell.edu/general.php.

Another possible measure is the acre-weighted mean farm size, which effectively averages farm sizes over acres rather than over farms. It can be interpreted as the farm size associated with an "average" acre. In the first panel of the example, this measure also equals 10 acres, but is 13.75 acres in the second panel.[2] Like the acre-weighted median, this statistic is more representative of the farm size associated with a typical acre farmed, and is less susceptible to changes in the number of very small farms caused by changes in the definition of a farm or enumeration techniques.

[2]In calculating the standard mean, each farm is weighted equally (in this example each farm has a weight of ¼), so mean = 5*1/4 + 5*1/4 + 10*1/4 + 20*1/4 = 10. For the weighted mean, each farm is weighted by its share of land in total acres, so weighted mean = 5*5/40 + 5*5/40 + 10*10/40 + 20*20/40 = 13.75.

show similar patterns for the mean, median, and weighted-median measures, but the weighted mean, which is more sensitive to outliers, differs from the trend for all farms. For farms with less than 10,000 acres, the weighted mean increased by 20.7 percent between 1982 and 2002.

How Have Commodity Program Payments Changed Over Time?

Commodity program payments (see box, "Defining Commodity Program Payments") per farm are closely associated with farm size in all census years from 1987 to 2002. Mean program payments per farm increase with farm size class up to 10,000 acres of farmland (table 4). In 2002, the median payment for farms operating 1,000-10,000 acres was $9,738—almost three times the median payment for farms operating 500-1,000 acres, and about 200 times the median payment for farms with 150 to 500 acres of farmland. For some census years, very large farms operating more than 10,000 acres actually received lower program payments per farm than farms operating 1,000-10,000 acres. A smaller portion of land managed by these very large farms is cultivated with crops normally targeted by commodity programs. Farmland as defined by the census includes pasture, range, woodland, and other land, some of which is not actively used in farm production activities.

Large farms receive an increasingly large share of program payments. The share of payments going to farms with 1,000-10,000 acres increased from 41.1 percent of all payments in 1987 to 49.5 percent in 2002. During the same period, farms with 150-1,000 acres received a smaller share of total payments, while farms with fewer than 150 acres received an increasing share (from 4.1 percent to 7.6 percent in 2002), reflecting their growing numbers. Still, over half of all farms with less than 150 acres receive no commodity program payments—a fact that has not changed since 1987. The share of payments going to farms operating more than 10,000 acres also increased over time (table 4).

Table 4
Commodity program payments by farm size category, 1987-2002

Farm size and payments	1987	1992	1997	2002	Change 1987-2002
					Percent
0-50 acres					
Mean payments ($)	182	108	183	227	24.4
Median payments ($)	0	0	0	0	0.0
Total payments ($ million)	107	59	102	127	18.6
(Percent of total)	(0.7)	(0.9)	(1.8)	(1.9)	171.6
50-150 acres					
Mean payments ($)	981	438	632	812	-17.2
Median payments ($)	0	0	0	0	0.0
Total payments ($ million)	508	206	305	373	-26.6
(Percent of total)	(3.4)	(3.2)	(5.5)	(5.7)	68.2
150-500 acres					
Mean payments ($)	6,262	2,389	2,390	2,904	-53.6
Median payments ($)	0	0	0	43	-
Total payments ($ million)	3,731	1,269	1,202	1,330	-64.4
(Percent of total)	(24.9)	(19.4)	(21.7)	(20.3)	-18.4
500-1,000 acres					
Mean payments ($)	21,676	8,553	7,403	8,062	-62.8
Median payments ($)	12,831	4,464	4,284	3,500	-72.7
Total payments ($ million)	4,264	1,567	1,278	1,255	-70.6
(Percent of total)	(28.5)	(24.0)	(23.1)	(19.2)	-32.6
1,000-10,000 acres					
Mean payments ($)	39,840	20,589	15,665	19,331	-51.5
Median payments ($)	23,469	11,540	9,206	9,738	-58.5
Total payments ($ million)	6,157	3,263	2,541	3,237	-47.4
(Percent of total)	(41.1)	(50.0)	(45.9)	(49.5)	20.4
10,000+ acres					
Mean payments ($)	28,605	21,355	14,636	27,481	-3.9
Median payments ($)	0	0	0	4,000	-
Total payments ($ million)	214	165	106	222	3.6
(Percent of total)	(1.4)	(2.5)	(1.9)	(3.4)	137.3
Total payments ($ million)	14,981	6,529	5,533	6,543	-56.3

Note: Payments are in 2002 dollars deflated using the Consumer Price Index. Farm program payments are defined as total payments received for participation in Federal farm programs (including CRP/WRP), not including government CCC loans.

Source: Census of Agriculture.

Defining Commodity Program Payments

Although the Federal Government has provided payments to farmers since the Great Depression, the programs that provide payments have changed markedly over time. In recent decades, most payments have been tied to a farm's "base acres," a measure of historical plantings of program crops, and to historical program crop yields. Program yields were fixed in 1985 (at an average of 1981-85 yields) until 2002. Base acres were fixed under the 1996 Farm Act (production flexibility contract acreage). Until 2002, program crops included barley, corn, cotton, oats, rice, sorghum, and wheat.

Payments tied to base acres have fluctuated over time, depending on whether and to what extent market prices fell below program-set target prices. In 1987 and 1992, participation in government programs also required farms to idle a share of their base. In these years farmers may have chosen not to participate in government programs in order to avoid annual acreage reduction requirements. By 1992, farmers could plant nonbase or other base crops on their base acres in accordance with flexibility rules, which changed over time. By 1997, annual acreage reduction programs were eliminated and farmers were given almost complete flexibility in planting.

In addition to payments tied to base acres, farmers have also received loan deficiency payments from the marketing loan program. These payments depend on current production, not base acres, and the payment amount depends on the difference between market prices and loan rates set by the program. Marketing loan payments were available for soybeans and minor oilseeds in addition to program crops that receive payments tied to base acres. Some kinds of marketing loan benefits are not included in our data because the census of agriculture does collect information about them.

The census of agriculture does not classify payments according to type beyond distinguishing payments from the Conservation Reserve Program (CRP) and Wetland Reserve Program (WRP). This study considers total payments net of CRP and WRP payments because these program payments are generally small and likely influence concentration growth differently than other kinds of payments. Data on payments were available starting in 1987. For the 1987, 1992, and 1997 censuses, respondents were asked for (1) "the amount received from CCC loans" by crop, (2) "total amount received for participation in Federal farm programs (do not include CCC loans)," and (3) "of the total amount [in 2] how much was received for participation in the CRP and WRP?" For 1987, 1992, and 1997, the value from (2) minus the value from (3) was used in the analysis, except for table 4.

In 2002, respondents were asked for (1) "total amount received in 2002 from Government CCC loans for all crops," (2) "how much was received for participation in the Conservation Reserve Program and Wetlands Reserve Program (CRP and WRP)" and (3) "amount received from other participation in other Federal farm programs (include loan deficiency payments)." For 2002, the value in (3) would be the appropriate measure of payments, but 2002 payments were not used in the analysis linking payments to concentration because we use past payments to observe subsequent growth.

Total commodity program payments recorded by the census are substantially below the net outlays to farmers reported by the USDA. For example, in 2002, census respondents reported commodity program payments net of Commodity Credit Corporation (CCC) loans and CRP and WRP payments totaling $5.2 billion. In contrast, the Farm Service Agency budget reports that total direct cash payments excluding conservation payments totaled $9.7 billion (USDA/ERS, 2007). Part of this discrepancy could be explained by the fact that landlords received a substantial portion of commodity program payments, and many landlords were not operators, so they were not included in the census of agriculture.

Chapter 4

Commodity Program Payments and the Concentration of Cropland

To focus more clearly on the impact of payments on crop producers, cropland (versus farmland) is used to characterize land concentration at the local (ZIP Code) level. Weighted-median cropland is constructed in the same way as weighted-median farmland in the previous chapter (cropland excludes pasture, range, woodland, and other minor uses).[8] The analysis includes almost all farms and ZIP Codes in the census of agriculture.

First, the study compares percentage changes in cropland concentration between consecutive census periods of ZIP Codes having different levels of payments. This indicates whether concentration increased more in regions having higher average payments per acre than in regions with lower average payments. Even if programs target farms that happen to be larger due to the nature of the crops they grow (that is, some crops are land-intensive), there is no apparent reason to expect programs to target farm types more inclined to grow in size over time. And, by examining percentage changes, growth is scaled relative to initial concentration levels.

Although a comparison of changes can control for many factors, the approach is not infallible. It might be that corn, wheat, cotton, and other crop farms traditionally targeted by programs have grown more concentrated for reasons other than government programs. To address this concern, the study controls for initial farm size and for ZIP Code location. This approach restricts comparisons to those between ZIP Codes with similar initial farm sizes that are close to each other geographically, and thus likely to have similar climate, soils, and crop types.

It is possible that areas with high yields, and hence higher payments, also have better land quality (flatter, more fertile soil, etc.). If scale-enhancing technological change favored higher quality land over lower quality land for the same crop, this could explain a correlation between payments and subsequent growth in land concentration. To account for variation in land quality, the study controls for initial crop sales per acre and the share of all land in crops.

If it were participation in farm commodity programs and not the payment levels associated with participation that drove farm size changes, one might expect a similar change in farm size between crops with higher and lower payment levels. For example, payments (per acre) tied to cotton production tend to be higher than those tied to corn, while corn payments tend to be higher than for wheat. Examining farm growth rates over a range of payment levels demonstrates that concentration growth steadily increases with steadily increasing payment levels.

Of course, other factors cause payment levels to differ across ZIP Codes (see box, “Defining Commodity Program Payments”). One source of variation in payment levels stems from regional differences in crop mix. Of particular importance is farmers’ planting decisions and yield outcomes. Yields between 1981 and 1985 determined 1985 base acres and program crop yields. Particularly high or low yields in those years because of weather variation would have longrun consequences in terms of payment

[8]An analysis using farmland instead of cropland produced qualitatively similar results.

Zip Code Data

The data used for this analysis 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, the first year for which farm-specific data on commodity program payments are available. The study examines ZIP Code areas because they are the smallest geographic unit where farms can be located with the data. This provides more observations and more variability in the concentration and payment measures than a county-level analysis would. Local variation in payment levels and concentration growth is important when attempting to identify the effect of payments on concentration while controlling for factors that vary geographically.

ZIP Code areas, like counties, vary markedly in size, with rural ZIP Codes generally larger than urban ZIP Codes and Western ZIP Codes generally larger than those farther east. To account for this variation, the study examines payments per acre of cropland rather than total payments. This standardization makes the payments measure insensitive to the size of ZIP Code areas. The concentration measure is not sensitive to the land area of the ZIP Code and therefore does not require standardization.

ZIP Codes can change over time. Most changes have occurred in more urban areas undergoing rapid population growth and where agriculture is less prevalent, which mitigates the issue for this analysis. When ZIP Codes do change, it is usually because one ZIP Code is split into two or more ZIP Codes, with one area retaining the old ZIP Code and the other(s) assigned a new code. Sometimes individual ZIP Codes are assigned to universities or large companies, and this can also change over time. Because the study restricts the analysis to ZIP Codes appearing in all four censuses, all farms in areas with new ZIP Codes are omitted. However, there are a few ZIP Codes that decreased in size between 1987 and 2002, with part of the earlier ZIP Code area split off into new ZIP Codes that were dropped. These changes, however, would not be expected to be systematically related to payments per acre or concentration measures.

Another consideration is that many farms likely straddle ZIP Codes. This issue is not likely to cause significant bias in this analysis because the ZIP Code associated with any particular farm is unlikely to change from one census to the next. Measurement issues may arise when farms with different ZIP Codes consolidate, causing reassignment of land from one ZIP Code to another. Such changes may create more variability in the concentration measure over time for ZIP Codes affected by consolidation, but there is no reason to expect this variability to be associated with commodity program payments per acre or other determinants of farm size.[1]

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; 23,293 ZIP Codes had 3 or more farms reporting in all censuses.[2] Of these 23,293 ZIP Codes, observations with undefined variables or extreme outliers are dropped, resulting in 21,524 ZIP Codes. Although the sample drops about a third of all U.S. ZIP Codes containing farms, it drops a much smaller share of total farms. The sample includes 1,716,814; 1,524,783; 1,541,547; and 1,341,306 farms in the 4 census years, compared with 1,799,926; 1,621,263; 1,653,098; and 1,486,895 farms in the raw census files.[3]

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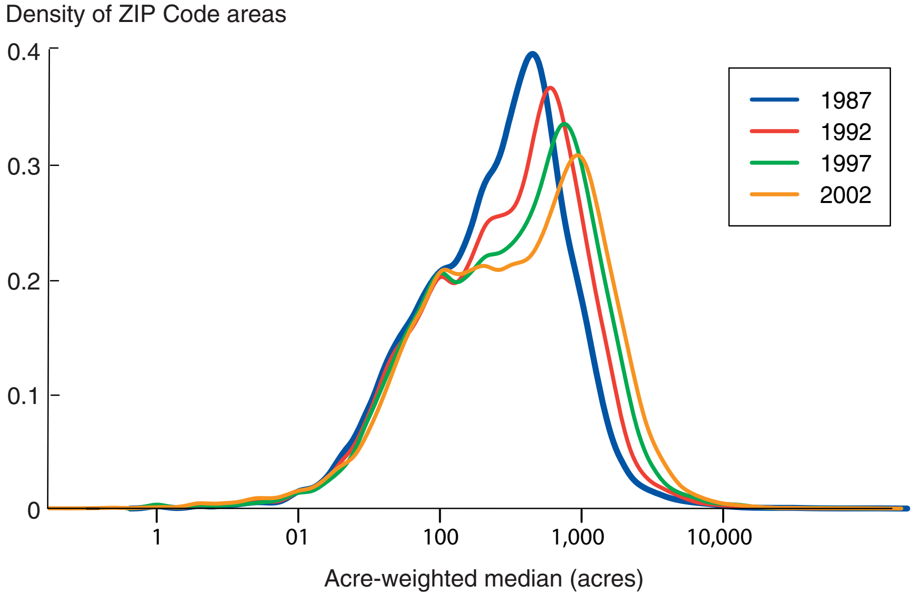
[1] Only a small portion of farms are dropped from the analysis because their ZIP codes were dropped. This suggests most farms are in areas relatively unaffected by changes in ZIP Codes. And the farms dropped are predominantly very small farms, which have little influence on the weighted-median farm size.

[2] These counts compare to a nationwide total of about 43,000 ZIP Codes currently in the United States.

[3] These numbers refer to actual census observations. Published census estimates of farm numbers are higher to account for nonresponse probabilities. Nonresponse weights were used in computing tables 2-4.

Figure 4
Distribution of cropland concentration across ZIP Codes, 1987-2002



Note: Data are from census of agriculture 1987, 1992, 1997, and 2002. Sample includes all ZIP Codes with at least three farm operations reporting in each year.

levels. Similarly, because base acres were fixed in 1996, cropping decisions prior to 1996 affected payment levels for many years.

Another factor driving variation in payments is historical participation in government farm programs. In the late 1980s, agricultural program restrictions may have discouraged some farmers from participating. Participation required farmers to limit their plantings to a share of acres historically planted and required that a certain portion be idled (called the Acreage Reduction Program). Farmers with environmentally fragile land (e.g., highly erodible) were also required to follow certain practices to limit environmental damages stemming from the cropping activities.[9] These costly participation restrictions probably limited program participation.[10]

For each ZIP Code region, the study estimates concentration using the acre-weighted median cropland area. This measure is the farm size at which half the cropland in the ZIP Code is operated by farms with more cropland and half the cropland is operated by farms with less cropland.

Figure 4 illustrates how the distribution of farm sizes has changed since 1987. The figure shows the frequency distributions of cropland concentration in the census years from 1987 to 2002. The horizontal axis is concentration, plotted on a logarithmic scale, and the vertical axis measures the frequency of ZIP Codes at each concentration level. The area under each curve equals one, by definition, so the area beneath the curve between any two points represents the share of ZIP Codes that are in the size range. The horizontal axis is plotted on a logarithmic scale where each step represents a ten-fold increase in farm size (rather than an increase of 10 units). Because there are relatively few ZIP Code areas with very high levels of concentration (the distribution is highly skewed), the logarithmic scale allows for a clearer representation of the whole distribution and more clearly illustrates

[9] See Claasen et al. for a description of cross-compliance provisions.

[10] Prior to 1996, between 15 and 40 percent of eligible cropland was not enrolled in a Federal program (USDA, various years).

the continuous temporal shift. The figure shows cropland distributions shifting markedly to the right: the share of ZIP Codes with weighted-median farm size above 600 acres increased every census from 1987 to 2002, indicating a relative increase in cropland controlled by larger farms.

Descriptive Statistics for ZIP Codes

The empirical approach is to compare how cropland concentration changes for ZIP Codes with different initial commodity program payments per acre (total commodity program payments divided by total cropland). The study measures changes in concentration over the three 5-year periods between censuses (1987-92, 1992-97, and 1997-2002). For example, it measures how payments per acre in 1987 correlate with changes in concentration from 1987 to 1992. It also measures the longrun relationship between payments per acre in 1987 and total percentage growth in concentration from 1987 to 2002.

For 1987, 1992, and 1997, ZIP Codes are sorted into six groups: the first group includes those ZIP Codes with zero program payments; the remaining ZIP Codes are sorted into five quintiles according to their level of payments per acre, with each quintile having the same number of ZIP Codes. There are two advantages to examining payment quintiles rather than estimating a linear or continuous relationship between payments per acre and concentration growth. First, estimating separate concentration measures for each quintile allows for the identification of nonlinear relationships between payment levels and concentration, if they exist. Second, pooling many observations into discrete categories of equal size greatly reduces the influence of miscoded or anomalous data.

For each of the six payment groups, table 5 reports summary statistics for the proportion of ZIP Codes, farms, and cropland; crop sales per acre; share of cropland in program crops and soybeans (a common rotation crop); and cropland concentration (weighted-median cropland), all for the beginning year of each census panel.   The payment levels that divide quintiles change from one census year to the next as the general level of payments varies, mainly due to changing commodity prices and target prices set by farm policy.

As one would expect, the share of cropland in program crops increases with payment levels. With the exception of the no-payment group, typical farm size (initial concentration) is not markedly different between the payment groups in the initial year, but grows more for the higher payment groups in the more recent panels. Figure 5 maps ZIP Codes according to the cropland payment groups used for the longrun analysis.

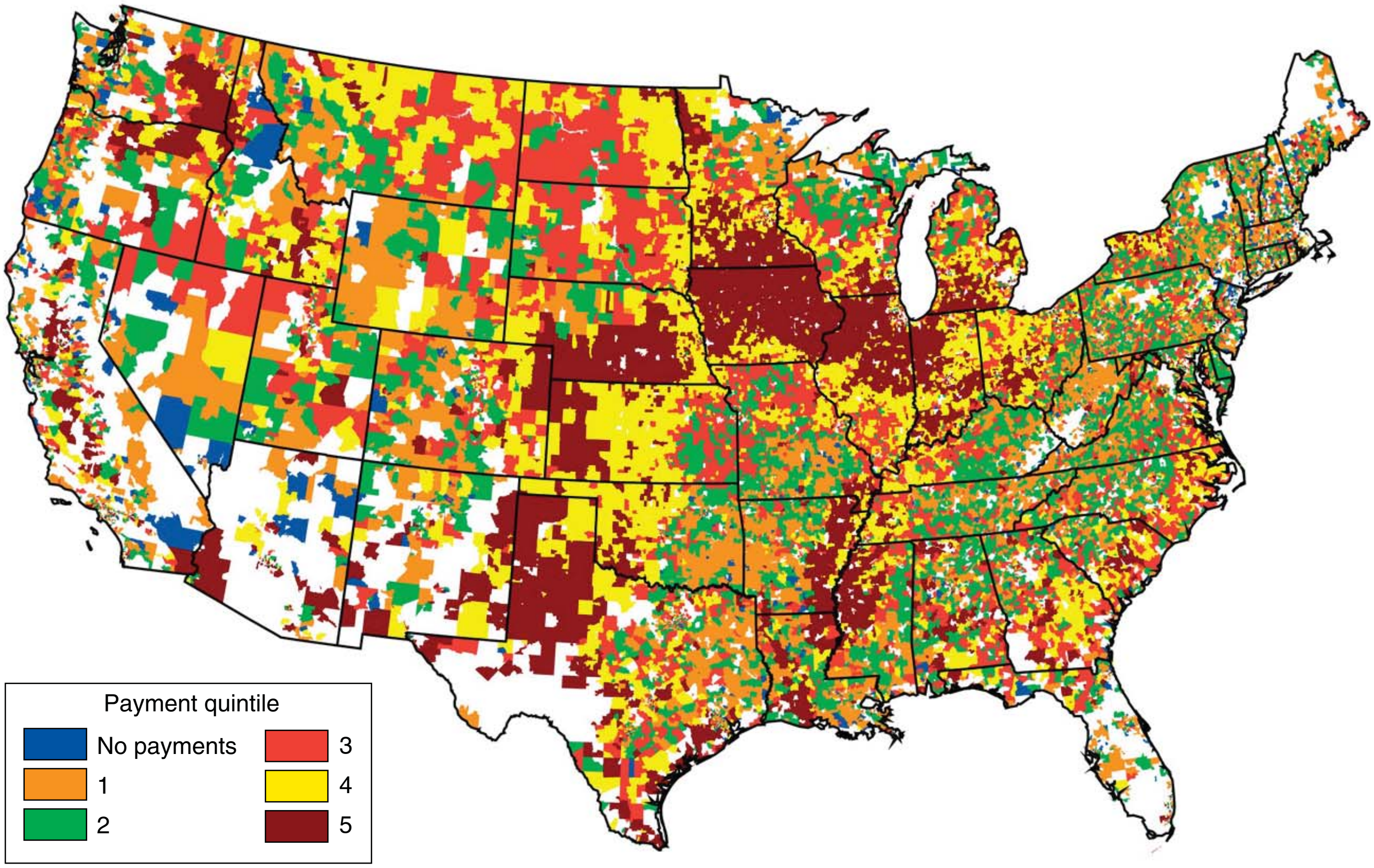
Table 5
Summary statistics for each payments-per-acre category

Years of analyses		Payments per acre of cropland in beginning year: No payments	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
1987-1992	Payments per acre in 1987 ($)	0	0.01-7.49	7.49-20.08	20.08-35.11	35.11-53.11	>53.11
	% of ZIP Codes	10.7	17.9	17.8	17.8	17.8	17.9
	% of farms 1987	2.3	15.0	20.4	20.5	20.8	21.0
	% of cropland 1987	0.5	5.0	10.1	21.5	29.7	33.2
	Crop sales per acre 1987 ($)	406.4	287.5	156.0	136.0	154.3	204.0
	% of cropland acres in program crops in 1987	9.6	18.5	41.2	65.8	80.6	75.1
	Weighted-median cropland acres in 1987	1,127.7	809.7	611.1	748.1	734.9	607.3
1992-1997	Payments per acre in 1992 ($)	0	0.01-3.62	3.62-7.79	7.79-12.34	12.34-18.32	>18.32
	% of ZIP Codes	12.1	17.6	17.6	17.6	17.6	17.6
	% of farms 1992	2.7	17.6	20.6	21.0	20.1	17.9
	% of cropland 1992	0.5	5.8	11.7	23.0	30.2	28.7
	Crop sales per acre in 1992 ($)	582.3	325.6	207.5	171.9	178.2	233.8
	% of cropland acres in program crops in 1992	15.7	25.2	52.7	72	80.6	75.1
	Weighted-median cropland acres in 1992	2161.1	780.6	717.3	835.7	882.6	993.6
1997-2002	Payments per acre in 1997 ($)	0	0.01-3.01	3.01-6.72	6.72-10.19	10.19-14.24	>14.24
	% of ZIP Codes	10.6	17.9	17.9	17.9	17.9	17.9
	% of farms 1997	2.3	17.0	20.4	20.8	21.0	18.4
	% of cropland 1997	0.4	5.0	12.3	23.8	30.2	28.3
	Crop sales per acre in 1997 ($)	724.9	416.1	214.6	206.9	230.7	304.6
	% of cropland acres in program crops in 1997	7.4	12.7	47.3	69.7	78.7	80
	Weighted-median cropland acres in 1997	1,198.6	984.8	1,124.1	1,185.6	1,040.2	1,011.9

Notes: Data from census of agriculture 1987, 1992, 1997, and 2002. Sample includes all ZIP Codes with at least three operations reporting in every year. All statistics correspond to the first year of each panel. Typical cropland acres are acre-weighted median. All payments are adjusted to 1997 dollars using the Consumer Price Index.

Figure 5

Mean payments per cropland acre by ZIP Code, 1987-1997



Note: Data from census of agriculture 1987, 1992, and 1997. Sample includes all ZIP Codes with at least three operations reporting in every year. White areas were dropped from the analysis due to extreme values or little data.

Land Concentration Change by Payment Category

Average growth rates in concentration for all payment groups are reported in table 6. Figure 6 displays the same statistics graphically. Each 5-year panel generally displays increasing concentration growth for higher payment levels, and the relationship is strongest and clearest in the cumulative 15-year panel.

Table 7 reports estimated differences in concentration growth rates for the same panels and groups as table 6, except the estimates include controls for beginning-year concentration levels, sales per acre of cropland (a proxy for land quality), cropland density (the ratio of cropland to land area in the ZIP Code), and location. These estimates are derived by restricting comparisons between ZIP Codes that have similar initial concentration rates, crop sales per acre, and ratios of cropland to ZIP Code area. Location is critically important because it controls for the effects of climate, soils, distance to markets, and other local economic factors that may influence changes in concentration. Controlling for the location of the ZIP Code areas reduces the chance that the effect of payments is confounded by these and other

Table 6

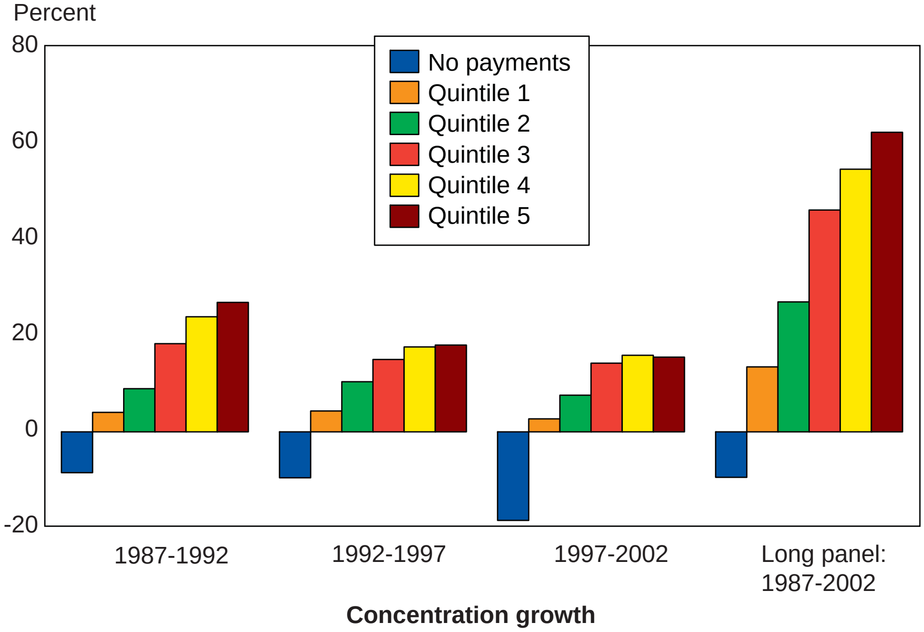
Percentage change in concentration by payments-per-acre quintile

Years	No payments	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
	Percentage change in concentration of cropland (Standard error)					
1987-92	-8.8 (1.7)	4.2 (0.8)	9.3 (0.7)	19 (0.5)	24.8 (0.4)	27.9 (0.4)
1992-97	-9.9 (1.5)	4.5 (0.8)	10.8 (0.6)	15.6 (0.5)	18.3 (0.4)	18.7 (0.4)
1997-2002	-21.2 (2.0)	2.8 (0.9)	7.9 (0.7)	14.8 (0.6)	16.5 (0.5)	16.1 (0.5)
Long panel 1987-2002	-9.8 (2.0)	14.0 (1.1)	28.0 (0.9)	47.8 (0.7)	56.6 (0.6)	61.4 (0.5)

Notes: Concentration is defined as the cropland-weighted median farm size in each ZIP Code. See appendix for details. Data are from census of agriculture 1987, 1992, 1997, and 2002. Sample includes all ZIP Codes with at least three farm operations reporting in every year.

Figure 6

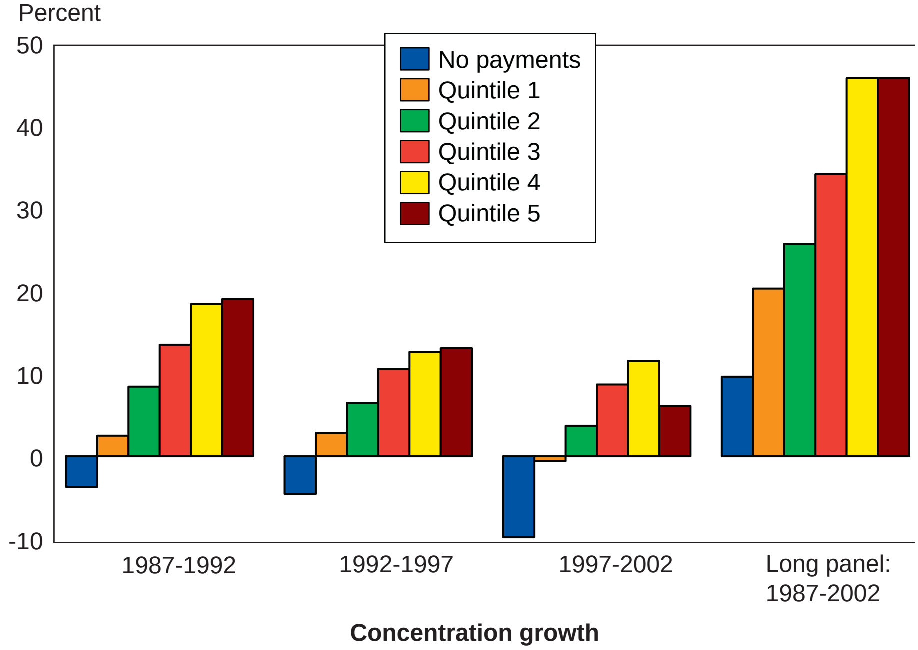
Change in ZIP Code farm size (weighted-median cropland) by payments-per-acre group, 1987-2002 (no controls)



Note: Data from census of agriculture 1987, 1992, 1997, and 2002. Sample includes all ZIP Codes with at least three operations reporting in every year. Payment quintiles are derived by sorting ZIP Codes by payment per cropland acre in the beginning year of each panel and choosing an equal number of ZIP Codes for each quintile.

factors varying geographically with payments. Beginning-year concentration measures capture the degree to which there is remaining scope for further concentration. Initial crop sales per acre and share of ZIP Code land in crops serve as further controls for land quality. The effects of all the controls are accounted for using a flexible semi-parametric regression model (see appendix). In comparison to standard regression techniques, the semi-

Figure 7
Change in ZIP Code farm size (weighted-median cropland) by payments-per-acre group, 1987-2002 (with controls)



Note: Data are from census of agriculture 1987, 1992, 1997, and 2002. Sample includes all ZIP Codes with at least three farm operations reporting in each year.

parametric model requires fewer assumptions about the way these control variables influence concentration growth.

The addition of controls (table 7) changes the estimated values somewhat, but a similar pattern across payment categories remains. For the long panel, the estimated difference in cropland concentration growth between the highest and lowest payment categories is 71.2 percentage points without controls (table 6) and 35.1 percentage points with controls (table 7). Figure 7 displays the adjusted growth rates associated with each panel.

What might the statistics imply in terms of the size of the relationship between cropland concentration and payments from agricultural programs? The estimates in table 7 can be compared to the average predicted cropland concentration growth between 1987 and 2002. The estimate of 11.2 percent for the zero-payments category is substantially lower than the average predicted growth rate of 41.5 percent.[11] This comparison may overstate the effect of payments on concentration, however, because there are few ZIP Codes with no payments and these ZIP Codes are likely quite different from those with modest payments.

An alternative way to estimate concentration growth in the absence of payments is to use the growth predicted for the first payment quintile (23.6 percent) rather than the zero-payments group. This alternative comparison suggests that about 43 percent of growth in cropland concentration between 1987 and 2002 is associated with commodity program payments (23.6 percent with low payments versus 41.5 percent with average payments).

[11] Because the regression model is nonlinear, the average fitted growth rate does not equal the average observed growth rate, which was 50.1 percent (the weighted average of the last row in table 6).

Table 7

Percentage change in ZIP Code farm size (weighted-median cropland) by payments-per-acre quintitle group, with controls

Years	No payments	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
	Percentage change in concentration of cropland (Standard error)					
1987-92	-4.3	2.9	9.8	15.7	21.4	22.1
	(1.7)	(1.8)	(1.8)	(1.8)	(1.8)	(1.8)
1992-97	-5.3	3.3	7.5	12.3	14.7	15.2
	(1.7)	(1.8)	(1.8)	(1.8)	(1.8)	(1.8)
1997-2002	-11.4	-0.7	4.3	10.1	13.4	7.1
	(1.7)	(1.8)	(1.8)	(1.8)	(1.8)	(1.8)
Long panel	11.2	23.6	29.9	39.7	46.3	46.3
1987-2002	(1.8)	(2.0)	(2.0)	(2.3)	(2.3)	(2.4)

Notes: This table reports estimated effects of the payment quintiles on concentration growth after controlling for location and concentration, sales per acre of cropland, and the ratio of cropland to area in each ZIP Code in the beginning year of each panel. Effects were estimated using a semi-parametric generalized additive regression model. Concentration is defined as the weighted-median farm size in each ZIP Code. For the long panel, quintiles are calculated using payments per acre in 1987. An appendix provides more detail about the methods used. Data are from census of agriculture 1987, 1992, 1997, and 2002. Sample includes all ZIP Codes with at least three farm operations reporting in every year. Extreme outliers were dropped from the analysis, as described in the appendix.

Chapter 5

Effect of Payments on Growth and Survival of Farms

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 the size of newly entering farms. Thus, to better understand how payments might be leading to higher concentration levels, it is useful to examine the relationship between payment levels and the survival and growth of individual farm businesses over time. These farm-level analyses complement the ZIP Code-level analysis and further indicate how payments could have altered farm structure. The farm-level analyses consider only producers who specialized in program crops.[12] This focus facilitates comparisons between farms with similar attributes. The study begins with an examination of farm survival, followed by an analysis of farm growth.

[12] The survival analyses focus on those farms specializing in wheat, rice, corn, soybeans, cash grains, or cotton. The growth analyses exclude rice and cotton producers because there were too few observations to perform crop-specific regressions. See Key and Roberts (2006) and Key and Roberts (2007) for more details.

Payments and Farm Survival

For the survival analysis, the study compares the mean lifespans of farms that received different levels of commodity program payments. The study then estimates how a farm's probability of surviving changes over its lifespan, and compares this relationship for farms with high and low levels of payments (see box, "Measuring the Duration of Farm Business Survival"). Finally, the study estimates the effect of program payments on the rate of farm business exit, and uses these estimates to simulate the effect of a policy that reduces payments by 50 percent for each farm.

The census of agriculture illustrates how survival rates change with the age of the operation for farms with different commodity specializations (SIC codes). Table 8 presents the survival rates by SIC code for program crop farms that were first observed in the 1982 census (these farms might have initiated production between 1979 and 1982, as 1978 was the year of the previous census). About 50 percent of new farms exited within the first 5 years. After 10 years, about 32 percent of the new farms remained in business, and after 15 years, 22.5 percent remained in business. These survival rates are comparable to what has been reported for non-agricultural firms (e.g., Audretsch, 1991; Mata et al., 1995; Disney et al., 2003). Findings are also consistent with earlier studies showing the probability of survival generally increases with the age of the firm (Evans, 1987a; Evans, 1987b; Audretsch, 1991), as well as a recent ERS report that shows the larger a farm and the more experienced its operator, the less likely the farm is to exit (Hoppe and Korb, 2006).

Comparing Survival Rates of Farms With Different Levels of Program Payments

To examine the relationship between program payments and farm business survival, the study first compares the mean observed lifespan for farm businesses of different sizes and different shares of payments in total sales. Total agricultural sales, like cropland or farmland area, is a measure of farm

Measuring the Duration of Farm Business Survival

Data used to estimate the relationship between commodity program payments and farm business survival are from the census of agriculture conducted in 1987, 1992, and 1997 (individual records from the 2002 census were not available at the time this analysis was performed). The census provides information about the duration of a farm business only if it was continuously operated by the same individual and tracks operations over time using a Census File Number (CFN). The census defines a farm as out of business if there is no response to the census questionnaire or if it is returned stating that the farm is no longer operating. However, if a farm changes operators through a business transaction or inheritance, the CFN may change even though the business is still operating. Hence, it is not possible to estimate the duration of a farm business based on how long the CFN appears in the census. Consequently, for the analysis, a surviving farm is defined as one remaining in business and having the same operator; farms remaining in business with a different operator were removed from the sample because it is not possible to observe why an operation transferred ownership.[1]

This study examines the survival of farms that were operating in 1987—the first year the census of agriculture began collecting information on commodity program payments. To increase sample homogeneity, the study focuses only on farms with Standard Industrial Classification (SIC) codes indicating they were primarily producers of wheat, rice, corn, soybeans, cotton, or "cash grains." The sample includes the 200,187 farms that had at least 10 acres of land and $10,000 in sales in 1987 and for which information on all variables was available.[2] The census allows one to identify whether a farm business ceased operating between 1987 and 1992, or between 1992 and 1997, or whether it was still operating in 1997. In addition, the census records the year in which the current operator began managing the operation. Therefore, the observed lifespan of the farm business is defined as 1987 minus the year the operator initiated farming on the operation plus 2.5, 7.5, or 10, depending on whether the operation ceased operating by 1992, ceased operating by 1997, or remained in business in 1997.

The data have two characteristics that must be accounted for in the estimation of the duration of farm business survival. First, if a farm operation remained in business in 1997, it is not possible to observe the lifespan of the business; only that the business was operating as of 1997. Second, the sample does not include businesses that exited prior to 1987. For example, of all businesses initiated in 1980, only those businesses in 1987 that survived at least 7 years are observed. Farms that exited before 1987 are not observed. The regression technique used accounts for these data issues.

The regression controls for many other factors that might be associated with farm survival, including specialization as indicated by the farm SIC code, operator age, the year the farm began operating, the farm's organizational structure, the State in which the farm operates, and the farm's debt-to-asset ratio. Controlling for the year a farm began operating captures effects stemming from time-specific events, such as changes in farm policy and the farm crisis of the early 1980s. More details can be found in Key and Roberts (2006).

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[1] A farm was considered to have the same operator if the age of the operator differed by 5 years between consecutive censuses.

[2] Deleting farms with less than $10,000 in sales (which represent about a fifth of the observations) focuses the analysis on farm households where farm business income is a larger share of total household income and where commodity program payments are thus more likely to play an important role in the decision to continue farming. Whether or not these small farms are included in the analysis has little influence on the results.

Table 8

New program crop farm (1982) survival rates by farm type

Farm category	1982	1987	1992	1997
All program crop farms				
Number surviving	140,876	70,478	45,122	31,630
Survival rate (%)		(50.0)	(32.0)	(22.5)
Wheat (SIC = 111)				
Number surviving	20,592	10,534	6,678	4,697
Survival rate (%)		(51.2)	(32.4)	(22.8)
Rice (SIC = 112)				
Number surviving	1,750	864	525	330
Survival rate (%)		(49.4)	(30.0)	(18.9)
Corn (SIC = 115)				
Number surviving	46,150	23,091	14,876	10,363
Survival rate (%)		(50.0)	(32.2)	(22.5)
Soybean (SIC = 116)				
Number surviving	34,875	15,398	9,311	6,392
Survival rate (%)		(44.2)	(26.7)	(18.3)
Cash Grain[1] (SIC = 119)				
Number surviving	32,643	18,330	12,396	8,927
Survival rate (%)		(56.2)	(38.0)	(27.3)
Cotton (SIC = 131)				
Number surviving	4,866	2,261	1,336	921
Survival rate (%)		(46.5)	(27.5)	(18.9)

Notes: The first column (1982) reports the number of new farm operations in 1982 that specialized in program crops. Subsequent columns indicate the number and share (in parentheses) of farms that began in 1982 that remain in each of the three subsequent censuses. Data from census of agriculture 1982, 1987, 1992, and 1997. Sample limited to farms with SIC codes indicating production of wheat, rice, corn, soybean, cash grains, or cotton.

[1]Cash grain farms include those growing sorghum, oats, barley, and/or other grain crops not otherwise classified.

size. Commodity program payments per dollar of sales scales payments relative to farm size, much like payments per acre of cropland did in the ZIP Code analysis. With few exceptions, within each sales quartile, a larger share of payments in sales corresponds to a longer mean lifespan (table 9).[13] For example, in the highest sales quartile, farms where payments comprise less than 12 percent of sales have a mean lifespan of 26.16 years, versus 28.29 years for those where payments comprise more than 36 percent of sales. The last column shows that the mean lifespan of farms in the highest payments-as-a-share-of-sales quartile is significantly longer (2.13 to 2.5 years) than the mean lifespan of farms in the lowest quartile.

[13] Average observed lifespans reported in table 9 do not account for the data issues discussed in the box, meaning these averages do not provide unbiased estimates of the true lifespans (see Key and Roberts (2006) for further discussion).

Controlling for Differences Between Operators and Operations

A statistically significant difference between estimated lifespans is not conclusive evidence that commodity program payments influence survival because other factors might be correlated with both payments and survival. For example, high-payment farms are larger on average, are more concentrated in certain regions (such as the Corn Belt and Mississippi Delta), and are more likely to grow certain crops (such as corn, soybeans, wheat and cotton). If these factors are correlated with both program payments and duration of farm survival, one might observe a relationship between payments and survival that is not causal. To address this issue, the study

Table 9

Farm business lifespan by sales and commodity program payments as a share of sales

	Quartiles (Commodity program payments as a share of sales)				
	Q1	Q2	Q3	Q4	Q4 – Q1
Sales quartile	(0-11.99%)	(12-21.99%)	(22-35.99%)	(36% +)	
Q1 ($10,000-$23,990)					
Years	25.37	25.22	26.24	27.87	2.50***
(Std. Err.)	(0.119)	(0.163)	(0.157)	(0.124)	(0.172)
Obs.	17,031	8,615	9,253	15,145	
Q2 ($23,991-$50,600)					
Years	25.94	26.60	28.00	28.48	2.54***
(Std. Err.)	(0.137)	(0.136)	(0.129)	(0.120)	(0.182)
Obs.	12,130	11,153	12,320	14,441	
Q3 ($50,600-$104,390)					
Years	26.04	27.45	28.66	28.28	2.24***
(Std. Err.)	(0.138)	(0.137)	(0.114)	(0.117)	(0.181)
Obs.	9,952	13,343	13,642	13,114	
Q4 ($104,390 or more)					
Years	26.16	27.80	28.03	28.29	2.13***
(Std. Err.)	(0.156)	(0.077)	(0.083)	(0.118)	(0.195)
Obs.	6,141	24,039	21,994	11,696	

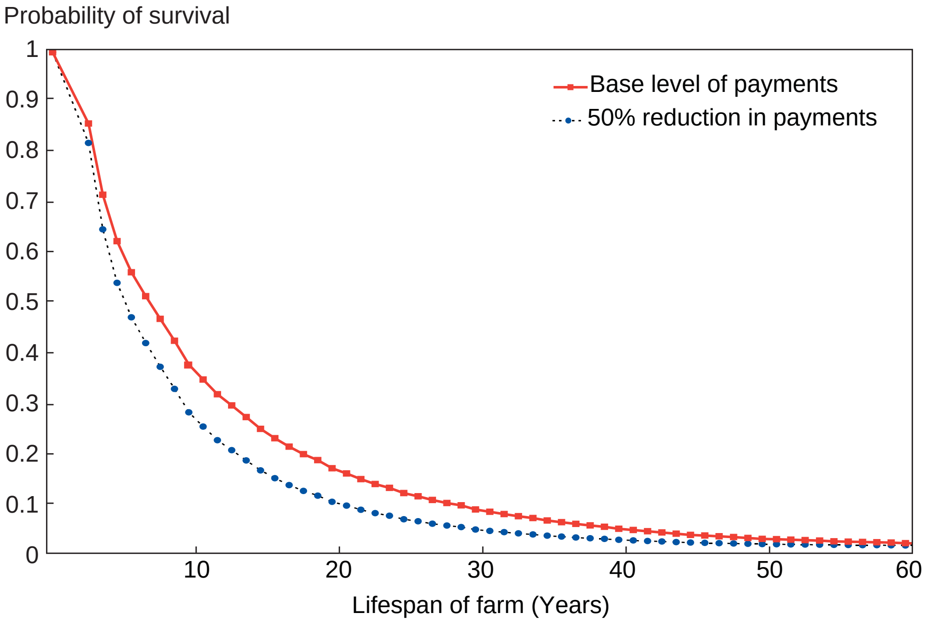
Notes: The table shows the average lifespan of farms in the sample. All farms were operating in 1987, but some ceased operation by 1992 or 1997. The business lifespan is defined as 1987 minus the year the operator began operating plus 2.5, 7.5, or 10, depending on whether the operation ceased operation by 1992, ceased operation by 1997, or remained in business in 1997. Three asterisks (***) indicate that the null hypothesis of equal mean lifespan for the first and fourth payments as a share of sales quartiles is rejected at the 0.001 significance level. Data from census of agriculture 1987, 1992, and 1997. Sample limited to farms with SIC codes indicating production of wheat, rice, corn, soybeans, cash grains, or cotton.

estimates the effect of program payments on the exit rate (in any year, the chance that a farm business will exit the sector within a year, given that it has survived up to that point in time) using an empirical approach that controls for characteristics of the operation and the operator (Key and Roberts, 2006).

An increase in commodity program payments as a share of sales is associated with a statistically significant reduction in the farm business exit rate. Specifically, a 10-percent increase in program payments is associated with a reduction in the exit rate of 0.35, 0.50, 0.74, and 0.90 percent for a representative farm in successive quartiles. For example, for a farm in the highest sales quartile with a 50-percent chance of exiting in the next period, a 10-percent increase in payments as a share of sales would decrease the chance of going out of business to 49.5 percent. While not particularly large, these numbers pertain to exit rates in a single year, and support the hypothesis that commodity program payments may affect farm structure.

With regard to the control variables, the study finds larger enterprises are less likely to exit than smaller ones, which is consistent with other studies of nonfarm businesses. In particular, a 10-percent increase in farm sales is associated with an estimated 4.3-percent decline in the hazard rate (the

Figure 8
Survival function estimates



Notes: The figure shows the average estimated probability of survival for all farms with observed levels of 1987 payments and with half the observed level. Estimates are based on the Cox proportional hazard model described in the appendix. Data are from census of agriculture 1987, 1992, and 1997. Sample limited to farms with SIC codes indicating production of wheat, rice, corn, soybeans, cash grains, or cotton.

probability the business will exit at any point in time). Younger farmers have a lower probability of exiting than older farmers: holding all else constant, the hazard is smallest for operators age 30-34 and it increases gradually with age until farmers are age 50-54, after which the probability of exiting increases rapidly, corresponding to the retirement of the operator.[14]

These estimation results can be used to explore the effect of a reduction in commodity program payments on farm survival. Program crop farms receiving the mean level of payments have about a 35-percent chance of surviving to 10 years, versus only a 25-percent chance for program crop farms receiving half the mean level of payments (fig. 8).

Table 10 illustrates the effect of a 50-percent reduction in farm commodity program payments on the expected lifespan of program crop farms of different sizes. The effect of the hypothetical policy is shown separately for payment recipients and for all program crop farms with at least $10,000 in sales. Larger operations would experience a greater reduction in lifespan for two reasons. First, the marginal effect of a reduction in payments is greater for larger operations. Second, a greater percentage of large farms receive program payments (97.0 percent for the largest sales quartile, compared with 78.6 percent for the smallest quartile). A 50-percent drop in payments would shorten the expected lifespan of the largest farms by 5.4 percent (from 14.25 to 13.48 years, or about 9 months) and the smallest farms by 1.7 percent (from 8.83 to 8.68 years, or about 2 months).

[14] A further discussion of the model results can be found in Key and Roberts (2006).

Table 10
Estimated effect of a 50-percent reduction in commodity program payments on the duration of farm businesses

	Estimated life of farm business in years (standard error)					
	Farms receiving payments			Farms with $10,000 in sales		
Sales quartile	Base	50 percent of base	Percent change	Base	50 percent of base	Percent change
Q1	9.44	9.24	-2.06	8.83	8.68	-1.71
	(0.021)	(0.020)		(0.020)	(0.019)	
Q2	10.93	10.58	-3.22	10.38	10.08	-2.89
	(0.024)	(0.023)		(0.022)	(0.022)	
Q3	12.91	12.32	-4.59	12.43	11.88	-4.38
	(0.027)	(0.026)		(0.026)	(0.025)	
Q4	14.67	13.86	-5.53	14.25	13.48	-5.41
	(0.031)	(0.029)		(0.030)	(0.029)	

Notes: The table reports average estimated life of farm businesses in each of four sales quartiles both with observed payment levels and payment levels of half the level observed. Estimates are based on the Cox proportional hazard regression model described in the appendix. Standard errors for the estimated lifespans are given in parentheses. The "percent change" column indicates the percentage difference in lifespan. Data are from the census of agriculture 1987, 1992, and 1997. Sample limited to farms with SIC codes indicating production of wheat, rice, corn, soybeans, cash grains, or cotton.

Payments and Farm Growth

Commodity program payments could influence farm size over time by altering both the probability of surviving in farming and the scale of those who survive (see box, "Estimating the Relationship Between Payments and Individual Farm Size"). The conditional expected farm size is the expected size of a farm conditional on its surviving to the next period, and the unconditional expected farm size is the average size that current farmers can expect to be, allowing for the fact that some farms will exit. Since farms have some probability of ceasing production (in which case they would have a farm size of zero in the next period), the unconditional expected farm size is smaller than the conditional expected farm size.

For the four crop types considered (wheat, corn, soybeans, cash grains), payments have a stronger link with the unconditional expectation in size than with the conditional expectation. For example, with no reduction in commodity program payments, wheat farms in 1987 have an expected farm size of 565.3 acres in 1992 (table 11). With a 50-percent reduction in payments, the expected farm size is 522.6 acres (a 7.5-percent reduction). Wheat farms that survive from 1987 to 1992 have an expected farm size of 960.3 acres without a payment reduction and 943.5 acres (a 1.8-percent decline) with a 50-percent reduction in payments. The change in the conditional expected farm size is smaller than for the unconditional expected farm size because program payments are associated with a reduction in the likelihood of exiting between periods.

A 50-percent reduction in commodity program payments is associated with a decline in farm size for all program commodity groups and all farm sizes. The drop in farm size is larger for the smallest farm size categories, reflecting a larger effect on the probability of survival.

Table 11
Unconditional and conditional expected farm size

Type of farm in beginning period	Unconditional expected farm size (farmland acres)		Conditional expected farm size (farmland acres)		
	Status quo	50% reduction in payments	Status quo	50% reduction in payments	Observations
Principal commodity					
Wheat					
1987-1992	565.3	522.6	960.3	943.5	37,012
1992-1997	663.0	616.1	1059.3	1040.7	34,352
1997-2002	703.9	653.5	1138.2	1118.3	32,312
Corn					
1987-1992	214.6	198.5	361.9	355.6	86,871
1992-1997	272.1	252.9	433.8	426.2	97,825
1997-2002	304.9	283.4	485.6	477.1	98,576
Soybeans					
1987-1992	166.4	153.7	288.6	283.5	87,405
1992-1997	167.5	155.1	281.7	276.8	52,035
1997-2002	222.4	206.5	360.0	353.7	68,700
Cash grains					
1987-1992	368.6	344.2	556.3	546.5	88,034
1992-1997	429.4	402.3	623.4	612.4	81,604
1997-2002	491.8	460.9	711.1	698.6	81,224
Total farmland					
10-249 acres					
1987-1992	57.0	51.9	118.1	116.1	149,591
1992-1997	59.6	54.5	117.2	115.1	120,725
1997-2002	61.4	56.2	119.9	117.8	121,427
250-499 acres					
1987-1992	200.3	185.0	343.5	337.5	60,812
1992-1997	204.6	189.5	338.4	332.5	51,788
1997-2002	204.6	189.6	339.1	333.2	53,998
500-999 acres					
1987-1992	419.4	389.9	662.3	650.7	51,232
1992-1997	431.6	402.4	659.9	648.3	49,598
1997-2002	431.0	401.7	662.6	651.0	52,922
1,000-1,999 acres					
1987-1992	822.3	766.5	1,261.4	1,239.2	25,989
1992-1997	853.9	798.9	1,256.9	1,234.7	29,559
1997-2002	858.9	803.2	1,270.9	1,248.5	34,306
2,000+ acres					
1987-1992	1,966.3	1,830.2	3,069.3	3,015.3	11,698
1992-1997	2,029.7	1,897.0	3,025.8	2,972.5	14,146
1997-2002	2,051.1	1,916.8	3,062.1	3,008.1	18,159

The table presents estimates of the unconditional and conditional farm size with and without implementation of a hypothetical policy that reduces commodity program payments by 50 percent. Data are from the Census of Agriculture 1987, 1992, and 1997, and 2002. Sample limited to farms with SIC codes indicating production of wheat, corn, soybeans, or cash grains.

Estimating the Relationship Between Payments and Individual Farm Size

An estimation of the relationship between commodity program payments and individual farm size must address the fact that the sample of farms that survive is not randomly selected from the population of all farms. Because it is only possible to observe the size of farms that survived, using an ordinary least squares regression to estimate the unconditional effect of commodity program payments on farm size could produce inaccurate estimates if unobservable factors are correlated with the likelihood of survival and farm growth. For example, if commodity program payments and an unobservable factor such as "farming ability" are both positively correlated with the probability of survival and the rate of farm growth, then farmers with high ability would be overrepresented among the sample of survivors. Within the sample of survivors, ability would be negatively correlated with commodity program payments: farmers would need high levels of ability to overcome low commodity program payments, and farmers with low ability would need high payments to survive. Estimates of the effect of payment on farm size would therefore tend toward zero. To address this potential problem, the study uses a maximum likelihood approach to obtain consistent parameter estimates.

Data for this analysis are from the census of agriculture, 1987, 1992, 1997, and 2002. To perform separate regression analyses for each type of crop producer, this analysis limits the sample to producers specializing in one of the four largest crops. The sample consists of 845,950 farms that had at least 10 acres of land and were identified as primary producers of wheat, corn, soybeans, or "cash grains." The data were organized into three panels: 1987-92, 1992-97, and 1997-2002. The regression specification allowed for separate effects by SIC code, year, and size of operation. More details can be found in Key and Roberts (2007), which develops the empirical model used in the policy simulations reported here. Unlike Key and Roberts (2007), which was developed before 2002 census data were available, results reported here are based on data that include observations from the 2002 census.

Chapter 6

Summary and Discussion

For the past several decades, crop production in the United States has shifted to larger operations. The shares of cropland and farmland operated by large-scale farms have steadily increased, while the shares operated by medium-sized farms have declined. Many factors, including changes in technology and factor prices, likely contributed to the increased concentration of production. To what extent have commodity program payments contributed to this phenomenon?

This report uses data from five censuses to explore a series of empirical relationships between program payments and changes in farm structure. In general, the findings indicate a positive association between program payments and subsequent increases in measures of farm concentration, survival, and growth. This association was maintained under different model specifications. Across ZIP Code areas, cropland concentration grew faster where beginning-period payments per acre were higher. Concentration growth increased consistently as payment levels increased, and this pattern was similar in different time periods. This pattern persisted after controlling for ZIP Code location, initial concentration, sales per cropland acre, and the ratio of cropland to other land uses.

The ZIP Code analysis was supplemented by analyses of farm business survival and growth. These analyses compared the survival rates over time of farms with high and low levels of payments as a share of sales, and estimated the relationship between payments and farm business survival rate while controlling for farm operator and operation characteristics. Findings indicate a significant positive association between past commodity program payments and farm survival rates, with and without controlling for other factors. Also, conditional on survival, payments are positively associated with growth in farm size.

Have Payments Made Farms Larger?

The findings of this report are consistent with the hypothesis that farm commodity program payments influence structural change in agriculture. However, it is not possible to rule out other explanations for the observed associations between payments and farm structure, despite efforts to control for factors that might cause spurious associations between program payments and structural change. It is impossible to know whether factors remain that have not been accounted for. This is a standard caveat to non-experimental studies that employ data observed in the natural world as opposed to data from a carefully controlled experiment (see footnote 4). Payment levels depend, to some extent, on farmers' decisions to participate in government programs and on their production decisions. Hence, unobserved factors might affect both payment levels and farm structure, and bias estimates of the effect of payments.

For example, if variation in land quality is not adequately accounted for by the controls, then this could be an alternative explanation for the findings in the ZIP Code and farm-level analyses. Much of the local variation in payments may be due to local variation in base acres and program yields. Areas with more base acres and higher program yields may also have superior land quality. Technological change might be more scale-enhancing in areas with better land quality—for example, larger harvesters might be more feasible in flatter and more productive regions. 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 payment-farm size relationship at a broader level. A technological effect of this kind would seem coincidental, particularly because it would need to be associated with payment levels in a consistent and gradual way in order to explain the similar and steadily higher rates of concentration growth across the five payment quintiles.

Another possible noncausal explanation for the findings is that variation in commodity program payments per acre reflects differences in farmers' managerial abilities. That is, "better" farm managers are able to obtain higher commodity program payments per acre due to their superior practices and yields. But it seems unlikely that farming ability would significantly influence variation in per-acre payments across farms, especially after controlling for grower and operation characteristics (crop type, farm size, region, farmer age, farm organization, etc.). Because it is not possible to measure farmers' ability to farm or obtain commodity program payments, it is not possible to measure the role of ability in the observed correlation between payments and farm size growth.

Reconciling the possible causal and noncausal explanations for the empirical findings of this study will require more research. For example, if payments facilitate growth in farm size by enhancing liquidity and lowering borrowing costs, then it should be possible to observe whether farmers who receive higher payments also receive better terms of credit from their lenders. Or, if technological advances drove farm growth in areas with both higher land quality and higher payments, researchers should be able to identify a set of technologies and show how they facilitated the whole range of greater farm sizes in different parts of the country. While technology has clearly played a role in the concentration of production, less clear is how these technologies might have acted to increase concentration in a pattern aligned so closely with payment rates. Identifying a series of facts that are broadly consistent with each other and with the observed pattern of farm size growth will provide a better understanding of the pattern, and then, perhaps, draw out some deeper implications of farm policies.

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Appendix: Estimating the Link Between Payments and Concentration Growth

The study estimated the link between payments and concentration growth in several ways, both with and without controls. Results were similar in all cases. This appendix provides more detail about the methods used to derive results in tables 6 and 7 and figures 6 and 7, as well as some additional results obtained using different estimation procedures.

For the estimates reported in table 6, concentration is defined as the weighted-median cropland area in each ZIP Code (the acres of cropland on the farm for which half the cropland acreage occurs on farms with more cropland and half on farms with less). For each ZIP Code and panel, the percentage change in concentration is calculated as 100 times the change in concentration divided by average concentration in the two years considered. The long panels calculate the percentage change between 1987 and 2002. Payments per acre in each ZIP Code are calculated by dividing total payments in the beginning year by total cropland. ZIP Codes with no payments comprised one payment group and those with positive payments were classified into five quintiles, each with the same number of ZIP Codes. The payment-per-acre cutoffs are different in the different panels because payments vary across years. The cutoffs were chosen so as to have the same number of ZIP Codes in each quintile with positive payments. For the long panels, the payment groups were constructed using payments per acre in 1987. Because ZIP Codes receive different payment levels in different years and are sometimes classified into different payment groups in different panels, the percentage change for the long panel does not equal the sum of the individual panels.

The sample of ZIP Codes in the analysis is somewhat less than the population of ZIP Codes in the census of agriculture. ZIP Codes were dropped from the analysis if (1) less than three farms returned census forms in any of the four censuses examined; (2) if the ZIP Code reported no cropland in any of the panel years; (3) if commodity program payments per acre, the ratio of cropland area to ZIP Code area, or the ratio of crop sales to cropland area were in the top 2 percent of all ZIP Codes. The extreme observations were omitted from the analysis due to the highly skewed distributions of these variables. For example, some ZIP Codes may have extremely high payment-to-cropland ratios if there are very few acres of cropland, but a modest level of payments, perhaps as a result of historical plantings. After omitting these observations, the analyses include 21,524 ZIP Codes.

Results reported in table 7 (with controls) are derived from estimation of *generalized additive models* with the form:

$$\Delta c_i = X_i\beta + f(x_i,y_i) + g_c(c_{0i}) + g_a(a_{0i}) + g_s(s_{0i}) + \varepsilon_i$$

where subscript i (omitted below to simplify notation) indexes ZIP Codes, c_0 denotes concentration in the beginning year, Δ_c is the percent change in concentration ($(c_1 - c_0)/ ½(c_1 + c_0)$), X is a matrix of indicator variables denoting payment-per-acre categories (one column of each row equals 1 and the others equal 0), β is a vector of payment-category effects, $f(x,y)$ is a smooth function of locations (x, y) of ZIP Code centroids, $g_c(c_0)$ is a smooth function of beginning-year concentration ($c0$), $g_a(a_0)$ is a smooth function of the ratio of cropland area to ZIP Code area in the beginning year (a_0), $g_s(s_0)$ is a smooth function of crop sales per acre of cropland (s_0), and ε is a random error. For the long panels, Δc is the sum of percentage changes in concentration in the three individual panels, and c_0, a_0, and s_0 are the average of values from 1987, 1992, and 1997.

The critical assumption is that, conditional on controls for location, beginning-year concentration, beginning-year ratio of cropland to ZIP Code area, and beginning-year crop sales per cropland acre, payments per acre are not correlated with other, unobserved factors affecting concentration growth (εi).

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. The software package used was the public domain package 'R' with the 'gam' package written by Hastie (www.r-project.org). See this reference for more details about the procedure.

The key modeling decision concerns the share of points considered local to each fitted point on the smooth functions. For the models, each point along the smooth functions was estimated using 5 percent of the ZIP Codes, which is the smallest share that was computationally feasible for the two-dimensional spatial surface using the hardware and software. Summaries of the models with payment quintiles are reported in appendix table A1, excluding the parametric components reported in table 7.

Appendix table A2 reports a series of alternative long-panel estimates that illustrate the general robustness of the link between payment levels and concentration growth. The first set of estimates in the table are ordinary least squares (OLS) estimates with the control functions $f()$, $g_c()$, $g_a()$, and $g_s()$ approximated using orthogonal polynomials of varying orders. The table reports the estimated payment-group effects conditional on the polynomial controls. The orders of single-variable polynomials ($g_c()$, $g_a()$, and $g_s()$) are the given in the first column; the orders of the two-variable spatial function $f()$ are twice the number in the first column. Results can be compared to the unadjusted estimates (without controls), replicated from table 6 at the top of the table.

The second set of estimates in table A2 are robust regressions, or M estimates, fitted using iterated re-weighted least squares (IWLS). The weights are derived from penalty functions that reduce or eliminate the influence of outliers. The estimates are derived using Tukey's biweight proposal. The estimates were implemented using the public domain software "R" and the "MASS" package written by Venables and Ripley. More details can be found in Venables and Ripley and in the R documentation for the "rlm" function in the MASS package. Estimates were derived using the default method for the "MM" option. Robust methods are more computationally expensive than OLS, which limits the order of polynomials to 10 for both the single variable and two-variable spatial controls.

Table A1

Summary of generalized additive model estimates

Panel	Factor	Non-parametric degrees of freedom	F-value	Goodness of fit
Cropland concentration 1987-1992	Spatial surface (*x,y*)	73.0	16.3	Adj. R^2 = 0.153
	Beginning-year concentration (c_0)	35.5	58.0	Est. VAR(ε) = 0.281
	Ratio of cropland to ZIP Code area (a_0)	35.8	10.7	
	Crop sales per acre of cropland (s_0)	36.3	2.2	
Cropland concentration 1992-1997	Spatial surface (*x,y*)	72.9	13.4	Adj. R^2 = 0.130
	Beginning-year concentration (c_0)	35.2	65.0	Est. VAR(ε) = 0.294
	Ratio of cropland to ZIP Code area (a_0)	35.7	11.4	
	Crop sales per acre of cropland (s_0)	36.1	4.5	
Cropland concentration 1997-2002	Spatial surface (*x,y*)	71.4	13.1	Adj. R^2 = 0.135
	Beginning-year concentration (c_0)	35.2	66.5	Est. VAR(ε) = 0.348
	Ratio of cropland to ZIP Code area (a_0)	35.6	11.0	
	Crop sales per acre of cropland (s_0)	35.7	3.2	
Cropland concentration Long panel 1987-2002	Spatial surface (*x,y*)	88.9	23.6	Adj. R^2 = 0.212
	Beginning-year concentration (c_0)	45.5	42.9	Est. VAR(ε) = 0.49
	Ratio of cropland to ZIP Code area (a_0)	45.5	13.3	
	Crop sales per acre of cropland (s_0)	46.0	4.7	

Notes: Estimates and standard errors for the parametric components of the models (the payment group factors) are reported in table 6. All F-tests for nonparametrically estimated smooth functions are statistically significant with at least 0.1-percent confidence.

Table A2

Summary of alternative model estimates

	Predicted 1987-2002 percentage growth in cropland concentration by payment level						
	No Payments	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	R-squared
Unadjusted predictions ("Long panel" from table 6 and figure 6)							
	-1.6	17.9	20.8	32.0	42.7	49.6	
Adjusted predictions using generalized additive model ("Long panel" from table 7 and figure 7)							
	-8.3	20.6	26.3	34.9	41.7	46.2	*0.212*
Predictions adjusted using OLS polynomial regressions[1]							
Order = 1	3.9	18.8	21.3	33.0	44.0	48.4	*0.104*
Order = 2	6.2	20.1	21.1	32.2	42.5	47.3	*0.123*
Order = 3	6.0	19.8	21.2	31.9	42.4	48.2	*0.146*
Order = 4	2.1	19.6	22.3	32.8	43.0	49.7	*0.167*
Order = 5	-1.4	19.5	23.6	34.3	43.7	49.7	*0.177*
Order = 6	-2.8	21.0	25.2	34.7	42.7	48.6	*0.188*
Order = 7	-4.1	21.4	26.4	35.4	42.7	47.7	*0.200*
Order = 8	-4.4	22.0	27.2	35.8	42.3	46.5	*0.210*
Order = 9	-4.6	21.9	27.5	35.7	41.8	47.2	*0.221*
Order = 10	-5.2	22.6	28.2	35.9	41.2	46.8	*0.231*
Order = 11	-4.9	22.6	28.6	35.8	40.9	46.6	*0.237*
Order = 12	-4.6	22.6	28.4	35.6	41.1	46.5	*0.242*
Predictions adjusted using robust "MM" polynomial regressions[2]							Estimated VAR(ε)
Order = 1	-1.4	16.8	18.5	34.4	48.3	52.9	*0.403*
Order = 2	9.0	22.1	20.5	31.6	41.8	44.5	*0.389*
Order = 3	7.3	21.1	20.3	32.2	42.5	46.1	*0.387*
Order = 4	5.8	20.3	20.1	32.8	43.0	47.5	*0.384*
Order = 5	2.9	20.1	21.7	33.8	43.3	47.6	*0.379*
Order = 6	0.0	20.2	22.9	34.1	43.8	48.4	*0.369*
Order = 7	-2.9	20.2	23.9	34.5	44.4	49.5	*0.365*
Order = 8	-4.4	20.4	24.4	35.0	44.6	49.4	*0.361*
Order = 9	-5.7	20.9	25.0	34.9	44.3	50.0	*0.362*
Order = 10	-5.3	21.3	25.2	34.9	44.0	49.3	*0.359*

Notes: The table reports estimated effects of the payment quintiles on concentration growth after controlling for location and concentration, sales per acre of cropland, and the ratio of cropland to area in each ZIP Code in the beginning year of each panel. Each row of the table reports predictions from an alternative specification.

[1]OLS polynomial regression include polynomials of each control variable for the given order except location. Location is given by two coordinates determined via an Albers equal area projection of the ZIP Code centroids. A polynomial spatial surface of two times the given order is estimated for each regression. For example, for "Order=12," a 12th-order, single-dimension polynomial is estimated for beginning-year concentration, sales per acre of cropland, and the ratio of cropland area to ZIP Code area; and a 24th-order two-dimensional polynomial is estimated over the two location coordinates.

[2]Polynomials for the robust regressions are limited to order 10 for all controls due to computational limitations and to ensure numerical stability. R-squared is not a well defined concept for robust regressions. Instead, we report the estimated variance of the uncorrupted error.