WHY ARE FARMS GETTING LARGER? THE CASE OF THE U.S.

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2011

Vortrag anlässlich der 51. Jahrestagung der GEWISOLA
„Unternehmerische Landwirtschaft zwischen Marktanforderungen und gesellschaftlichen Erwartungen“
Halle, 28. bis 30. September 2011

Paper prepared for the annual meeting of the German Association of Agricultural Economists (GeWiSoLa), Halle, Germany, September 28, 2011. The views expressed herein are my own, and not those of the US Department of Agriculture.

Agricultural production continues to shift to larger farms in the U.S. I show that the shift is persistent over time, large, and ubiquitous across commodities. I review theories of farm size, and classify three channels for analysis: 1) scale effects, through technological economies and managerial diseconomies; 2) the roles of relative factor prices and factor shares; and 3) policy and institutions. Finally, I evaluate the empirical evidence on the forces driving structural change, distinguishing between crops and livestock because of important differences in the role of scale economies and coordination, and I offer some directions for the future.

Why are Farms Getting Larger? The Case of the U.S.

Agricultural production continues to shift to larger farms in the U.S. It's not uncommon to find dairy farms milking 4,000 head, or field crop operations with 10,000 acres of corn, soybeans, cotton, wheat, and other crops. This is not an isolated phenomenon. Stories about Brazilian agriculture frequently mention super-farms with 100,000 or more acres. One of the striking features of post-transition agriculture in Central and Eastern Europe is the survival of former state-owned cooperatives as large corporate farms. Most observers expected those farms to disappear into small family farms in the transition from communism, but they still account for significant production. There is ongoing controversy over farm structure in Africa and Asia, with some arguing that an increased reliance on large farms will lead to expanded productivity growth.

Different specifics attend each of these examples, but they raise several common questions. Has technology created new economies of scale in agriculture? Family farms have long been the most efficient way for organizing agricultural production: are we witnessing their demise? Do vast new farms represent the wave of the future, or are they driven by hope and circumstance, with little economic efficiency behind them? How well do theories of farm structure account for structural change in farming?

This paper will assess changes in U.S. farm structure. I provide new evidence of changes in US farm structure. I then review theories of farm size, and classify three channels for analysis: 1) scale effects, through technological economies and managerial diseconomies; 2) the roles of relative factor prices and factor shares; and 3) policy and institutions. Finally, I evaluate the empirical evidence on the forces driving structural change, distinguishing between crops and livestock because of important differences in the role of scale economies and coordination, and I offer some directions for the future.

My analysis draws heavily on ERS research, and two farm-level datasets. The Census of Agriculture, conducted every five years, covers all U.S. farms and provides data on inventories, acreage, production, revenues, and some expenses. The Agricultural Resource Management Survey (ARMS), an annual sample survey, solicits detailed data on farm finances, production practices, and farm operator characteristics, and therefore allows us to link farm-level decisions to financial and productivity outcomes.

U.S. Farm Structure

Three facts are fundamental to changing U.S. farm structure. Production has shifted to larger farms. However, those farms are still operated by families and closely held partner groups. Agriculture now features greater reliance on formal and informal contractual relationships, with less reliance on spot markets, and it is here that publicly held corporations play an important coordination role.

The shift to larger farms is not obvious in simple summary data. Mean farm size (in acres) grew rapidly between 1935 and 1975, but then stabilized (figure 1). But simple means provide a distorted picture when the size distribution is highly skewed. More detailed analyses are necessary.

Shifts in the Aggregate Size Structure of U.S Farms

Table 1 conveys key details about the farm size distribution: production has shifted to larger farms at the expense of small commercial farms, while the number of very small farms has grown dramatically (Hoppe, MacDonald, and Korb, 2010). The data are based on individual farm records in the 1982 and 2007 Censuses of Agriculture. Because farm prices rose by 43 percent in the period, we adjust for inflation and express all sales in 2007 dollars, using the U.S. Producer Price Index for Farm Products.

There were 2.2 U.S. million farms in 2007, just two percent less than in 1982. But 55,000 farms had at least $1 million in sales in 2007, compared to less than 16,000 in 1982 (with sales expressed in 2007 dollars). Moreover, those large farms accounted for 59 percent of farm sales in 2007, more than double their 1982 share.[1]

The increase in the largest farms' share of sales came at the expense of small commercial farms, those with sales of $10,000 - $250,000 . In 1982, there were 1.1 million of them, and they collectively held 40 percent of agricultural sales (table 1). But the number of small commercial farms fell by 40 percent, and their share of farm sales by nearly two-thirds, over the next 25 years.

The Census shows more very small farms, with less than $10,000 in sales. USDA, under the direction of Congress, defines a farm as any place that produces, or normally could produce, at least $1,000 of agricultural commodities. A place with less than $1,000 in sales is classified as a farm if it has cropland or animal assets that could generate $1,000 in sales (the "normally could produce" element). There were 254,000 such farms in 1982, and 689,000 in 2007, an increase of 171 percent. When combined with farms

[1] The growth of the class reflected a large increase in the number of such farms, as their average inflation-adjusted sales changed little between 1982 and 2007.

with $1,000 to $9,999 in sales, farms in the smallest size class in table 1 accounted for nearly 60 percent of all U.S. farms in 2007, but less than 1 percent of production.[2]

Why are there so many more very small farms? There's probably a real increase in the number of rural residences with enough horses or cropland to qualify as a farm under the definition; but the current farm definition is not adjusted for inflation, so it will capture more very small places as prices increase over time, and USDA has also made a concerted effort in recent years to better identify and track very small farms.[3]

Physical Measures, and Shifts at the Commodity Level

Sales-based data show that production has shifted to larger farms, even as more very small farms are counted. We can see similar shifts using physical measures based on cropland, harvested acreage, and livestock. The physical measures are weighted medians. For all cropland, the acre-weighted median is the median of the distribution of cropland acres by farm size, where half of all cropland is on farms with more cropland acres and half is on farms with fewer acres. Weighted medians differ from simple medians in that half of all farms are on each side of the simple median farm size, while half of all acres (or animals) are on each side of the weighted median. Weighted medians for specific crop

[2] It doesn't take much to produce $1,000 in agricultural commodities at 2007 average prices: 1.5 acres of corn, or a tenth of an acre of tomatoes, at average yields. You could generate $1,000 in revenue from the sale of a single steer, or eight hogs, or 3 months production from a single dairy cow.

[3] Given a 43 percent increase in farm prices between 1982 and 2007, places with $699-$999 dollars in sales in 1982, which would not have qualified as farms then, would qualify in 2007. For more on expanded efforts to track small farms, see the "Special Note Regarding the 2007 Estimates" on p. 31 in U.S. Department of Agriculture (2009). For more on defining farms, see O'Donoghue, et al (2009).

commodities are based on harvested acres of the commodity, while weighted medians for livestock are based on annual sales/removals of poultry, hogs, and cattle, and on herd inventory for dairy cows. [4]

Figure 2 compares simple means and weighted medians for farms with cropland. The simple means show no trend, as in figure 1. But the weighted median grew rapidly, from 589 acres in 1982 to 1,105 in 2007, or 88 percent. While cropland was shifting to larger farms, there were more very small farms with small amounts of cropland.[5]

Across crop commodities, production has generally shifted to much larger enterprises (table 2). Note that corn shifted from 200 acres in 1987 to 600 in 2007, a jump that was no doubt affected by the relatively high corn prices of 2007. But other field crops also showed large changes in the period, as did the selected vegetables and tree crops shown. The shift is persistent over time, large--with the typical increase being a doubling between 1987 and 2007--and ubiquitous, covering almost all commodities.[6]

Now consider livestock. The US has had dramatic and widely publicized changes in the structure of dairy and hog production, and it shows here. In 1987, the typical cow

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[4] The measure has been used in industrial organization and in labor economics for many years, and has been applied to the measurement of farm size by Lund and Price (1998), who refer it as the mid-aggregate size, and by Key and Roberts (2007).

[5] Tomatoes provide an extreme but telling example of the difference between simple means and weighted medians. In the 2007 Census, 25,809 farms harvested 442,225 acres of tomatoes, compared to 14,366 farms and 414,624 acres in 1997. That is, the mean fell from 29 to 17 acres, but the acre-weighted median rose to 820 acres. USDA introduced procedures designed to capture more very small farms in 2007, and counted 17,536 farms with less than an acre of tomatoes, up from 7,407 in 1997. But farms with less than an acre accounted, collectively, for just 1 percent of tomato acreage. While the average farm was getting smaller, the average tomato was being grown on a much larger farm.

[6] ERS has calculated medians for 12 field crops and 70 fruit and vegetable commodities not reported in table 2. All field crops, and 66 fruit and vegetables crops, show increases.

was in a milking herd of 80 cows; by 2007, the weighted median was 540 cows. The change in hogs was even more striking, from 1,200 hogs to 30,000.[7]

The other livestock categories—broilers and cattle--did not have revolutionary changes in organization during the period. Farms simply got larger—weighted medians for broilers and fed cattle doubled between 1987 and 2007. Even cow-calf operations (cattle, less than 500 lbs.) showed important changes, as small-scale part-time producers found it increasingly difficult to stay in the industry.

Continued Dominance of Family Farms

Despite the shift of production, family farms still dominate U.S. agriculture. ERS defines a family farm as one whose principal operator, and people related to the principal operator by blood or marriage, own at least 50.1 percent of the farm business.[8]

Family farms account for 97 percent of all U.S. farms, and 84 percent of production. The numbers imply that large farms are less likely to be family farms, but among those with $1-5 million in sales, family farms accounted for 87 percent of farms and 85 percent of sales. The numbers fall off when sales rise above for $5 million, but family farms still accounted for 64 percent of those farms and 57 percent of sales.

Nonfamily farms cover a range of organizational types. Among the largest ($5 million or more in sales), only one in nine were organized as corporations with more than

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[7] Hog production was also reorganized. Whereas most hogs in 1987 were in farrow-to-finish operations, by 2007 a pig would likely move from a sow operation that removes about 50,000-100,000 weaned pigs in a year, to a specialized nursery operation, and finally to a finishing facility handling 6,000-20,000 head a year.

[8] The definition emphasizes family ownership and control by those operating the farm.

10 shareholders, a useful indicator of a publically held corporation with dispersed ownership. Half of the remainder were organized as closely held corporations, with less than 10 shareholders.[9] Others were partnerships in which no single family held more than half of the partnership shares, cooperatives, or farms operated by hired managers on behalf of non-operator owners (Hoppe, Korb, and Banker, 2008).

Vertical Coordination

Family farms dominate U.S . agricultural production, and most nonfamily production is on farms operated by tight groups of unrelated people. Large corporations do little farming directly, but they influence farm practices and organization through contractual relationships with farmers.

The use of formal contracts to govern agricultural production grew rapidly until about 2003 (MacDonald and Korb, 2011). Contracts governed 11 percent of production in 1969, 28 percent in 1991, and 39 percent in 2003, but there has been no systematic growth in the contract share since then. Vertical integration, production from farms owned by firms that are also involved in processing and/or retailing, accounts for about 5 percent of agricultural production. Cash markets do not necessarily account for all of the rest, since some production may be consumed on-farm as animal feed.

Production and marketing contracts allow contractor/processors to obtain commodities with required specific attributes, in volumes and timing needed to run processing plants and distribution systems efficiently. Contracts can reduce price and marketing risks for farmers, and they may allow farmers to obtain credit and grow more

[9] Family farms can be incorporated. They are classed as family farms if the family (principal operator and relatives) owns more than half of the shares.

rapidly. U.S. farmers with contracts carry significantly more debt than those who do not use contracts, for given levels of net worth and commodity mix (Key, 2004; MacDonald and Korb, 2011). Easier access to debt financing may allow for faster growth, and in that sense contracting may have encouraged the shift of production to larger farms.

Production contracts are widely used in poultry and hogs, and allow contractors, often major corporations, to exercise greater control over agricultural decision-making. Under a production contract, a farmer provides housing, utilities, and labor, while the contractor, called an integrator, provides feed, chicks or pigs, veterinary services, and guidance. The farmer is paid a fee for services (not a market price), which may vary with production performance, and usually obtains additional compensation from the use or sale of manure as a fertilizer.

Major integrators own feed mills, processing plants, and chick hatcheries or sow farms.[10] They provide precise instructions for contract farmers to follow, and invest in developing improved genetics and feed formulations. While they contract with independent farmers, presumably because contract producers are more efficient than integrator-owned operations, these firms are intensely involved in agriculture.

Major meat processors, such as Tyson Foods, Smithfield Foods, and Cargill, coordinate their livestock supplies as integrators. Production contracts are also used in horticulture and seed production, and have replaced some types of plantation agriculture in the U.S. For example, Dole Foods still sources some of its pineapple, banana, and fresh

[10] This arrangement is typical in poultry. There are a considerable number of smaller and less-integrated contractors in hogs, farms who contract with other farms to raise hogs for them, and who contract with processors to slaughter the hogs. They may farrow pigs on their own sow operations, but may also contract for that service or purchase pigs. Some have joined to form ventures that operate processing facilities.

vegetable production on farms that it owns and operates, but much of its production comes from production contracts with independent growers operating leased land.

Until recently, most contracting in grains and oilseeds was for specific varieties, like high oil corn or non-GMO soybeans, but farmers began to rely more on marketing contracts in recent years, as another tool in a world of high and fluctuating commodity prices. Marketing contracts also allow farmers to lock in prices and market outlets. Grain and oilseed farmers may also use contracts for seed and chemical purchases, with joint prices for products provided through the same supplier. These contracts do not lock farmers into the long-term relationships embodied in livestock production contracts, and they switch among contractors frequently.

A Theoretical Framework for Analyzing Farm Size

Economists have used a consistent framework for analyzing changes in farm size over time and across regions, for both developing and highly industrialized economies Binswanger and Rosenzweig, 1986; Eastwood, Lipton, and Newell, 2007; Gardner, 2002). It's convenient to sort the framework into three channels: 1) scale economies and diseconomies; 2) relative factor prices, technology, and farm size; and 3) policies and institutions. For brevity, I will focus on those elements that are most relevant to the U.S.

Scale Economies and Diseconomies

Managerial diseconomies of scale play an important role in analyses of farm size, since most production in most commodities around the world is carried out by family farms, regardless of a country's level of development. Success depends on the precise timing and efficacy of specific production tasks, and the optimal timing, composition, and performance of those tasks can vary with subtle changes in weather and with local topographic conditions. Moreover, because of the seasonal nature of agriculture, the amount of effort that must be expended on the farm can vary widely throughout the year, and in unexpected ways. For those reasons, the supervision of hired labor and managers can be quite costly (because agricultural production doesn't lend itself to routines and standard operating procedures, and because effort is difficult to measure and reward). Therefore, it's widely thought that owner-operator enterprises have a better incentive structure, and have hence been more efficient than bureaucratically organized farms.

The same general observation, of production organized around family farms, suggests that technological economies of scale are generally modest in agriculture, and in most activities not so large as to provide bureaucracies with advantages over owner-operated family farms. Technological scale economies can arise from several sources: fundamental physical relations[11]; factor indivisibility, or lumpiness;[12] and labor specialization.[13] Technological scale economies appear in many agricultural processes,

[11] For example, the volume that can be moved through a pipeline increases disproportionately with increases in the pipeline's circumference. If material costs are proportional to circumference, and if energy and labor costs are also proportional to circumference, then output will increase more than proportionately with increases in costs, and average costs will fall with volume. Such factors are important in flow-process industries like brewing, cement, aluminum, and chemicals, as well as in transportation.

[12] Stamping presses for the production of automotive components are an example—they can turn out hundreds of thousands of units annually, and smaller target volumes would best be done through more labor-intensive methods, at higher cost. Indivisibility can also apply to knowledge generation, as in advertising or R&D.

[13] A worker focused on a limited set of tasks can be much more productive in the performance of those tasks. Family farms with multiple operators are a good example, as each operator usually specializes in a different set of tasks.

but in most cases they are exhausted at farm sizes well short of those that can be operated by a single family.

In an industry like agriculture with many producers, we should not see unexploited scale economies—that is, the largest producers operating in a range of increasing returns to scale--without a convincing explanation of why the largest producers can't get larger. Moreover, while new scale economies could lead to structural change, we ought to see a rapid response as farms expand to realize lower costs—in short, statistical evidence of persistent unexploited scale economies ought to invite skepticism (Gardner, 2002).

Cross-section studies of scale economies are also subject to a well known limitation: differences in managerial skills may give rise to apparent scale economies (Mundlak, 1961). If better managers have lower costs, they will have an incentive to expand under a wide variety of technologies. In that case, larger farms will have lower measured costs—apparent evidence of scale economies if we cannot account for managerial skills.

This critique holds greater force in some circumstances than in others. Some analysts have been able to use panel datasets of farms; and use farm fixed effects to account for unobserved managerial skills. In other cases, where measured scale economies are accompanied by substantive changes in farm size, such that the measured economies do not remain unexploited, the observed structural change gives support to the cost estimates.

Scale-related technological innovations could, in principle, be so large and important as to overwhelm the management advantages held by family farms, and lead to their replacement by large organizations. Innovations that routinize production and reduce the costs of supervision could erode managerial diseconomies of scale and, with them, the managerial advantages held by small family businesses. But technological and management innovations can also expand the range of control of family farms—that is, they can allow families to effectively farm more acres or raise more animals, without losing their management advantages over bureaucracies.

Relative Factor Prices, Technology, and Farm Size

U.S. family farms got steadily larger during middle of the 20th century (figure 1). Moreover, while subject to many caveats, contemporary studies found only a limited range for scale economies during the post-WW2 period when farm sizes grew rapidly. But if scale economies were limited, what would explain the growth in farm sizes?

During the period, earnings in non-farm occupations grew steadily, so the opportunity costs of farm family labor continued to grow. At the same time, costs of capital declined, relative to labor, as productivity in machinery-producing industries grew. Changes in relative factor prices gave farm operators an incentive to adopt machinery. With a given amount of available labor hours in a farm family, an operation that adopted new capital equipment could expand the size of the operation. Families left the farm sector for non-farm jobs in response to higher wages, and capital was substituted for labor, allowing for larger farms and greater capital intensity in agriculture.

The process outlined above sees a causal path as going from developments in the non-farm economy to rising opportunity costs of farm labor, and a substitution of capital for labor in the farm sector.[14] But that's not the only possible causal path. Machinery innovations in the first part of the 20th century, which followed from broader developments in science and engineering, were labor-saving, allowing farmers to cover more acreage or raise more animals with a given amount of labor. The introduction of labor-saving machinery in agriculture may have reflected technological change, and not simply a responses to shifts in relative factor prices.

Kislev and Peterson (1982) argued that relative factor prices and input substitution mattered. Changes in relative prices, when combined with estimates of the elasticity of substitution between capital and labor, could account for most of the growth in mean farm size (measured by mean acreage per farm) between 1930 and 1970. In their conclusion, they point out that the long-run trend of rising relative labor prices ended during the 1970's and that farm size growth flattened after 1970 as well (figure 1).

Policy and Institutions

Institutions play an important role in analyses of farm size in developing countries, where poorly developed rights to land ownership and transfer, limited land rental markets, and limited credit and insurance facilities may all influence farm sizes (Eastwood, Lipton and Newell, 2007).

U.S. discussions focus more on the role of policy. Some elements of policy have had clear effects on farm structure. Until recently, for example, marketing quotas were

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14 There's a lively literature concerned with the role of induced innovation here: specifically, did industry develop labor-saving innovations in response to a rising relative prices of labor, or does the process simply reflect the substitution of capital for labor in response to changes in factor prices? See Peterson and Kislev, 1986; or Thirtle, Schimmelpfennig, and Townsend, 2002.

used to manage production and target prices for peanuts and tobacco. Quotas were tradable, but within strict limits, and the effect was to keep production in small farms in traditional area. After elimination of quotas, production shifted to lower cost locations and larger farms (Foreman and McBride, 2011; Dohlman, Foreman, and Da Pra, 2009).[15]

Most discussion focuses on the broad commodity programs aimed at producers of corn, barley, cotton, grain sorghum, oats, peanuts, rice, soybeans, sugar, and wheat. Commodity payments received by farms reflect their production of those commodities, and larger crop farms therefore receive more total payments than smaller farms, even if payments per acre or per bushel of production do not vary with farm size.[16]

Those who argue that commodity programs encourage a shift of production to larger farms see it as working through a wealth channel or a credit channel. The argument for a wealth channel asserts that larger farms, having realized more total payments, can outbid smaller farms for land, and that the greater resources available through payments allows large farms to grow larger. Arguments for a credit channel are more sophisticated. Proponents argue that internal financial capital has a lower cost than external sources, due to imperfect credit markets, and at the provision of payments, which adds to internal

[15] Another commodity-specific policy favors small dairy farms. Under the Milk Income Loss Contract (MILC) program, all dairy farms receive direct payments when prices fall below a target level, but the aggregate amount is capped, so that that large farms receive less support, per unit of milk produced, than small farms. The policy is intended to keep smaller farms in operation, although the effects are modest (USDA, 2004).

[16] Payments made through marketing loans vary with the commodity and the gap between market and target prices, but provide constant per bushel amounts given those parameters, so the total payment amount varies directly with production. Direct payments are provided on land historically enrolled in commodity programs. Per acre payments vary with the historic enrolled commodity and with historic yields, so total direct payments to a farmer reflect acreage and historic yields, which correlate closely to total current production.

financial capital, therefore allows farms to make profitable investments that would be unprofitable if financed from external sources. Proponents argue that the credit channel may apply especially strongly to large crop operations, who rent most of their land and are often highly leveraged.

In each case, it is important to note that credit can only be an enabling factor: farm expansion must still be a profitable option, and commodity payments which provide constant per unit payments do not by themselves make expansion more profitable to large farms than to small.

Finally, U.S. tax policy has a clear theoretical impact on the farm size distribution, but has not been widely studied. A standard measure of the user cost of capital uses the following equation:

$$c = [q(r + \delta)][(1 - k - uz)/1 - u)]$$

where c is the annual cost per dollar of a capital asset, q is the relative price of one unit of the asset, r is the discount rate, δ is the economic depreciation rate, u is the tax rate on income from capital, z is the present value of depreciation for tax purposes, and k is the investment tax credit.

The second term in brackets is the tax term, the amount by which tax policy alters the cost of capital relative to no taxes. Assuming for the moment that k=z=0, increases in the tax rate u will raise costs of capital; by raising costs of capital relative to labor, it will reduce the adoption of machinery and reduce farm sizes.

However, capital investment in agriculture (structures and equipment) receives favorable tax treatment, which in turn reduces the cost of capital for farmers. Most recently, the degree to which depreciation could be accelerated was expanded, until almost all farms could expense all of their equipment and structures purchases in the year of purchase (Durst, 2009). That is, z has effectively been set equal to one; absent any role for the investment tax credit k, full expensing eliminates taxes on income from capital. Moreover, the nature of expensing provisions provide direct advantages to large farms over small, since only the largest farms carry potential tax liabilities as large as the maximum allowable deduction.

There have been many changes to tax policy over the years, which likely reduces the effect of policies on investment, but the recent trend has been to reduce taxes on capital, which ought to reduce the relative price of capital to the farm sector. That should lead to farm consolidation under the Kislev and Peterson model of farm size.

Empirical Analyses of U.S. Farm Growth: Livestock

Economies of scale in farm production and in processing, combined with tighter vertical coordination, play an important role in accounting for increased farm size in livestock.

During the 1980's and 1990's, U.S. meatpacking plants got much larger to realize technological economies of scale (MacDonald and Ollinger, 2000, 2005; Ollinger 2011). With slow growth in beef and pork consumption, larger plants also implied fewer packers and increased concentration. Scale economies arose from some lumpiness embodied in new capital equipment, but also from increased specialization that was realized by converting multi-species plants to single species of uniform sizes, and by creating greater labor specialization through assembly line organization of plants. MacDonald and

Ollinger (2005) estimate that the realization of scale economies through shifts to larger plants reduced annual processing costs in beef packing by 27 percent.[17]

Larger plants will only realize lower costs if they can run consistently near full capacity. Hog packers regularized these flows by developing contracts with producers. The contracts included incentives to deliver uniform animals (for efficient processing) with desired attributes (to meet consumer preferences). Contracts also specified volumes and timing of deliveries, to assure efficient operation of processing plants.[18]

Hog farms grew much larger during the 1990's and 2000's. There appear to be significant farm-level scale economies in hog finishing, up to a point. Farms removing 5,000-10,000 hogs a year realized unit costs that were 25-30 percent below those removing 500-5,000 (figure 3). But economies in finishing are limited, and even larger operations (20,000 head) didn't appear to realize lower unit costs. The scale economies stem from labor specialization and from lumpiness in capital inputs, and consequently a more intensive use of housing, feeding, and manure removal systems in larger operations (Key and McBride, 2007; Key, McBride, and Mosheim, 2008).

Production contracts, more common among larger operations, had separate strong effects on costs. Growers with production contracts consistently realized better feed conversion and more intensive use of capital and labor inputs (Key and McBride, 2003).

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17 The consolidation also followed from a series of labor battles in the early 1980's, which reduced wages at large plants, thus reinforcing the technological cost advantage arising from scale economies. Our estimates of cost effects are for the technological scale economies only, holding factor prices constant. Firms expanded quickly in response to new scale economies, and the largest plants reached constant returns.

18 Packers used price incentives in marketing contracts to realize desired animal attributes, while directly specifying volume and timing. Packers and non-packer integrators also used production contracts, under which they can directly manage animal attributes through the provision of genetics, feed, and production guidance to growers.

Cattle feedlots are among the largest firms in U.S. agriculture. The largest have one-time capacities of 100,000 cattle, and they employ staff nutritionists, veterinarians, economists, and accountants in addition to sales staff and production workers in feed preparation and animal care. Most large feedlots have longstanding relationships with one or two packers. Some are owned by packers, and most use contracts to manage flows of cattle through feedlots and to packing plants.

There appear to be some scale economies in cattle feeding, stemming from the ability to fully use specialized labor skills and from modest scale economies in feed processing. Moreover, feedlots grew to their current large size at the time that beefpacking plants became much larger, and it appears that the complementary linkages to packers further encouraged growth in feedlot size (MacDonald and McBride, 2009).[19]

Live poultry can't travel very far without incurring unacceptable mortality and weight loss. This fact, combined with the costs of transporting feed, means that poultry production and processing are managed within complexes of hatcheries, feed mills, processing plants, and grow-out farms located in close physical proximity to one another.

Broiler production has shifted steadily to larger farms over time. There may be modest scale economies in broiler production: large modern houses can handle more birds, per dollar of invested capital, than smaller houses (MacDonald and Wang, 2011). But the more important driver of increased farm size lies elsewhere.

There are substantial scale economies in poultry processing, stemming from capital indivisibilities and from labor specialization. Plants got much larger in the 1970's

19 There are no feedlot commodity versions of the ARMS survey, so we are unable to do the detailed cost analyses performed for hogs, dairy, and broilers. Because cattle feeding is dominated by a relatively small number of firms, a useful survey would have to achieve nearly complete levels of response to provide a statistically accurate picture.

and 1980's, but the largest plants still operate at volumes that are too small to realize all available scale economies in processing (Ollinger, MacDonald, and Madison, 2005; Ollinger, 2011). In order to increase plant volumes to realize scale economies, integrators could expand their catchment area by adding growers at further distances from the plant. However, that strategy raises transportation costs for feed and birds. They can also realize increase production at existing operations, as long as they can expand without raising risks from the spread of avian diseases or without violating environmental regulations. In short, external transportation and environmental costs limit the scale economies available to poultry complexes.

Finally, consider dairy farming, where production shifted to much larger farms. Complementary stages play minor roles here. Because of transportation scale economies, farms that ship daily truckloads of milk can realize some modest premiums. There are also scale economies in fluid milk processing, but dairy product processing (cheese, dry milk, ice cream) has few significant scale economies, and in any case dairy farms are not as closely linked to specific processing plants as poultry, cattle or hog operations are.

There do appear to be important economies of scale in dairy farming (MacDonald, et al, 2007; Mosheim and Lovell, 2009; McBride and Greene, 2009). Costs fall sharply with herd size as size expands up to about 500 head, and costs continue to fall, albeit modestly, as herd size expands further (figure 4). Mosheim and Lovell (2009) tested for diseconomies of scale in their sample (which went up to 3,000 head); while unit costs declined modestly among farms with more than 1,000 head, they found no evidence that costs stopped declining or turned up.

The economies stem from fundamental physical relationships in the design of milking systems, as well as in feed formulation and delivery systems and in manure disposal. These advantages appear to be exhausted at herd sizes below 3,000 head, so that expansion beyond that size embodies replication of existing physical systems. Land availability (for feed production and manure disposal) may limit growth opportunities for farms, but those with available land can reduce costs over a wide range of herd sizes.

In summary, since 1980 U.S. livestock production consolidated in much larger farms as processing consolidated in much larger processing plants. There is strong evidence that technological scale economies were important elements of that shift in processing, and that they played a role in farm production as role. But coordination between farm production and processing also played an important role through formal contracting and through cash market transactions.

Empirical Analyses of U.S. Farm Growth: Crops

Production is shifting to larger US crop farms, and on average larger farms show a better financial performance. Table 3 reports median rates of return on equity, for farms in each of five crop specializations, sorted by farm size (measured in this case by total harvested acreage).[20] To increase sample size, the data are pooled across 2008, 2009, and 2010. Median ROEs rise sharply and (with one exception) monotonically with acreage, and the largest farms realize substantially higher returns than small and midsize farms.

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[20] ROE is defined as net farm income, minus imputed estimates of the opportunity cost of unpaid farm operator labor and management, divided by farm net worth (assets minus debt). Since the measure is based on annual net income, it does not account for any capital gains on farm assets. The farm specialization is the commodity accounting for the largest share of a farm's gross income.

However, technological scale economies are less apparent in crops than in livestock, and labor-saving innovations and public policy may play significant roles.[21] While measures of farm-level financial performance show significant advantages to farm size, ERS commodity cost-of-production (COP) estimates, based on field-level analyses, typically show no systematic impacts of enterprise size (measured as the number of harvested acres of a commodity) on costs per acre or per bushel.

ERS COP analyses cover specific field crop commodities and are based on surveys of randomly selected fields, carried out as part of the ARMS program (Baldwin, et al, 2011; Foreman, 2006, 2001; Foreman and Livezey, 2002; Ali, 2002). Starting with data on the size of the field and production (expected and actual), analysts draw on responses to detailed questions about field tasks, as well as the material quantities and expenses, equipment, and labor hours associated with each task, to calculate unit costs per acre and per bushel.[22] When these estimates are compared across commodity enterprises of different sizes, unit costs do not fall as size increases, especially for enterprises with more than 50 acres.

Field-level cost estimates are based on equipment services--hours of machine use and hours of associated machine operator labor per acre. The approach implies that farms harvesting 1,000 acres of corn, for example, use the same amount of machine and labor

[21] Cost modeling is more difficult for crops than for livestock. We have good physical measures of output for livestock enterprises (pounds of milk produced or weight gained), and we have been able to effectively model livestock farm-level costs with just a few outputs (the primary livestock product, jointly produced products like culled animals, and a crop aggregate). In contrast, crop operations tend to be more diversified, with multiple crops; moreover, land quality matters but is rarely controlled for; and unmeasured temporal production decisions, such as rotations, also matter.

[22] These estimates also include farm-level overhead, allocated according to the commodity's share of farm production.

hours, per acre, as farms harvesting 500 acres. The analyses assume that equipment and operator labor are divisible—that equipment can be rented and that operator labor can be hired on an hourly basis—and therefore rules out lumpiness in capital equipment as a source of scale economies.

But innovations in farm equipment, farm production practices, and other inputs are often labor-saving—they reduce the hours needed to manage a given amount of cropland, thereby allowing a family farm to farm more acres. Moreover, one key element in scale economies is capital indivisibilities—a larger and faster piece of equipment may allow the farmer to manage more acres, when it is fully utilized. ERS COP analyses do not take account of differences in capital utilization between large and small farms.

Several important labor-saving innovations have been introduced in U.S. field crop production in recent years. Each allow farm operators to manage larger farms.

First, equipment has gotten bigger and faster, allowing a farmer to cover more acreage (table 4). A machine operator could plant more than 10 times as many acres per day, and could harvest more than 7 times as many bushels per day, in 2005 as in 1970. The largest and fastest equipment now available allows for further large increases in 2012 as compared to 2005.

Moving larger pieces of equipment between fields takes more time and expense, and larger pieces also require more set-up time at fields. For these reasons, bigger and faster equipment should be most valuable in regions where fields are large, flat, and contiguous. They ought to therefore be more valuable, and have greater effects on farm size, in the Western Corn Belt, the Plains, and the Delta, and contrast to the Eastern Corn Belt, to Appalachia, and to the Northeast.

Second, the spread of genetically engineered seeds in corn, cotton, and soybeans has affected farm production practices and the allocation of operators' time (figure 5). Herbicide tolerant (HT) seeds, used in all 3 crops, allow farmers to apply one herbicide product at a post-emergent stage, instead of several herbicides applied at different times (Fernandez, 2007). HT seeds thereby allow for reductions in machine and machine operators' time, as well as reductions in the time applied to management and planning for weed management. Other GE seeds (Bt), used in corn and cotton, are pest-resistant. In principle, they allow farmers to forego spraying of pesticides, allowing for savings in machine and machine operator hours.

Third, no-till conservation practices have become an important soil conservation practice in the U.S. A no-till system leaves crop residue from the previous harvest on the soil, and soil is left undisturbed from prior harvest to planting, except for the injection of nutrients. HT seeds allow for easier use of no-till practices, and the recent spread of no-till owes something to the expansion of acreage planted to HT seeds.

USDA has not performed annual comprehensive surveys of tillage practices, but surveys specific crops in different years. Shares of acreage under no-till have increased for most crops in most states, and Horowitz, Ebel, and Ueda (2010) estimate that shares of planted acreage under no-till expanded at 1.5 percentage points per year between 2000 and 2009, when no-till covered 35 percent of planted acreage for eight major U.S. field crops (barley, corn, cotton, oats, rice, sorghum, soybeans, and wheat). No-till allows for reduced machinery passes, along with the associated operator times, in fields, and is therefore a labor-saving, as well as capital- and energy-saving, innovation.

A fourth major set of innovations—precision agriculture—refer to management practices and technologies that measure and manage intra-field variations in soil attributes, pest presence, and production outcomes. Specific technologies include yield monitors that measure and map intra-field variations in yields at harvest; pest monitors that identify the presence of insects and fungi at spraying; GPS systems that map soil attribute, yield, and pest data and transmit the information to vehicles in fields; variable rate spraying and injection technologies that match the application of chemicals to intra-field variations in nutrients and pest presence; and auto-steering and guidance systems for tractors.[23] Precision technologies were used on 58 percent of wheat acres in 2009, up from 14 percent in 1999; on 49 percent of corn acres in 2005, up from 35 percent in 1999; and on 45 percent of soybean acres in 2006, up from 31 percent in 1999.

Precision technologies are best viewed as chemical- and nutrient-saving, and may be labor-saving. Because the innovations are embodied in lumpy capital equipment, they likely create scale economies. Precision technologies are more likely to be adopted on larger farms.[24]

Innovation, Relative Factor Prices, and Changes in Farm Size

As noted above, Kislev and Peterson (1981, 1982) and Peterson and Kislev (1986), denoted as KP in what follows, argued forcefully that the adoption of labor-

[23] Precision technologies, such as laser guidance for field leveling and drip irrigation, are also important for water management in agriculture.

[24] Livestock consolidation may also lead to larger crop enterprises. The number of farms with livestock enterprises has declined sharply over time, as farmers are far less likely to combine field crop production with a small-scale hog, beef cattle, or dairy operation. Dropping livestock leaves farm operators with more time to manage more crop acres.

saving capital equipment was an important driver in the growth of U.S. farm size between 1930 and 1970, and that adoption was driven by a rising price of labor relative to capital.

Between 1930 and 1970, mean U.S. farm size increased from 157 to 374 acres (of farmland, not cropland). KP (1982) argue that a model that combines changes in relative factor prices with estimates of the elasticity of substitution between capital and labor can account for almost all of that growth. Moreover, they argue that the growth in mean farm size slowed considerably, and then stabilized, after 1970, and that this slowdown corresponded to a new stability in factor price ratios.

KP opposed their view to the argument that scale economies drove farm growth. They argued that capital services are divisible enough, either directly or through the opportunity to rent equipment, to limit divisibility arguments for scale economies. They also argued that labor-saving technological change couldn't account for the observed changes in farm size, on the grounds that such shifts would have led to declines in the relative price of paid and unpaid farm labor.

I think that KP dismiss the role of scale economies too easily, and I'm skeptical of the implication that adoption of innovations in seeds and in precision agriculture largely follow from relative factor prices instead being driven by developments in the broader scientific community (genetics and information technology). Nevertheless, the relation between changes in farm size and factor prices is worth considering.

Mean farm size has changed little since the 1970's (figure 1). With little growth in median U.S. real wages or in median U.S. household income, one might think that the KP model still holds. However, I believe that mean farmland acreage is a poor guide to farm size, for reasons outlined earlier; my preferred measure of crop farm size, the weighted median, shows a large increase since 1982 (figure 2).

However, that doesn't invalidate the KP model, because relative labor prices have continued to rise, essentially because capital prices have declined. Figure 6 displays trends in the relative prices of labor and capital, as used in the USDA national agricultural productivity accounts. Note that the relative price is stable through the mid-1980's. After that time, however, declines in real interest rates led to sharp declines in capital prices and in capital-labor price ratios. The timing of the price decline fall corresponds closely to the acceleration in weighted median farm sizes noted in figure 2. Shifts in tax policy may also have reinforced the decline in relative capital/labor prices shown in figure 6. In short, while I believe that scale economies and labor-saving innovations play a role in the growth of crop farms, changes in relative factor prices, and hence factor substitution, may play larger role than is commonly realized.

Evidence on the Role of Government Payments

Key and Roberts (2007; 2008), hereinafter KR, found a strong association between government payments and changes in farm size. They used Census of Agriculture farm records to calculate weighted medians for cropland at a highly disaggregated level—postal zip codes--for 1987, 1992, 1997, and 2002.

Census records report government payments received during a Census year (the first year of reporting was 1987), allowing KR to calculate total government payments per cropland acre for each zip code.[25] KR then analyzed the relationship between payments and subsequent growth in farm size (weighted median cropland) in 21,524 zip codes that had complete data and at least three farms (63 percent of U.S. zip codes, and 95 percent of farms).

They sorted zip codes into 6 classes. One consisted of those with no government payments, while zip codes with payments were sorted into quintiles according to the value of payments per acre. KR then compared farm size growth rates (weighted median cropland) across the six classes of farms, for each of four time periods: 1987-92, 1992-97, 1997-2002, and 1987-2002. They did so in simple comparisons of means, in OLS regressions with other controls, and in a general additive model (GAM) with controls for location effects, crop mix measures, and initial farm size.

Table 5 displays the key results in the lower panel. Cropland shifted more rapidly toward larger farms in those zip codes with higher levels of payments per acre at the beginning of the period. The linkage is statistically significant, large, and robust in each time period. KR argue that payments account for one-half of the growth in the largest farms over 1987-2002, since growth in the lowest quintile is only half that of growth in the highest quintile (bottom row, table 5). If instead the no-payment class is the baseline, then payments account for three-quarters of large farm growth.

[25] Government payments include payments made directly to farmers from USDA conservation and commodity programs. In 1987-2002, conservation payments accounted for 14 percent, and commodity payments 86 percent, of the total. The data are self-reported, and appear to be underreported, in that aggregate Census sums are considerably less than total payments made to farms by USDA.

Is the relationship causal—that is, do higher government payments cause farm consolidation? I have two major concerns—omitted variables, and the marginal association of growth with payments

The highest rates of growth in farm size occurred in the Plains, Corn Belt and Delta regions. These have heavy concentrations of program crops, but they also have large, flat, and contiguous fields, land best suited for the labor-saving innovations described earlier. While KR included several control measures (sales per cropland acre, the fraction of land devoted to cropland, beginning-of-period median size, and locational controls), I'm still concerned that the association between payments and growth reflects the adoption of capital equipment.

Now consider the marginal association between payments and large farm growth. Farms in the second highest quintile in table 5 realize payments that much lower than those received by farms in the highest quintile, yet there is no difference in farm size growth between the two. Farms in the third payments quintile receive much lower payments per acre than those in the top two quintiles, but farm size growth is only 15 percent lower than the top two quintiles. The really large gap in growth rates, and the source of the association between payments and growth, lies between the bottom three classes and the top three. But note that most cropland (85 percent, and 92 percent of land planted to program crops) is in the top three classes. The model doesn't do much to account for differences in size growth in the classes where the cropland is.

Major labor-saving innovations clearly allow farmers to manage larger crop enterprises. What's a bit less clear are the drivers of adoption of those innovations—that is, the roles played by relative factor prices, tax policy, and agricultural policy in speeding adoption. Moreover, some of the innovations can be provided via custom services, thus potentially eliminating lumpiness in the equipment and extending the innovations to smaller and part-time operators.

The Future: Are Family Farms on the Way Out?

Large U.S. farm now manage more acres and more livestock—the largest farms have gotten larger. Some farmers now manage multiple farms, and some in multiple countries. These developments raise an important issue: are we simply seeing an expansion in the size of farm that a family can manage, or are we seeing a more fundamental shift toward large scale, bureaucratically organized farming firms?

These arguments have been made in the past for livestock operations, especially regarding the emergence of large hog, poultry, dairy, and fed cattle enterprises that rely on confined feeding and tightly controlled genetics (Allen and Lueck, 2002). Some now see such an emergence in field crops. Specifically, it is argued that the communications, measurement, and monitoring capabilities now incorporated in farm equipment provide managers with the detailed and localized field and farm level information that was previously available only through persistent personal experience in fields. It is also argued that modern seed genetics greatly reduce the amount of time that farm operators must spend in making field-level weed and pest management decisions.

With eroding managerial diseconomies of size, larger operators can effectively use equipment much more intensively, thus realizing cost advantages. However, field crop operations that are farming 10,000-20,000 acres require a major investment in land and capital equipment. Much of this may be leased or rented, but it opens the way for much more complex organizations—with sets of professional farm managers, possibly holding equity interests in the farming business, as well as hired labor and managers and with passive external equity investments from non-farm sources.

Boehlje and Gray (2009) allude to these possibilities when they argue that the biological, informational, and mechanical innovations described earlier now allow firms to introduce routines, process controls, and standardized operating procedures into farm management, and to thereby rely more on trained managers and hired labor to make and carry out farm operating decisions.

I remain a bit skeptical of the argument. Family farms, as defined by ERS (that is, according to ownership by the principal operator and relatives), still dominate crop production in the U.S.—in 2009, they accounted for 70 percent of vegetable and 76 percent of fruit production, 94 percent of wheat production, and 95 percent of corn and of soybean production. Much of the expansion that we see in large farm production reflects expansions in what families can effectively manage. While there is evidence of scale economies in production, particularly in some livestock commodities, there is still little evidence that scale economies are so extensive as to provide large bureaucracies with technological advantages over large family farms.

Conclusion: What Do We Know About Farm Consolidation?

Production has shifted to larger farms in the U.S. The shift has been large, persistent, and ubiquitous, but the size of the shift is also obscured in published farm statistics by the concurrent expansion in the number of very small noncommercial farms.

We have had successes in understanding the causes and effects of consolidation in livestock commodities. New scale economies in production and in processing played an important role, and the exploitation of those new economies was facilitated not only by increased size, but also by increased reliance on contracts and formalized alliances in order to manage livestock flows through the system. Consolidation increased productivity sharply and reduced costs, but it also consolidated manure production and thereby created new policy challenges for environmental management, animal welfare, and food safety.

No crops have undergone the radical structural shifts that we've seen in U.S. hog and dairy production. But there's nevertheless been a steady and widespread shift of acreage and production toward much larger farms. We've had much less research on crop farm consolidation compared to livestock, but labor-saving innovations must play an important role. An important research challenge lies in understanding the incentives to adopt those innovations, and the role played in adoption decisions by input prices, tax policy, and credit markets.

There are three other features of large scale farm operations that I have not touched on, because our data are quite limited, but they strike me as important for analysis. They are land assembly, custom services, and family dynamics.

Most large US field crop farms rent most of their land; their farms rarely consist of contiguous pieces of land, and they often farm plots that are at considerable distances from one another. Large U.S. livestock farms must find land for manure disposal, either by assembling it into the farm or by finding nearby farms that are willing to take manure. There are deep and well-defined land rental markets in the U.S., but ownership is quite dispersed. With a shift to larger farms, land assembly, landlord relations, and task scheduling across dispersed sites have become more important skills for farm operators. Moreover, there appears to be a growing flow of outside investors into farmland ownership. There appear to be opportunities for alliances between large-scale operators and large-scale investors, but we have little current data on it.

Equipment innovations play an important role in growing farm size, either because they are labor-saving or because they are lumpy and embody scale economies. But the U.S. also has deep markets in the hire of custom service providers for land preparation, planting, spraying, and harvesting. In principle, custom services make capital divisible and eradicate scale economies. They can also allow farmers to operate even larger farms by taking over some tasks from farm operators (some large dairy farms own and rent large amounts of cropland for feed, but rely on custom providers to perform all cropping tasks, thereby focusing the operators' time on dairy enterprise tasks and farm management). We don't know as much as we need to about the extent of use of custom services, or their role on changing farm structure.

Finally, large U.S. farms are still usually large family farms, and family dynamics play an important role on farm expansion and contraction decisions. Large farms usually have multiple operators, and in family farms those generally consist of combinations of spouses, siblings, children, and relatives. That provides an important random element to the management capacity and expansion decisions of individual large farms—can they assemble enough managers from the pool of willing relatives and friends?

Table 1: Changes in the Farm Size Distribution, 1982-2007

Item	**1982**	**2007**
Farms	2,240,976	2,204,793
Sales (2007 $, in millions)	189,151	297,220
Sales Class (2007$)	-Share of farms-	
<$10,000	42.5	59.8
$10,000-$250,000	50.5	30.7
$250,000-$999,999	5.9	7.0
>$999,999	0.7	2.5
	-Share of sales-	
<$10,000	1.8	0.9
$10,000-$249,999	40.8	14.2
$250,000-$999,999	30.0	25.6
>$999,999	27.4	59.2

Note: all sales are expressed in 2007 dollars, using the Producer Price Index for Farm Products.
Source: ERS calculations, based on Census of Agriculture data.

Table 2: Production Shifted to Larger Enterprises: Florence Medians

Commodity	**1987**	**1997**	**2007**
		Harvested Acres	
Field Crops			
Corn	200	350	600
Cotton	450	800	1090
Rice	295	494	700
Soybeans	243	380	490
Wheat	404	693	910
Vegetables			
Asparagus	160	200	240
Lettuce	949	1461	1815
Peppers, Bell	88	180	300
Potatoes	350	556	990
Sweet Corn	100	173	250
Tomatoes	400	589	820
Tree Crops			
Apples	83	122	146
Almonds	203	292	450
Oranges	450	767	1113
Peaches	92	100	120
Livestock		Annual Head Removed or Sold	
Broilers	300,000	480,000	681,600
Hogs	1,200	11,000	30,000
Fattened Cattle	17,532	38,000	35,000
Cattle, <500 lbs.	50	65	128
		Milk Cow Inventory	
Dairy	80	140	570

Source: ERS calculations, from Census of Agriculture

Note: estimates are weighted medians. Half of all harvested acres (or head in the case of livestock) are on larger farms, and half are from smaller.

Table 3: Median ROE for Crop Farms, by Harvested Acreage and Commodity

<table>
<tr><th rowspan="2">Harvested Acres on Farm</th><th colspan="5">-Principal Crop Commodity-</th></tr>
<tr><th>Corn</th><th>Soybeans</th><th>Wheat</th><th>Fruits & tree nuts</th><th>Vegetables</th></tr>
<tr><td><10</td><td></td><td></td><td></td><td>-2.4</td><td>-6.4</td></tr>
<tr><td>10-49</td><td>-1.5</td><td>-1.6</td><td>-3.2</td><td>-1.1</td><td>-3.1</td></tr>
<tr><td>50-99</td><td></td><td></td><td></td><td>-0.3</td><td>-1.6</td></tr>
<tr><td>100-249</td><td>1.4</td><td>-0.6</td><td>-0.3</td><td>1.8</td><td>0.1</td></tr>
<tr><td>250-499</td><td>2.3</td><td>0.3</td><td>-1.0</td><td>3.8</td><td>3.0</td></tr>
<tr><td>500-999</td><td>5.0</td><td>2.1</td><td>-0.1</td><td>6.1</td><td>4.8</td></tr>
<tr><td>1000-1999</td><td>5.6</td><td>6.8</td><td>3.4</td><td rowspan="2">7.2</td><td rowspan="2">9.3</td></tr>
<tr><td>>1999</td><td>7.7</td><td>4.1</td><td>5.8</td></tr>
</table>

Source: Agricultural Resource Management Survey, all versions, 2008-2010 pooled. Size classes of less than 100 acres were combined for corn, soybeans, and wheat, and classes exceeding 999 acres were combined for fruits and tree nuts and vegetables.

Table 4: Changes in Planting and Harvesting Machinery in Field Crops

	Planting Efficiency		Harvesting Efficiency	
Year	Technology	Outcome	Technology	Outcome
1970	4 rows @ 2 mph	40 acres/day	4 rows, 12 hrs/day	4000 bu./day
2005	16 rows @ 6 mph	420 acres/day	12 rows, 12 hrs/day	30,000 bu./day
2010	36 rows @ 6 mph	945 acres/day	16 rows, 12 hrs/day	50,000 bu./day

Source: Bechdol, Gray, and Gloy (2010)

Table 5: Cropland Consolidated More Where Government Payments Were Higher.

	No Payments	-Payments Per Acre Quintile-				
		First	Second	Third	Fourth	Fifth
1987 Share of:	-Percent of Zip Codes, Cropland, Program Crop Acreage-					
Zip Codes	10.7	17.9	17.8	17.8	17.8	17.9
Cropland Acreage	0.5	5.0	10.1	21.5	29.7	33.2
Program Crop Acreage	0.1	1.3	6.2	20.7	35.1	36.6
	-Percent of Zip Code Cropland in Program Crops-					
1987 Program Crop %	9.6	18.5	41.2	65.8	80.6	75.1
Time Span	-Percentage Change in Cropland Concentration (Modeled)-					
1987-1992	-4.3	2.9	9.8	15.7	21.4	22.1
1992-1997	-5.3	3.3	7.5	12.3	14.7	15.2
1997-2002	-11.4	-0.7	4.3	10.1	13.4	7.1
1987-2002	11.2	23.6	29.9	39.7	46.3	46.3

Source: Key and Roberts, 2007.

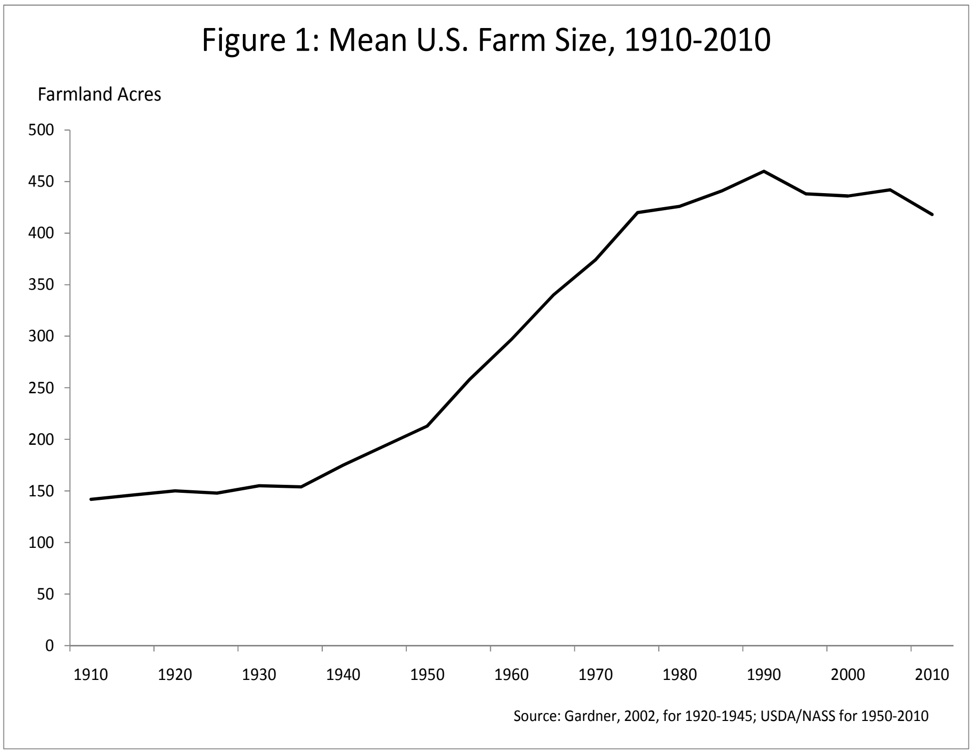
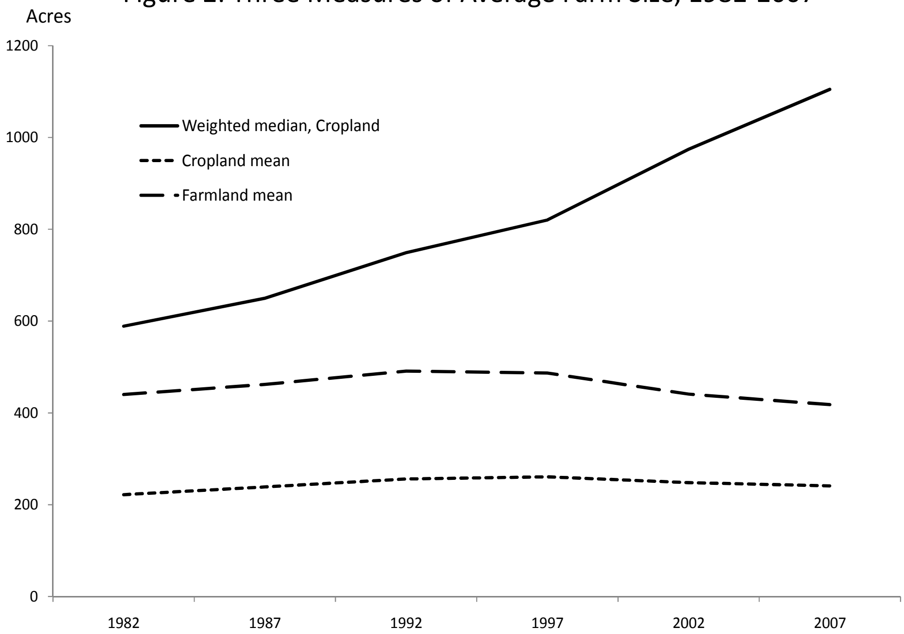


Figure 1: Mean U.S. Farm Size, 1910-2010

Figure 2: Three Measures of Average Farm Size, 1982-2007



Source: Author's calculations, based on Census of Agriculture. Weighted median is weighted by cropland: half of all acres are on larger farms and half are on smaller.

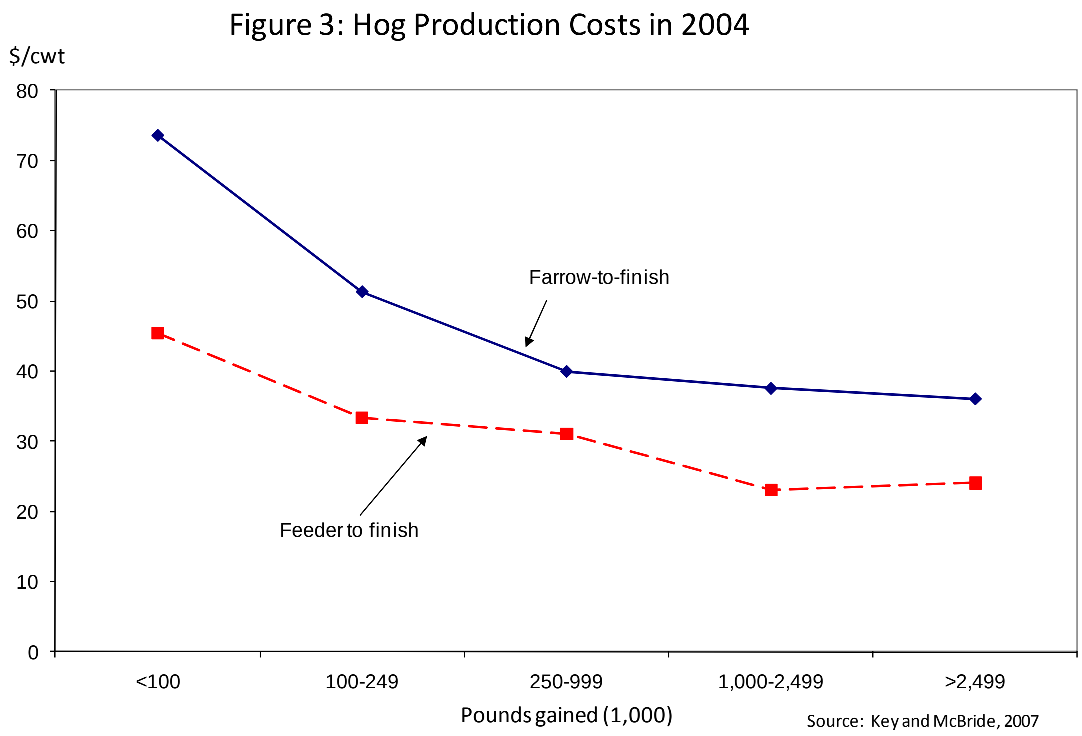
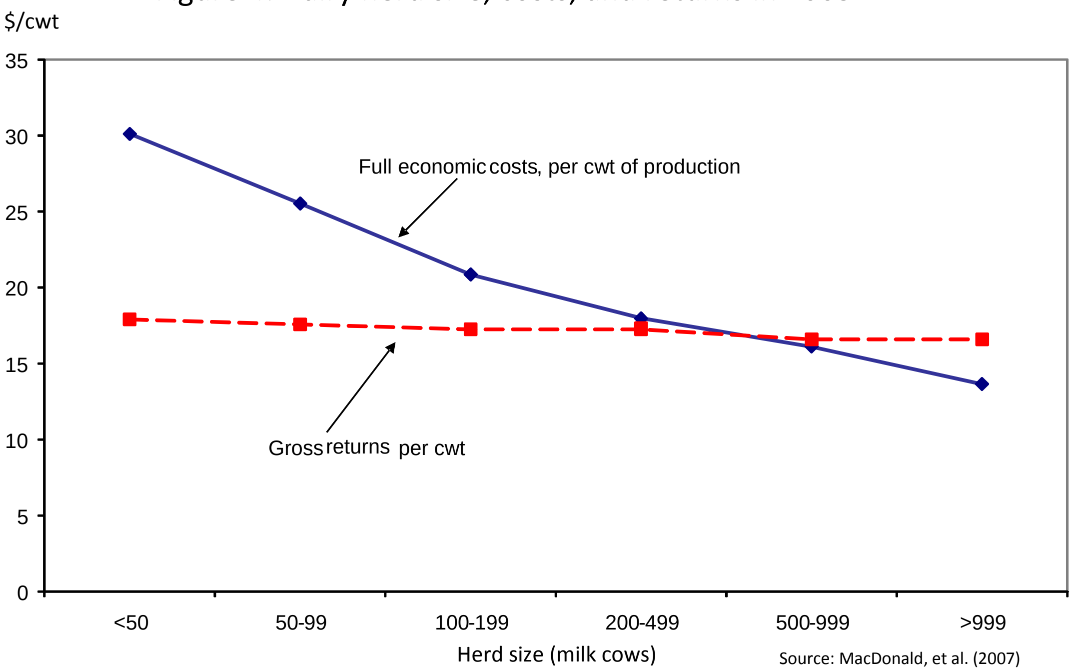
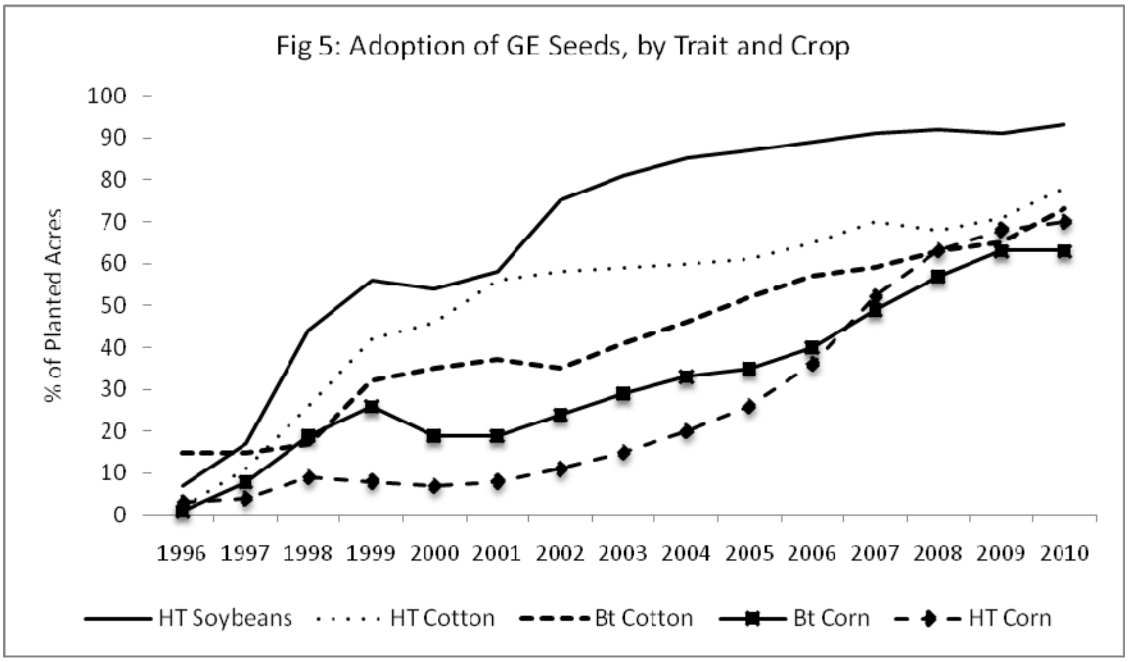


Figure 3: Hog Production Costs in 2004
$/cwt
80
70
60
50
40
30
20
10
0
Farrow-to-finish
Feeder to finish
<100
100-249
250-999
1,000-2,499
>2,499
Pounds gained (1,000)
Source: Key and McBride, 2007

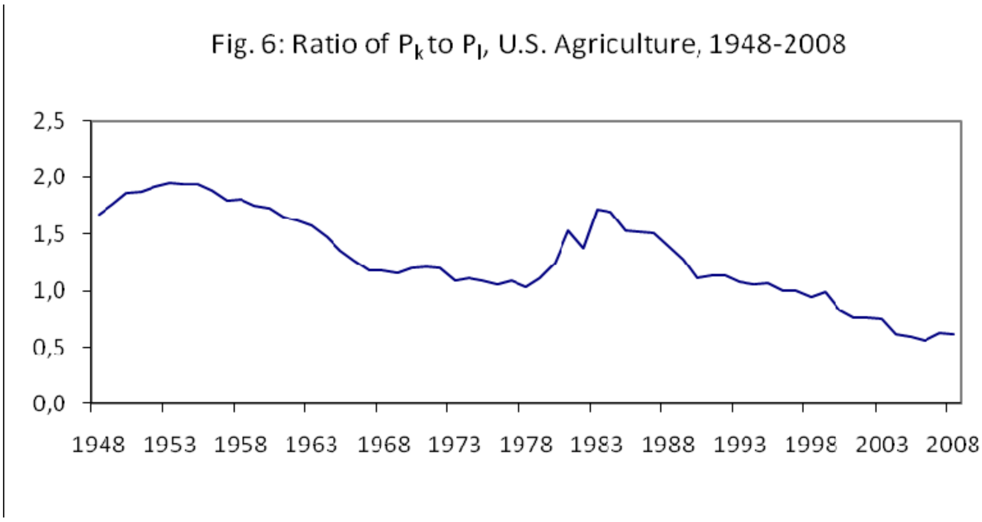
Figure 4: Dairy herd size, costs, and returns in 2005



Source: MacDonald, et al. (2007)



Data for each crop category include seeds with both HT and bT (stacked) traits.
Source: 1996-1999 data are from Fernandez-Cornejo and McBride (2002). Data for 2000-2010 are from U.S. Department of Agriculture, National Agricultural Statistics Service, *Acreage,* annual issues.



Source: USDA Economic Research Service, National Productivity Accounts, price indexes (1996=1) for equipment (P_k) and unpaid labor (P_l)

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