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Structural transformation in North America: what does it mean for agricultural statistics?

J. MacDonald | USDA Economic Research Service | Washington, DC | USA

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ABSTRACT

Farming in North America is undergoing a series of structural transformations: production is shifting to larger farms; farms are adopting more complex organizational arrangements; and consumer demand is changing, with a greater emphasis on more highly differentiated agricultural products. Analysis of these changes is complicated by another feature of farm structure—the farm size distribution is highly skewed, with many very small farms and a heavy concentration of production by a relatively small number of large farms.

Structural transformation creates a series of challenges for statistical agencies; the challenges are not completely novel, as statistical agencies have been dealing with each of these issues for many years. However, agencies may have to organize and design surveys in different ways to capture the key elements of transformation, and to continue to provide reliable measures of standard variables of interest. Even where existing surveys are adequate to the task, agencies may need to rethink the measures and reporting that they use to summarize survey results.

Keywords: Farm structure, farm size, farm organization, census of agriculture

PAPER

1. Introduction

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Structural transformation creates a series of challenges for statistical agencies; the challenges are not completely novel, as statistical agencies have been dealing with each of these issues for many years. However, agencies may have to organize and design surveys in different ways to capture the key elements of transformation, and to continue to provide reliable measures of standard variables of interest. Even where existing surveys are adequate to the task, agencies may need to rethink the measures and reporting that they use to summarize survey results.

We describe these elements of farm structure and structural change below, and then show how each affects statistical surveys and reporting. We use U.S. data from censuses of agriculture, including a 2014 followon to the 2012 census called to Tenure, Ownership and Transition of Agricultural Land (TOTAL) survey, which replaced USDA's large annual farm survey--the Agricultural Resource Management Survey (ARMS)--in that year.

2. Structural Change

We focus on three key elements of structural change: shifts of production to larger operations, increasing organizational complexity in the farm sector, and increasing commodity differentiation. Analysis of each is complicated by an ongoing feature of the farm sector: the extreme skewness of the farm size distribution.

What do we mean when we say that the U.S. has a skewed distribution of farm sizes, and why does it matter? We use U.S. crop farms as an example, using data from the 2014 TOTAL survey (figure 1). Most crop farms are quite small: nearly half had less than 50 acres of cropland in 2014. However, those small farms collectively accounted for only 3.5 percent of cropland and less than 7 percent of the value of crop production. The distribution also features a long tail: over 50,000 farms had 1,000-2,000 acres of cropland, and the range extends to nearly 100,000 acres. Farms with at least 1,000 acres of cropland—6.2 percent of all crop farms--accounted for well over half of cropland and crop production.

The skewness is apparent in summary statistics. The mean farm size (261 acres of cropland) far exceeds the median of 50 acres. However, most cropland and crop production is on farms that are far larger than the mean: the midpoint, where half of all cropland is on larger farms and half is on smaller, was at 1,296 acres in 2014. The U.S. farm size distribution has grown more skewed in recent years, as the middle has hollowed out while farms and acreage have moved to the extremes (MacDonald, Korb, and Hoppe, 2013).

We have used cropland acreage as an example, but similar patterns appear for livestock (herd and flock sizes) and for distributions using farm sales or value of production. Most farms are very small, while most animals, acreage, or sales are on a relatively small number of large farms.

The skewness of farm sizes is particularly pronounced in the U.S. because of the way we define farms, using a commodity sales threshold that is relatively low ($1,000 worth of commodity sales, or land or animal assets capable of generating $1,000 in sales) and not adjusted for inflation. We have seen sharp increases in the reported number of very small farms since 2002; with increasing numbers of very small and very large farms set against declining numbers of midsize farms, and stable total cropland acreage, we see little change in mean size even as land shifts to larger operations. However, while skewness is extreme is the U.S., it is a feature of agriculture sectors in other OECD countries as well (OECD, 2015)

2.1 Production is shifting to larger farms

Why does a skewed distribution matter? It affects sample design choices, as we see below, but it also complicates reporting on structural changes. For example, the mean crop farm size in 2014—261 acres—was only slightly above the 1992 mean of 257 acres. If one looks only at the mean, easily calculated and widely reported in our official publications, one would not think that there was much consolidation in the U.S. farm sector (figure 2, using census data only). However, that conclusion is shaken by the trends in midpoint sizes. For cropland, the 2014 midpoint of 1,296 acres was noticeably larger than the 2012 midpoint of 1,201 acres, and much greater than the 1992 midpoint of 749 acres, which in turn represented a large increase from 589 acres in 1982 (figure 2). The U.S. has undergone a substantial shift of cropland and production to larger farms, but our simple measures don't capture it.

The shift of acreage and animals to larger operations is large, and an important element of structural change. It has been occurring in almost all U.S. states and almost all crop and livestock commodities, and has been persistent over time (MacDonald, Korb, and Hoppe, 2013). The census of agriculture provides enough commodity detail to track midpoints for harvested acreage in specific crops, as well as animal inventories and removals, from 1987 through 2012. We report estimates for selected crop and livestock commodities in table 1. Dramatic changes occurred in hog and in dairy sectors, but we can also see quite striking changes in fruits and vegetables and in field crops.

The pattern is not unique to the United States. A recent OECD study documented a general pattern of shifts of acreage and animals to larger operations, although the shift was most pronounced in the U.S. and in Canada (OECD, 2015).

2.2 Farm businesses are becoming more complex

Structural change also encompasses increasing organizational complexity, covering how agricultural tasks are allocated among firms, and how farms and other agricultural businesses are organized.

Consider how farms are organized. Some farms are now part of multi-farm businesses: for example, some family businesses own several large dairy farms, or large grain operations in several states, or multiple cattle feedlots. Farms may also operate non-agricultural "value added" businesses that complement the farm business. For example, a farm family may also operate a bed and breakfast agri-tourism business, or a cheese-making business linked to a dairy farm, or a trucking business growing out of the farm's livestock or grain movements. We think that each of these are growing phenomena,

but we don't have comprehensive data on the topic.

In other instances, businesses that look as if they are based on a single farm operation may organize themselves into several ownership entities for purposes of minimizing taxes, maximizing government payments, or managing family conflicts (or example, a farm may organize a land-owning entity, held by various farming and non-farming family members, and an equipment owning entity also owned by family members; each entity may then rents land and/or equipment to one or more farming entities, also owned by various family members).

The above examples concern how farm businesses are organized. The other issue of complexity concerns the performance of agricultural tasks by non-farm businesses. For example, contract agriculture links independent farms and farm input providers through a network of contracts. For example, about 95 percent of U.S. broiler production is coordinated by 20 large integrators, which own hatcheries, feed mills, and processing plants (MacDonald, 2014). The integrators contract with farms to provide eggs for hatcheries, and they contract with about 15,000 independent growers to raise chicks to market weight. Contract growers, who invest in housing and equipment, are provided with feed, chicks, and support services by integrators, and their compensation reflects pay for growers' services rather than payment for the value of the birds. Similar arrangements, where farm production costs are shared by several different firms, can be found in egg, turkey, and hog production, and in some areas of vegetable production and horticulture. In these cases, farms provide only some of the inputs in agricultural production, while integrator, who are necessarily defined as farms provide the rest.

Similarly, some farm tasks may be performed by specialized service providers that are not farms. Crop tasks—like field preparation, planting, spraying, or harvesting—are frequently performed by custom service providers for a fee. Some custom providers are also farm operations aiming to use their equipment and labor more intensively, but others do not operate their own farms and are not captured in surveys. Other specialized service providers include labor contractors, farm management firms, and equipment lessors.

2.4 More differentiated agricultural products

There is growing interest in agricultural products with differentiated physical attributes, like taste, color, or size. Examples can be found in many fruit and vegetable products, such as eggplants, peppers, potatoes, tomatoes, cantaloupes or tangerines, but they can also be found in some meat products, such as pork from "heirloom" varieties of hogs.

However, there is also growing consumer interest in the processes associated with farm production, and therefore with products that are differentiated not by their physical attributes but by their production processes. Examples include livestock raised without antibiotics, pork from farms that don't use gestation crates, grass-fed beef, cage-free eggs, or food products that have no ingredients from genetically modified plants, to name a few. The common feature of these products is that the relevant attributes are features of farm-level production processes; consumers care about the processes, but cannot observe them. In these cases, consumers rely upon some sort of certification of processes, whether provided by farmer advertising, retailer assurance, third party certifiers, or government agencies.

There's also a growing interest in locally produced agricultural commodities, which bear some resemblance to products differentiated by production processes, in that consumers can't observe whether a product was actually produced locally.

There is every reason to believe that interest in these and other alternative agricultural products will continue to grow, and that statistical agencies will have to consider how to track and report on the products, and how to account for their influence in existing reporting.

3 Structural Transformations and Statistical Surveys

Statistical agencies have been dealing with each of these challenges for many years. They use stratified sample designs, with greater sampling probabilities attached to larger operations, to handle skewed size distributions, especially when the reporting of production or sales aggregates is the goal. They sort data into farm size classes—measured by acres, animals, value of production or sales—when reporting on the farm size distribution itself. They put extra—sometimes special—effort into handling complex farms and operations that are large enough to appear in many survey samples. In a sense, our story is about the accentuation of issues that statistical agencies have been dealing with for some time

3.1 Structural change, reporting, and survey design

USDA puts considerable effort into reporting on farm structure. For example, census of agriculture

publications report the number of farms, harvested acreage, and production, sorted by harvested acreage class, for 31 different field crops (USDA/NASS, 2014). The classes are well thought out and their range updated for structural change, so that the largest class listed rarely accounts for more than one-quarter of acreage and production. For most of those crops, one could estimate the midpoints reported in table 1 with considerable accuracy, based only on publically available data and not the confidential data that underlie the table. One could also generate means and good estimates of medians from the data at hand, and could use the reported distributions to provide comprehensive information on changing structure.

However, the effort is not quite as successful in other vegetable and livestock commodities, where the largest size class reported frequently accounts for well over half of harvested acreage or animal inventories. In that case, one can't really generate a good estimate of a midpoint, and one can't use the full distribution table to track changes in structure. The critique also extends to several of the all-farm size distributions based on value of production or acreage (the summary tables), where the largest size class again includes most production or acreage.

Structural change affects survey design as well as reporting. With production consolidating in a smaller number of large farms, some farms now have a high probability of appearing in many surveys. Since many of these same farms are also approached by private data collectors, and since many of them also have regulatory reporting requirements, statistical agencies face a growing problem of respondent burden. Declines in large farm response rates, should they occur, would threaten the viability of many estimates.

One approach to dealing with the particular respondent burden faced by larger operations would be to take a more tailored approach to them. Statistical agencies could seek to acquire information in ways that reduce burden, by adjusting to the reporting systems used by large operations; by altering survey forms to ask for updates, rather than newly filed information in each visit; or by seeking to allocate common information acquired in one survey to other surveys as well. Each of these could be extended from statistical surveys to regulatory and administrative filings, in order to further reduce respondent burden, with one major caveat. Data collected in statistical surveys retain confidentiality protection, such that individual records cannot be disclosed to the public or to regulators; administrative and regulatory filings are not subject to the same protections.

3.2 Farm complexity: who and what to survey

Complexity creates several interrelated statistical challenges. USDA surveys generally use farm respondents to generate data on production, acreage, input use, financial outcomes, and other features of the agricultural economy. With a focus on farms as respondents, samples for agricultural surveys and censuses are drawn from sampling frames that are lists of farms, and considerable effort is put into building and maintaining lists.

With organizational complexity, farms are not always the best source of information. In contract production arrangements, where some inputs are provided by farms and some are provided by contractors, the contractor may be better informed (for example, about feed or chick expenses in contract poultry production). Similarly, for multi-farm firms, a central office may be better placed to provide information on certain expenses. Farms can provide information on expenses and tasks associated with custom services, but may not be informed about other specific features. Statistical agencies often maintain contacts with contractors and central offices to obtain these data in their normal course of business, but the relationships are often informal and non-systematic.

Because sampling frames are built from farms, USDA can also provide extensive reporting on farm structure. For the same reason, however, USDA surveys are not organized to support reporting on multi-farm firms, providers of farm sector services, or non-farm contractors. Efforts to track and report on multi-farm firms, agricultural service providers, or contractors would require a new effort to build business lists into sample frame. That exercise could use some non-comprehensive sets of linkages built by statistical agencies as part of their normal business. However, they would most likely need to use tax and other administrative records to build up to a more comprehensive file. In short, reporting on multi-farm firms and farm service providers would require an investment in building sampling frames.

The notion of complexity also includes "value-added" activities associated with farm businesses—such as further processing of agricultural commodities, or the joint production of farm and tourist services with farm inputs. Value-added activities matter for the agricultural sector farm income and productivity accounts produced by USDA: to the extent that they are joint products that depend upon at least some of the same inputs used for farm production, each account needs to take account of the returns to such farm-related activities. USDA surveys aim to elicit enough information on them to fulfill the needs of those accounts, but agencies do not aim to report separately on them.

3.3 Product differentiation: tracking and interpretation challenges

Because they are more costly to produce, differentiated products typically generate higher prices than conventional products. This can create challenges for reporting on farm productive and financial performance. If differentiated products are not reported separately from conventional products, then average measures of costs of production, gross returns, and net returns may be reflective of neither the conventional nor differentiated product, but an amalgam of them. Moreover, if differentiated products account for a growing share of production, or if their cost and price trends do not track conventional cost and price trends, then aggregate reported trends may not be reliable indicators or trends for either differentiated or conventional products.

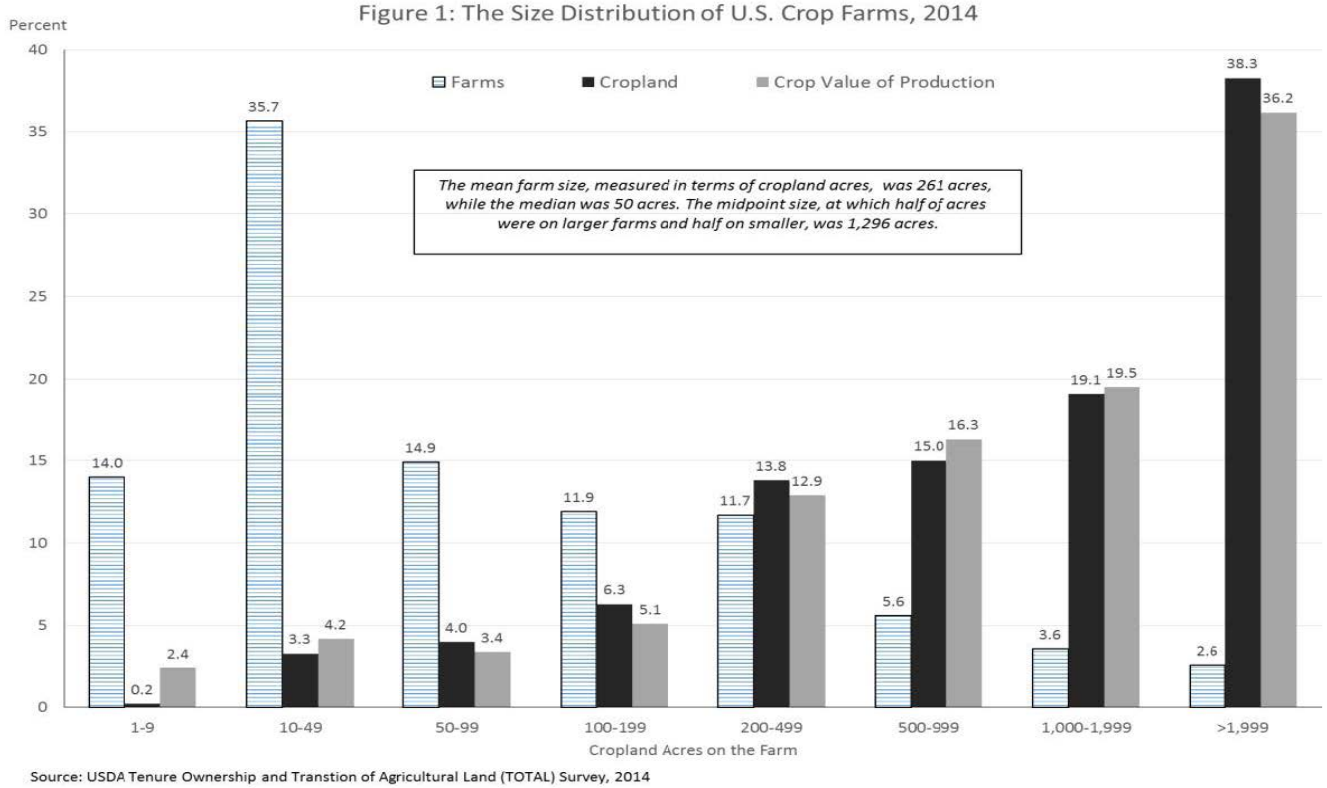
For this reason, but primarily because of interest by industry participants, differentiated products create new demands for reporting on specific differentiated commodities—for timely information on production, inventories, and sales as well as reporting on prices. These demands may sometimes be met through low-cost adjustments to ongoing surveys, but they also may require new surveys. These are standard tasks for statistical agencies, but doing new surveys can put resource pressures on agencies.

4. Conclusion

Structural change in agriculture results partly from changes in technology that allow farmers to manage more cropland or more animals, and to utilize more complex organizational forms. Some technological change results from innovations derived from biological sciences and some results from mechanical innovations; however, some also results from improvements in information technology (IT), bit directly and as applied in biological and mechanical innovations.

IT innovations also affect statistical agencies, by facilitating improvements in survey design, administration, and editing as well as facilitating more rapid and more widely disseminated reporting. Thus while structural change in agriculture create new challenges for statistical agencies, the accompanying changes in information technology create some opportunities for different ways of gathering and reporting on data.

Figure 1: The Size Distribution of U.S. Crop Farms, 2014



Source: USDA Tenure Ownership and Transtion of Agricultural Land (TOTAL) Survey, 2014

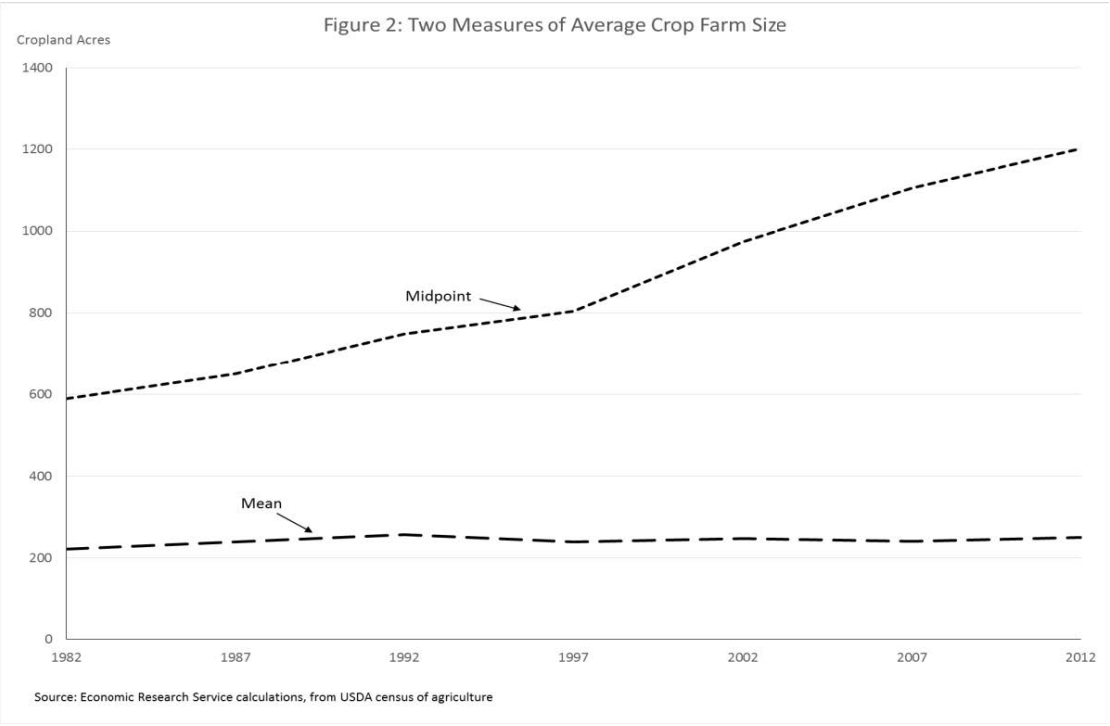


Table 1 Acreage and animals shift to larger operations

Crop commodities	Midpoints		Livestock commodities	Midpoints	
	1987	2012		1987	2012
	Harvested acres of crop			Inventory (cows/layers)	
Corn	200	633	Milk cows	80	
Soybeans	243	567	Beef cows	89	
Wheat	404	1.000	Egg layers	117.839	
Carrots	350	1.053		Head sold or removed	
Cucumbers	115	450	Fattened cattle	17.532	38.369
Potatoes	350	1.054	Hogs and pigs	1.200	40.000
Tomatoes	400	930	Broilers	300.000	680.000
Apples	83	179			
Almonds	203	547			
Oranges	450	961			
Strawberries	24	180			

Source: Economic Research Service calculations, from USDA census of agriculture records.
Note: the midpoint is the size of farm at which half of all acres, or animals, are on larger farms and half are on smaller. For livestock, inventories are at end of year, and removals are annual.

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