

**Alternative Measures of Farm Size: Trends and Determinants**

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**Paper Prepared for Presentation at the  
Southern Agricultural Economics Association Meetings  
Tulsa, Oklahoma  
February 14-18, 2004**

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## **Alternative Measures of Farm Size: Trends and Determinants**

**Mary Clare Ahearn and Jet Yee**

**Abstract:** Because of policy interest in the size distribution of farms, there is an interest in understanding the causes of changing farm sizes. This paper addresses an overlooked issue in the literature on the determinants of farm size, namely, the empirical specification of farm size. We examine 5 different size measures: acres operated, land and building value, cash receipts, cash receipts plus government payments, and a constructed measure of the rental value of farms. We graphically show the difference in trends in farm size using the various measures for the U.S. and selected states. We then discuss how the results of an analysis of the determinants of farm size depend on the farm size measure employed. The data set is a panel data set of 48 states from 1960 to 1996.

### **Introduction**

The consolidation of agriculture is proceeding at a rapid rate. For example, between 1987 and 1997, the number of farms in the U.S. declined by 8 percent, and even more telling, the number of farms accounting for 50 percent of U.S. production declined by 39 percent (USDC, 1989; USDA, 1999). The perception that “family farms” are dwindling in number often results in expressions of social concern. At the same time, society benefits from having a highly productive farming system and low food prices that may come with increased consolidation. Because of the policy interest in the size distribution of farms, there is an interest in understanding the causes of changing farm sizes. The causes of changes in farm size are complex and interrelated and include government policies, technological change, and changes in farm and nonfarm markets.

Conclusions about how the relevant factors affect farm size depend on the measure of farm size employed. There are a variety of ways to measure farm size. Size concepts are both output-based and input-based. Different size concepts can be constructed using different statistics. For a particular population of farms, say farms in one particular state, average farm sizes are most commonly reported. Other statistics provide information on the size distribution

of farms for a particular population of farms, which may be especially important to consider because of the increasing proportion of farms at both tails of the size distribution.

The most commonly used concept of farm size is average acres per farm. While number of acres has the advantage of being a fixed unit of space that is easily quantified, it also has the distinct disadvantage of being a meaningful measure of farm size only within a rather limited context. A major reason for this is because of the great variation in land quality for agricultural use purposes over space, as well as its lack of connection between land and productivity changes over time. Other measures of farm size that capture market values of the land or the agricultural output, are useful ways to account for variation in the agricultural use value of farmland. The market value-based measures also necessitate a choice of deflators when comparing farm sizes over time.

We examine 5 different size measures across time (1960-1996) and space (the 48 contiguous states): acres operated per farm, real land and building value per farm, real cash receipts per farm, real cash receipts plus government payments per farm, and an imputed measure of the real rental flow per farm. Imputed real rental flow per farm can be considered a measure of the agricultural service flow from the land and is calculated as the product of the average acres per farm and the per-acre rental rate for rented farmland from the Census of Agriculture. We use the prices received (PR) index to deflate the two cash receipts-based measures and the imputed rent flow measure. We use the GDP deflator to calculate real land and building value.

## **Purpose and Methods**

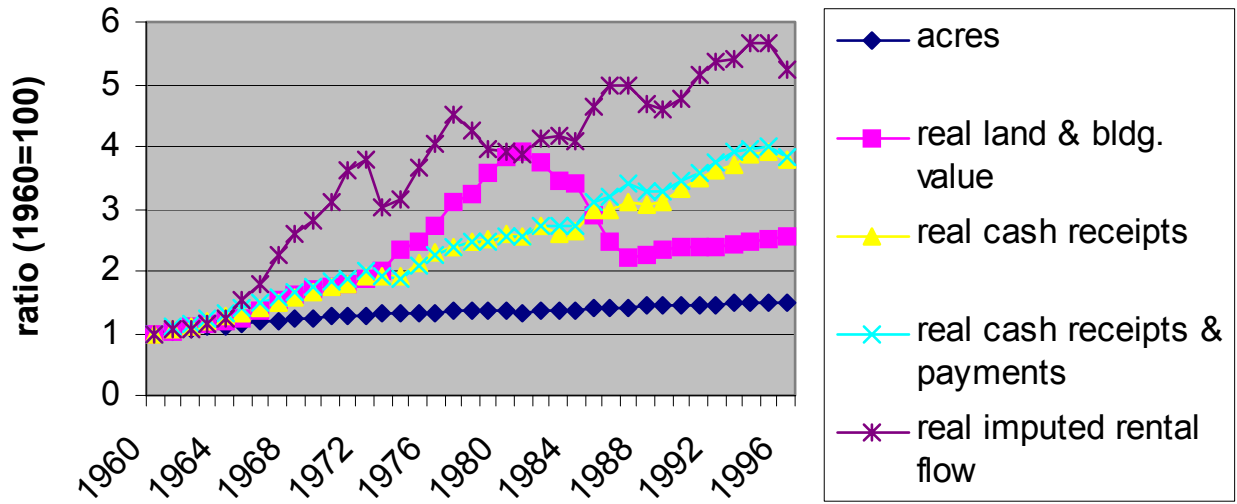
We will compare the trends in farm size for the U.S. for 1960 to 1996, using the common size measures. By way of example, we will also provide a few graphs which show that size

trends vary by state. We will then compare the results of empirically estimated models of the determinants of farm size, varying the farm size measure in an econometric model. The data set is a panel data set of 48 states from 1960 to 1996. We highlight the econometric results for one variable of interest, direct government payments, and discuss in detail the results for one particular measure of farm size, rent per farm.

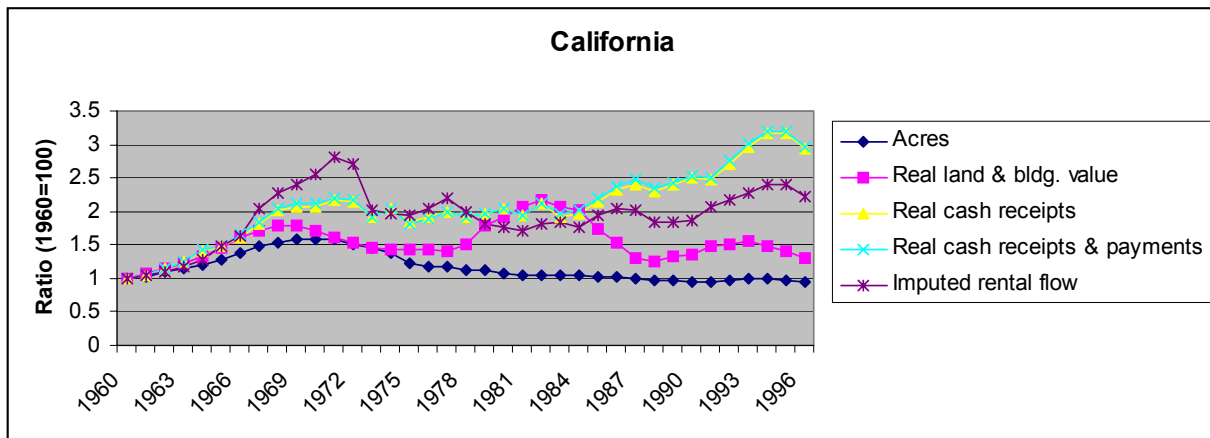
### **Trends in Farm Size**

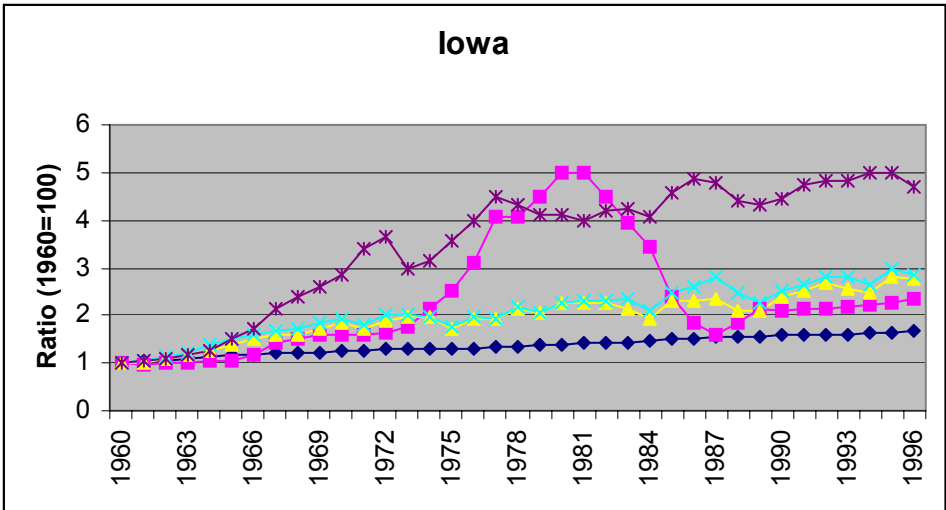
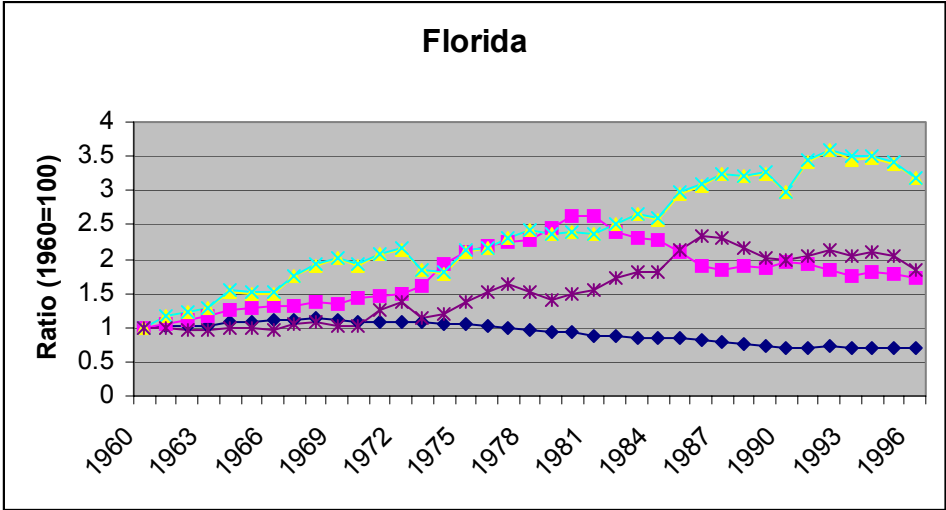
The common indicators of farm size all indicate that during the 1960-96 period average farm size increased in the U.S., leveling off in the later part of the period. However the rate of growth for the different size measures differs for the full period, and for subperiods. The most basic of measures, average acres per farm, has increased slowly and steadily over time. This is because, while the total land in farms has decreased slowly, the number of farms has decreased at a somewhat higher rate. For examining trends in the U.S., where land quality and/or commodity mix vary greatly across space, a measure based on the cash rental market has advantages because it accounts for the agricultural use value of the land. The cash rental market is not expected to be unduly affected by the other factors affecting farmland asset value, such as expectations about future nonfarm development, or annual short-term fluctuation in production values. Using the imputed rent measure, the average U.S. farm size increased at a faster rate than average acres in farms. The use of the prices received (PR) index to calculate real values for the cash receipts-based measures and the imputed rental flow measure incorporates more annual variation in the farm size measures as a result of the usual fluctuation in annual commodity price markets. The PR index and the GDP deflator increased at different annual rates, in particular, the PR index rose at a much slower rate in the latter part of the period than did the GDP price deflator.

### Trends in U.S. farm size, using common size measures, 1960-96



While the general trends in farm size for the U.S. are realized for many states, especially the major farm states of the Midwest, there are many states with differing trends. We compare the trends in farm size using the 5 size measures for 3 major agricultural producing states. One of the states, Iowa, exhibits trends similar to the U.S. trends. For California and Florida, the various size measures show differing trends. In both California and Florida, the average farm size measured in acres has actually declined since the 1970s. The growth in the proportion of farms that are small in California and Florida is a major factor for the observed state trends in the acres-based measure of farm size for those states. The majority of output in those states is increasingly produced on very large farms. Not surprisingly, the measures based on output show considerable annual variation, but they are generally increasing over the full period. The size measure based on asset values shows the expected build up until the 1980s followed by sharp declines, but some states, such as California, show additional state-specific build-ups for other time periods using this size measure. The imputed rental flow measure indicates a general increase in farm size. In fact, in Iowa, as with the U.S., the imputed rental flow measure indicates the most rapid growth in farm size of all the measures.





## Causes of Structural Change

In spite of the lengthy history and volume of the literature on farm structural change, there is little agreement on a conceptual model for the structural change process in agriculture. Several useful review articles address the diversity and conflict among competing conceptual models (e.g., Harrington and Reinsel 1995). Cochrane's technology treadmill is perhaps the most widely recognized hypothesis on structural change forces (Cochrane 1958). Cochrane's hypothesis focuses on the impact of technological innovation reducing real per unit cost of output at the farm level and with competition encouraging farmers to adopt new technologies. As adoption becomes widespread, prices of farm commodities fall differentially across the country and possibly by size of farm, triggering structural adjustments. Technology adoption certainly plays a prominent role in the structural change process, but many mechanisms are believed to play important roles in this process. Instead of relying on the existence of scale economies to explain farm structural change, Kislev and Peterson showed that most of the changes in U.S. farm size (between 1930 to 1970) could be explained by changes in relative factor prices. Other schools of thought, including asset fixity and political economy, also make contributions to understanding the structural change process in U.S. agriculture. In this study of the determinants of farm size, we draw on many of these ideas in our specification and explanation of relationships, because there is not a sufficiently comprehensive single model.

We have specified a three equation simultaneous model. Besides the farm size equation, we include equations for productivity and the odds that an operator works off-farm at least 200 days per year. The basic conceptual model is similar to that found in Yee, Ahearn, and Huffman (forthcoming 2004), except that we employ a 2SLS-estimation procedure. 3SLS can potentially yield estimators with greater asymptotic efficiency than 2SLS. However, if the equations of the



3SLS model are not correctly specified, the estimates of all of the structural parameters are affected. Given the lack of agreement on a single conceptual model and our interest in the size equation, we prefer to use 2SLS.

For the variables of the size equation using the 5 different measures of farm size, Table 1 provides information on the regression results<sup>1</sup>. Five of the 10 exogenous variables were significant with consistent signs for all 5 measures of size. Another 2 of the exogenous variables had consistent signs, when they were significant, but the exogenous variables were not significant in all of the size models. For the remaining 3 exogenous variables and the 2 endogenous variables (productivity and off-farm work of the operator), the results varied across the 5 models with differing size specifications. The size measures employed when the results were less common and/or counter-intuitive were those where farm size was measured as the average acres per farm and the average real land and building value per farm.

To highlight the sensitivity of the model to the size concept employed, we focus on one variable of interest in the farm size model, namely government commodity payments. Have agricultural commodity payments contributed to the increasing farm size? The sign of the coefficient was positive and significant for all measures of farm size, indicating an affirmative answer to our question. However, the magnitude of the coefficients and their significance levels varied across the measures. When size was measured as average acres per farm, payments had the largest coefficient. Of the two output-based measures, government payments was most significant when the output measure included consideration of payments. This is not surprising, given that payments added as much as 11% additional value to cash receipts at the U.S. level, depending on the year.

We will discuss in detail the results for what we believe is the superior measure of farm size, rent per farm (last column of Table 1). We turn first to the relationships among our three endogenous variables. We found that an increase in agricultural productivity increases farm size. Increased off-farm work is associated with a smaller farm size, as more time spent working off-farm means less time available for working on the farm.

Turning to public policy effects, we found that R&D, both own and spill-in, and extension increase farm size. It is generally considered desirable that public investments in research and extension should be size neutral. However, our results indicate that both R&D investments and extension have a positive influence on farm size over the time period studied.

We found that government transfer payments under commodity payments were positively related to farm size. Farmers may use part of the commodity payments to expand their farm size. This finding is consistent with Cochrane's "cannibalism" model of payment recipients to out bid farmers not receiving payments for farm land (Cochrane,1958).

Other factors also influence farm size. A decrease in the farm machinery price - hired farm labor wage ratio leads to an increase in farm size. A decrease in this ratio makes farm machinery cheaper relative to farm labor. Purchase of farm machinery generally entails a high fixed cost, which the farmer wants to spread over a higher level of output. An increase in the share of a state's land in non-metropolitan areas increases farm size. This indicates that, with less competition for land for urban uses, farm sizes are larger. Increased specialization and the use of production contracting were not significant in explaining farm size. The proportion of farmers with college education had a positive effect on farm size. However the proportion aged was not significant.

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<sup>1</sup> Yee, Ahearn, and Huffman contains a data appendix with description of the sources and

## Conclusions

Our major conclusions are:

- Although understanding the determinants of farm size is seemingly a very basic question for agricultural economists, there has been little agreement in the literature. A reason for the lack of consensus on this much-researched question is, in part, due to the variety of ways in which farm size is empirically measured.
- Key determinants of farm size are technological factors, public policies (such as R&D, extension, and commodity payments), farm organizational characteristics, operator demographic characteristics (including engagement in off-farm work), and urban influence.
- In terms of the impact of government payments on farm size, we believe conclusions depend on the time period studied, given that the nature of payments and their interplay with the market conditions have changed over time. For our study period, 1960-1996, we found that payments have a positive impact on farm size, but the extent of that impact depends on how size is measured in the model.

**Table 1. Two stage least squares estimates of farm size equation: state aggregate data, 1960-96 (n = 1776)**

Variables	Average farm size in state measured by				
	Acres	Land & bldg value	Cash receipts	Receipts & govt.payment	Imputed rent
Time	-0.020 (-6.063)	-0.007 (-1.993)	-0.028 (-12.973)	-0.027 (-12.636)	-0.033 (-9.177)
Machinery price to labor wage ratio	-0.159 (-2.521)	-0.583 (-9.404)	-0.327 (-7.955)	-0.309 (-7.610)	-0.434 (-6.393)
Own state research stock	0.166 (5.144)	0.066 (2.080)	0.192 (9.135)	0.214 (10.315)	0.089 (2.563)
Spillin research stock	0.200 (6.598)	0.174 (5.829)	0.030 (1.498)	0.020 (1.020)	0.331 (10.132)
Extension stock	0.379 (11.677)	0.457 (14.309)	0.446 (21.064)	0.453 (21.658)	0.242 (6.926)
Specialization (Herfindahl)	1.031 (5.335)	-0.186 (-0.978)	0.243 (1.928)	0.393 (3.153)	0.168 (0.809)
Commodity payments	0.047 (5.376)	0.029 (3.321)	0.001 (0.135)	0.016 (2.880)	0.014 (1.457)
Share with college	0.553 (11.464)	0.346 (7.313)	0.264 (8.415)	0.278 (8.946)	0.455 (8.776)
Share aged	0.312 (3.570)	-1.112 (-12.969)	-0.204 (-3.584)	-0.160 (-2.851)	-0.308 (-3.275)
Share with contracts	0.007 (0.562)	-0.074 (-6.223)	0.043 (5.439)	0.050 (6.395)	-0.010 (-0.742)
Share of non-metro area	0.151 (12.835)	-0.054 (-4.654)	-0.001 (-0.177)	-0.001 (-0.177)	0.115 (9.039)
Productivity	-1.036 (-5.607)	0.465 (2.561)	1.027 (8.532)	0.881 (7.403)	1.069 (5.378)
Off-farm work	-0.605 (-7.791)	0.270 (3.536)	-0.161 (-3.184)	-0.193 (3.858)	-0.315 (-3.766)
R <sup>2</sup>	0.863	0.754	0.826	0.829	0.699

Notes: A log-log specification was utilized. T-ratios in parentheses.

Regional dummy variables are included in each equation. The regions considered in this paper are:

1. Northeast (NE): CT, DE, ME, MD, MA, NH, NJ, NY, PA, RI, VT
2. Southeast (SE): AL, FL, GA, KY, NC, SC, TN, VA, WV
3. Central (CENT): IN, IL, IA, MI, MO, MN, OH, WI
4. Northern Plains (NP): KS, NE, ND, SD
5. Southern Plains (SP): AR, LA, MS, OK, TX
6. Mountain (MOUNT): AZ, CO, ID, MT, NV, NM, UT, WY
7. Pacific (PAC): CA, OR, WA

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