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FARMER PRODUCTIVITY AT VARIOUS AGES

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Abstract

The productivity of farmers at six different age cohorts was computed by estimating production functions using 1987 census data. The results suggest that farmers of different ages operate with slightly different technologies and use various inputs at different efficiencies. Compared with previous 1978 estimates, the productivity of middle-aged farmers appears to be even greater than the productivity of younger and older farmers. The average age of U.S. farmers exceeds the age of highest productivity from these estimates.

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FARMER PRODUCTIVITY AT VARIOUS AGES

It is believed that as a farmer ages and gains experience he or she becomes more productive with improved managerial ability. Productivity may fall later in life. An early study by Loomis, reinforced by Long, found a cyclical relationship between the age of farmers and size of the farm, use of some inputs, and outputs. More recently, Tauer used 1978 agricultural census data and concluded that farmers do display first an increase and then a decrease in productivity, with farmers between the ages of 35 and 44 being the most productive. The average age of U.S. farmers in 1978 was 50.3, an age cohort that was 6 percent less productive than those farmers aged 35 through 44. The average age of U.S. farmers is now 52.0 (1987 Census). If this age is beyond the age of maximum productivity and continues to increase, the implications for the U.S. remaining globally competitive in agriculture are severe. To determine current productivity by age, the study of Tauer will be replicated using 1987 data.

Data and Estimation

To examine the hypothesis that age has an important impact on production efficiency, separate farm-level gross revenue production functions were estimated for six age cohorts using data from the 1987 Census of Agriculture. Researchers have augmented census data with other data sources for a more concise measure of variables, but the census is the only source available where data are differentiated by age of the operator. For each state, data from operators who indicated that their major occupation is farming are summarized by age of the farm operator into six age intervals: under 25 years of age, 25 to 34 years, 35 to 44 years, 45 to 54 years, 55 to 64 years of age and older.[1] These data for 44 states (Alaska, Arizona, Hawaii, New Hampshire, Nevada

[1] Unfortunately, the data include partnerships and corporations as well as sole proprietorships. Since only the age of the principal operator is recorded, it is not known in what age categories parent/child businesses might be located. Also, since the published aggregate data are arithmetic rather than geometric sums, the computed averages are also arithmetic, although geometric averages are more appropriate for a Cobb-Douglas function.

and Rhode Island were omitted because of the unavailability of data for some age groups because of nondisclosure rules) were used to estimate the following Cobb-Douglas farm production function for each of the six age groups:

$$y = A\prod_{i=1}^{8} x_i^{\beta i}$$

The dependent variable (y) was the sum of the market value of agricultural products sold, plus income from machine work, custom work, and other agricultural services, plus direct government payments. The value of home-consumed products was not included because it was not available by age group.

The independent variables included the average value of land and buildings used (owned and rented) per farm (x_1). This is a stock, rather than a flow, variable. This variable was used rather than acres to incorporate a quality as well as a quantity measure of land and to include the value of buildings. Likewise, the estimated value of machinery and equipment was used as a variable (x_2). If service flows are proportional to capital stocks, then a measure of capital stock can be used as a proxy for services. Yotopoulos shows that this procedure is not accurate whenever assets vary in their durability, whenever their age or vintage distribution is uneven, and when the magnitude of productive services varies with the age of the asset itself. A correct specification requires original market value and length of life for each asset and the discount rate. This information is not available by age group, but if young farm operators have equipment newer than average, and older farmers have equipment older than average, then young operators' equipment services are going to be small relative to the value of the stock, while older farmers' will be larger. Some young farmers may also be borrowing significant amounts of machinery services from older farmers, either gratis or by trading labor.

Farm production expenses were grouped into complementary or substitutable categories. Grouped together as livestock expenses (x_3) were livestock and poultry

purchases, plus feed for livestock and poultry, while crop expenses (x_4) were defined as the sum of fertilizer, chemicals including lime, and seed, bulb, plant, and tree purchases. All energy and petroleum expenses (x_5) were treated as one variable because of their high degree of substitutability. Grouped together as hired labor and custom expenses (x_6) were hired farm labor, contract labor, and custom work hired. The census category of "all other production expenses" was defined as miscellaneous expenses (x_7).

Livestock breeding inventory is not included as a variable because of inherent problems of constructing the variable. Correctly measuring the service flow from breeding stock requires much the same information as does machinery, none of which were available by age group. With machinery, however, the value of inventory is collected which reflects both quantity and variation in machinery quality. Only livestock numbers and not values are collected, and assigning an inventory value or service flow to each livestock type assumes that livestock age and quality are homogeneous across age groups. Also, the purchased livestock expenditure variable combines breeding and feeder purchases. Using livestock inventory, but not expenses, would exclude feeder livestock purchases not inventoried at the census date, while including both inventory and purchases would double-count some livestock. Thus, livestock purchases were used as a variable with no inventory variable. Since all the expenses of producing breeding livestock should be included in other expense items, the input costs of raising replacement livestock is also included, although some of that expense may have occurred during previous years.

No family labor data were available unless the family labor was paid a wage, in which case it would be included as labor expense. The only data on operator labor are the number of days of work off the farm, grouped by number of respondents into four categories: none, 1 to 99 days, 100 to 199 days, and 200 days or more. An average composite of days worked off the farm (x_8) was compiled by weighting the number of respondents in each of the four groups by their respective means -- 0 days, 50 days, 150

days, and 250 days -- and then dividing by the total number of respondents. The estimated coefficient for this variable should be negative, reflecting the opportunity cost of working off the farm. This may be an appropriate variable since the farmers indicated that farming was their major occupation. The implicit assumption is that the total number of farm and off-farm work is equal for all farms. The averages for the data are reported in Table 1.

Table 1. Averages of Inputs for U.S. Farmers Whose Principal Occupation is Farming, by Age Group, 1987.

	Age group					
Input	Under 25	25-34	35-44	45-54	55-64	Over 65
Real estate inventory	$262,718	$386,981	$504,291	$502,502	$431,302	$303,191
Machinery inventory	45,025	59,565	72,883	73,559	62,795	38,280
Livestock expense	54,296	57,628	83,481	87,212	63,437	38,912
Crop expense	10,964	17,904	21,961	21,579	16,580	9,971
Energy expense	4,504	6,583	8,325	8,171	6,489	3,696
Custom and labor expense	16,155	29,299	36,292	38,394	34,206	24,090
Miscellaneous expense	8,032	13,909	19,001	18,499	15,073	8,048
Days off-farm work	59	54	50	44	29	13
Sales	65,074	108,286	145,300	144,331	110,359	55,924
Number of farms	21,503	133,311	180,818	198,462	285,245	318,840

Source: *1987 Census of Agriculture.* Data excludes Alaska, Arizona, Hawaii, New Hampshire, Nevada and Rhode Island, except for number of farms.

Much recent production analysis has estimated frontier production functions and then measured efficiency as deviations from that frontier. That approach is not used here. Separate production functions are estimated for each age group implying an error structure composed of only random terms. The individual production functions are compared, with differences in productivity associated with the production function and

quantities of inputs used. This approach is more in keeping with Ben French's statement that "a firm is said to be technically efficient if its production function yields the greatest output for any set of inputs, given its particular location and environment. *If some other production function is used*, the ratio of output obtained with this function to output obtained with the best function, given the input combinations, is a measure of the degree of technical efficiency."

The typical assumptions of expected profit maximization and perfect competition, random disturbances from weather, and no omitted variables are made for each equation (Griliches). The same functional form was estimated for each age group because *a priori* there is no reason to expect different functional forms. However, the error terms across the six estimated functions may be correlated. A random event which affects output in a state, such as a drought, would affect all age groups in that state. Thus, iterative seemingly unrelated regression (ISUR) from Micro TSP was used to estimate the six production functions in log linear form.

Results

The coefficients of the production functions estimated for the six age groups by ISUR are shown in Table 2. Some of the real estate, machinery, and energy coefficients have low t-ratios. However, all coefficients are of the correct sign, except for real estate inventory for farmers under age 25, machinery inventory for farmers under age 25 and between ages 25 to 34, and energy expenditures for those ages 35 to 44. The correlation matrix of the OLS error terms for the six equations is shown in Table 3. The greatest positive correlations occur between adjacent age groups. Thus, stochastic elements that affect output for a given age group have a stronger impact on an adjacent age group than on a much older or younger group. This could occur because adjacent age groups use similar technologies relative to nonadjacent age groups.

Table 2. Coefficients (Elasticities) of Cobb-Douglas Production Functions for U.S. Farms, by Age Group, 1987.

Input	Age group: Under 25	25-34	35-44	45-54	55-64	Over 65
Intercept	5.21 (5.02)*	5.45 (6.32)	3.08 (3.57)	2.56 (3.70)	1.86 (3.43)	1.76 (2.93)
Real estate inventory	-.02 (-.31)	.04 (.85)	.03 (.61)	.01 (.12)	.04 (1.13)	.12 (2.48)
Machinery inventory	-.09 (-1.07)	-.15 (-1.67)	.05 (.44)	.05 (.61)	.03 (.49)	-.17 (-2.06)
Livestock expense	.07 (4.51)	.19 (8.05)	.30 (12.35)	.29 (13.36)	.27 (15.69)	.28 (12.97)
Crop expense	.14 (2.47)	.22 (4.77)	.15 (3.55)	.03 (.92)	.07 (2.25)	.02 (.41)
Energy expense	.13 (.97)	.09 (.92)	-.01 (-.11)	.21 (2.38)	.19 (2.88)	.22 (2.51)
Custom and labor expense	.24 (6.71)	.07 (1.78)	.09 (1.56)	.13 (3.27)	.13 (3.71)	.12 (3.58)
Miscellaneous expense	.26 (3.35)	.24 (3.50)	.28 (3.16)	.21 (3.10)	.27 (4.72)	.47 (5.37)
Off-farm work	-.16 (-2.05)	-.14 (-2.00)	-.14 (-1.86)	-.08 (-1.39)	-.11 (-1.95)	-.32 (-4.26)
$\bar{R}^2$	.68	.81	.94	.94	.95	.97

* t-values are in parentheses.

Table 3. Correlation of Error Terms by Age Group, 1987.

Age group	Age group: 25-34	35-44	45-54	55-64	Over 65
Under 25	.88	.51	.66	.74	.48
25 - 34		.56	.69	.75	.38
35 - 44			.74	.67	.50
45 - 54				.81	.64
55 - 64					.77

The pattern of the computed marginal products shown in Table 4 are generally consistent with those from the 1978 census but with some important differences (Tauer). The major difference is that more of the marginal products (MP) of the expenditure inputs are less than one, implying that an additional dollar of expense did not generate an additional dollar of revenue during 1987. A difference between the current production functions and the previous estimates by Tauer is that the earlier estimates did not include all expenditures. The 1987 census asked farmers for all other expenditures, which is categorized here as miscellaneous expenses. However, except for the age group over 65, the estimated coefficient in the miscellaneous category ranged only from .21 to .28, within a standard error of each estimate. Thus, omission of this variable in the 1978 results may have biased all age groups similarly so that intra-year comparisons for 1978 were valid.

The marginal revenue products on real estate inventory are again low, mostly $.01 like the 1978 data, except for those farmers under 25 years of age. Tauer had computed a much higher MP of $.06 for this group and attributed the higher value to the youngest group's inability to obtain access to land. The data from 1987 would indicate that the youngest group now has access to too much real estate. However, the census respondents are asked to estimate this value and, given the deteriorated financial condition of agriculture in 1987 compared to 1978, many respondents may have entered an optimistic value that they had provided to their creditors.

The MP of machinery investment is again low for the younger and older age groups, with a peak in the middle ages. The ratio of machinery to real estate is the highest for those farmers under 25, and they may be using too much machinery. Farmers over age 65 may have obsolete equipment that is not as productive.

The computed marginal revenue product of livestock expenditures is lowest for the farmers under age 25. In fact, the MPs of livestock for all age groups are under

Table 4. Marginal Revenue Products of Inputs Computed at Geometric Means (With 1978 Estimates in Parentheses).

Input	Age group: Under 25	25-34	35-44	45-54	55-64	Over 65
Real estate inventory	$-.01 (.06)	$.01 (.00)	$.01 (.01)	$.00 (.01)	$.01 (.01)	$.02 (.01)
Machinery inventory	-.11 (-.47)	-.31 (.24)	.10 (.31)	.09 (.18)	.05 (.23)	-.24 (.09)
Livestock expense	.12 (.54)	.47 (.93)	.64 (1.07)	.52 (1.23)	.50 (1.12)	.49 (1.35)
Crop expense	.75 (1.88)	1.67 (1.54)	1.11 (1.73)	.20 (1.59)	.47 (1.53)	.12 (1.28)
Energy expense	1.57 (.39)	1.72 (4.55)	-.18 (3.49)	3.46 (3.86)	3.04 (3.51)	3.32 (3.74)
Custom and labor expense	.95 (3.11)	.37 (1.83)	.44 (2.07)	.53 (2.04)	.48 (2.28)	.35 (2.41)
Miscellaneous expense	1.79	2.23	2.30 (not estimated)	1.56	1.96	3.35
Off-farm work	-141 (-109)	-318 (-19)	-413 (-187)	-233 (-173)	-368 (-209)	-1,228 (-192)

$1.00. This marginal revenue product, however, may be the result of a deficiency in the data. The dependent variable, sales and miscellaneous income, was not adjusted for inventory changes because inventory values were not available by age group. Livestock prices were relatively high during 1987 with low sales, and farmers may have been incurring large expenditures to increase their herds during the year. Any reduced sales resulting from building livestock inventory may bias the marginal revenue products because this increase in value is not reflected in cash sales.

The MPs of energy expenditures are high except for the age group 35 to 44 where it is negative, although a t-value ratio of -.11 provides little confidence in the validity of that coefficient value. The negative coefficient for energy expenditures is difficult to

explain for the age group 35 to 44 because the data for that age group are similar to the adjacent age groups, and most of the other estimated coefficients are similar. In fact, the correlation of energy expenditures by state between the 35 to 44 age group and the 45 to 54 age group is .92. Furthermore, recursive least-squares tests of the equation for the 35 to 44 age group did not indicate parameter instability.

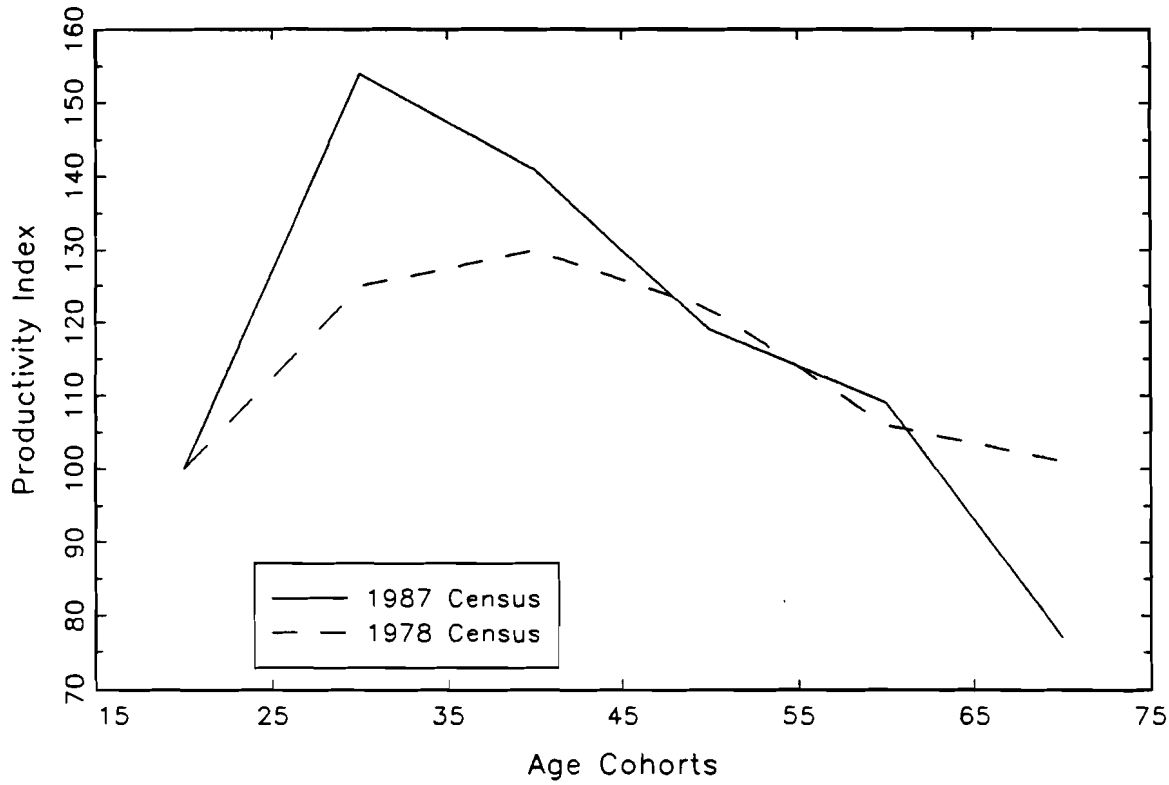
The low MPs of crop inputs (below $1) are from those coefficients with low t-values, questioning the validity of those MPs. The MPs of the hired custom work and labor are all below $1, although fairly consistent across age groups compared to higher estimates from 1978. The MPs for miscellaneous inputs range around two for all age groups, except for those over 65 where it is greater than three. Finally, an additional day of work off the farm has the lowest opportunity cost for those farmers under 25 ($141), and the greatest opportunity cost for those over 65 ($1,228). Those over age 65, on average, only work off the farm 13 days a year, and the character of that work may be noticeably different from that performed by those under 25, who work an average of 59 days a year off the farm.

Conclusion

In his 1984 article, Tauer computed the geometric average of each input from the entire data set for the six age groups. These input quantities were inserted into each of the six production functions, and the corresponding outputs were computed. Using the output of the under-25-years-old age group as the base, the productivity of the other age groups was expressed relative to that base. That procedure was repeated here using the results from the 1987 census. The results are illustrated in Figure 1, along with the earlier results of Tauer.

The results are again a concave function of age. Now, however, output peaks at the earlier age cohort of 25 to 34, with output at 154 percent of those farmers under age 25. Productivity decreases slightly for the age group 35 to 44, but falls more

Figure 1. Productivity of Farmers at Various Ages



dramatically to 119 percent for ages 45 to 54. The most significant differences, however, are for those farmers over age 65. Tauer found those farmers to be 1 percent more productive than farmers under age 25, but the more recent data indicate that they are only 77 percent as productive as farmers under 25 years of age. In general, what the new results suggest is that age is even more important in determining productivity, that productivity now peaks at an earlier age, and that the productivity of farmers over age 65 is extremely low. These results do not bode well for a goal to remain globally competitive as the average age of the U.S. farmer increases.

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