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FARM AND NONFARM FACTORS INFLUENCING FARM SIZE¹

by

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Abstract

The impact of the price of capital, nonfarm employment opportunities, and returns in agriculture on farm size was analyzed. A 10 region panel model using data for 1950-2000 was used. The impact of agricultural government payments was also examined. The results demonstrated the capital-labor substitution phenomenon and the importance of nonfarm employment changes.

Key Words: Farm Size, Capital-Labor Substitution, Nonfarm Impacts

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Introduction

The issue of farm size is of major and continuing interest to farm producers, those living in rural areas, and the public in general. Concern over changes in the structure of agriculture is widely expressed and many advocate policies directed to small farms. Generally the policies recommended suggest that increased value added in agriculture along with greater commodity program payments (except to large farms) would reduce farm consolidation.

The economic understanding of farm size changes has traditionally used a long run average cost (LRAC) function framework. In this framework farm size expands when there is opportunity to gain efficiencies from size. Research into the LRAC of agriculture has, however, generally shown major cost disadvantages of small farms but little cost advantage beyond moderate sized units. Yet, small farms have continued as a significant proportion of the U.S. farm structure, in spite of their perceived inefficiency. Also, farm size changes have been anything but uniform by region, state, and substate aggregates. Kislev and Peterson approached farm size structural issues from the perspective that the price ratio of capital and labor was the major determining factor of farm structure. Thus, as the price of capital decreases relative to labor, capital is substituted for labor and farm size increases. Capital prices in the U.S. economy have declined significantly in real terms. Hence, under technological advances capital substitution in agriculture has become commonplace. This has enabled farm operators to control more assets replacing labor intensive tasks.

Another factor affecting the farm size structure which has become increasingly obvious is the availability of nonfarm employment opportunities. Where part and full time nonfarm employment opportunities are growing, a small farm structure tends to be strong. This suggests that farm related earnings may be declining in relative importance to nonfarm earnings of family members. As a result,

where there are few nonfarm employment opportunities, farm producers are forced to expand farm operations to earn comparable earnings. This perspective of the opportunity cost of farm labor stresses the reduced pressure for farm earnings if other family earning potential is high. This is increasingly important in two-spousal working families. In such cases being involved in a small farm may appeal to the family and be "affordable" while fewer families have this opportunity in more rural settings. This perspective is not unrelated to the contention that one reason farm sizes grow is not only because of efficiency reasons but to simply achieve higher incomes.

Farm size issues have increasingly been discussed as they relate to agricultural commodity programs. In particular there has been increasing support for program payment limitations. Some view that the current payment structure supports larger farms and farm size expansion. The causal relationship between commodity programs and farm size is not clear, however. What is important to this issue is that the impact of commodity programs on farm size must be determined simultaneously with other factors which influence the farm size structure.

Objective

The objective of this analysis is to quantify the agricultural and nonagricultural factors affecting farm size changes in the U.S. Because agricultural and nonagricultural influences vary so widely in the U.S., the factors affecting farm size are analyzed by region.

Opportunity Cost of Operator Labor

In this analysis the behavioral force of labor opportunity cost in agriculture is stressed. Traditionally opportunity cost of labor is discussed in terms of labor qualities including factors such as education, training, mobility, etc. While not inconsistent with that emphasis, the perspective of labor opportunity cost in this paper stresses the relation between family earnings required in

agriculture to achieve a degree of comparability to family earnings in the nonfarm economy.

Where nonfarm employment opportunities are high, less pressure is observed in the expansion of farm operations. This is because farm operators and spouses have more opportunities for part time or full time nonfarm employment. Conversely, with limited nonfarm job opportunities farm operators must secure a greater proportion of family earnings from agriculture.

This behavioral phenomenon of family opportunity costs is stressed in this analysis but not to the exclusion of other structural forces affecting labor and capital use in agriculture. Further, the opportunity cost principle emphasized here is not exclusively directed to the number of employment opportunities in the nonfarm economy. Labor opportunity costs in agriculture may also be influenced by the disparity in labor returns in agriculture vs. nonagriculture. It is unclear if it is the availability of nonfarm employment opportunities which enables relatively more farmers to continue in agriculture or if increased wages earned in or out of agriculture also is an important behavioral aspect of labor opportunity costs. Few but well paid nonfarm positions may provide family income support to farm families to those who can secure those positions. More effective, however in providing farm family income support thereby lessening the pressure for farm expansion, is the opportunity of supplemental nonfarm earnings.

Structural Forces

The structural changes which are hypothesized to impact farm size in agriculture involve 1) a rightward shift in the capital supply function, 2) farm labor opportunity cost changes resulting from changes in nonfarm employment, and 3) farm labor changes influenced by a substitution of capital resulting from changes in farm returns and commodity programs. These changes can be visualized in a comparative statics model of two agricultural input sectors - capital and operator labor, each with

their respective supply and demand functions. Input demands are derived from the production process which varies by region, enterprise type, and mix. The three structural forces are discussed separately.

Capital Supply Function

The conventional capital substitution for labor phenomenon occurs here where the prices and use of capital and labor are impacted emanating from reduced capital costs. Rightward shifts in the capital supply function characterize developed economies including agriculture. These shifts over time lead to reduced capital prices and increased capital use. Simultaneously this results in a reduced demand for operator labor followed by reduced labor (increased farm size). Under usual input supply and demand relationships a decreased price of capital as well as a reduced ratio of the price of capital to the return for labor is expected. Thus, a negative relationship between farm size and the price of capital is expected. However, should slow rightward shifts in capital and/or elastic demands for capital characterize a region's agriculture, capital price changes may be relatively inflexible downward compared to labor prices.

Changes in Nonfarm Employment

Following rightward shifts in the demand and level of nonfarm employment, labor opportunity costs in agriculture are impacted leading to rightward shifts in the operator labor supply function. Increases in nonfarm employment demands which result in large increases in nonfarm employment provide significant opportunities for farm operators and spouses to secure part or full time employment outside agriculture thereby reducing the need to expand agricultural operations. Thus, a negative relation is expected between growth in nonfarm employment and farm size. However, where nonfarm economic growth is very large a "pull" on the agricultural labor supply function

(leftward shift) may occur. In the latter case nonfarm employment growth is positively related to farm size.

The nature of the nonfarm employment supply function may also impact these shifts in agricultural labor supplies through the opportunity cost relationship. Where nonfarm employment growth results in large increases in nonfarm returns, farm operators are required to expand operations due to an increase in opportunity costs of labor in agriculture (greater returns necessary to match nonfarm employment returns). This is experienced through a leftward shift in the agricultural labor supply with the result that farm size is positively related to the growth of nonfarm employment opportunities. It is possible that this can occur where the nonfarm economy is either very large relative to the agricultural economy or where there is extraordinary growth in the nonfarm economy.

The interrelationship of nonfarm employment opportunities and nonfarm labor returns both of which could affect agricultural opportunity cost is complex. Thus, while a negative impact of nonfarm employment growth is hypothesized to be the usual case, it is not inconceivable that a positive relation may exist caused either by a "pull" on labor supplies in agriculture or by significant increases in nonfarm labor returns thereby causing opportunity labor costs in agriculture to rise.

Agricultural Returns - Commodity Payments

The impact of changes in agricultural returns on farm size is suggested to follow the conventional capital-labor substitution phenomenon. In such a case increased returns in agriculture lead to an increase in the demand and use of capital in agriculture and reduced labor. In a comparative statics framework this occurs as a "wedge" in the agricultural labor sector. Thus, just as a reduced capital price leads to capital substitution for labor in agriculture, increased labor prices result in the same substitution and farm size increases.

Given the previous emphasis on labor opportunity cost another perspective could be suggested related to how agricultural returns impact farm size. Instead of the substitution process it can be hypothesized that increased agricultural returns whether earned in commercial agriculture or through government payments reduce the opportunity cost disparity with nonagricultural returns thus reducing the pressure for farm consolidation. In this framework increased agricultural returns help meet a target family income reducing the need to expand farm size. Because agriculture varies widely between regions and further due to the relative size of the farm vs. nonfarm economy, it is unclear how these two opposite forces (substitution vs. opportunity cost) operate in different regions. It can also be hypothesized that both forces may be operating simultaneously within a region.

The consideration of commodity program payments adds another degree of complexity to in analyzing changes in returns in agriculture on farm size. Ordinarily government payments might be considered as simply an additive component to returns earned from agricultural operations. Thus, when the usual capital-labor substitution process is in effect increased government program payments increase farm consolidation pressures. But if the opportunity cost reduction process resulting from higher agricultural returns is in effect, farm consolidation is reduced under greater government payments. Two complicating features related to the impact of commercial agricultural returns and government agricultural payments must be considered here and these aspects may vary considerably from region to region. One is the size of the commodity program relative to the commercial agriculture sector. A second is the nature of payment changes in the commodity program in terms of their relation to changes in agricultural receipts. First, commodity programs may be relatively constant across time. Next, commodity programs may be counter cyclical in nature, highest when commercial returns are lowest. Last, commodity payments may be additive and not counter cyclical.

The relation of commodity payment changes to commercial agricultural returns varies among regions of the U.S. as will be seen in later discussion. This is important to the performance of analytic variables used to analyze how important commodity programs act in impacting farm size.

Model, Data, and Equations

The analysis examined farm size changes for the 1950-2000 time period for 10 U.S. regions using a fixed coefficient panel econometric model. The regions and states included are 1) Northeast - Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont; 2) Lake States - Michigan, Minnesota, and Wisconsin; 3) Corn Belt - Illinois, Indiana, Iowa, Missouri, and Ohio; 4) Northern Plains - Kansas, Nebraska, North Dakota, and South Dakota; 5) Appalachian -- Kentucky, North Carolina, Tennessee, Virginia, and West Virginia; 6) Southeast - Alabama, Florida, Georgia, and South Carolina; 7) Delta States - Arkansas, Louisiana, and Mississippi; 8) Southern Plains - Oklahoma and Texas; 9) Mountain - Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming; 10) Pacific - California, Oregon, and Washington.

Farm size (the dependent variable) was acres per farm while seven independent variables were used. These included 1) time (year), 2) the price of capital (the price index for agricultural equipment and machinery), 3) nonfarm employment (number), 4) farm returns (\$000), 5) agricultural government payments (\$000), 6) total agricultural returns [(4) plus (5)], and 7) the ratio of (5) to (4). All return variables were deflated (GDP Implicit Price Deflator) to real terms. The capital price variable (producer price index for farm machinery) was held constant across all regions. Source of data for farm returns and nonfarm employment is provided in the reference section.

Four models were estimated in the analysis. The independent variables were:

Model 1. Year, Price of Capital, and Nonfarm Employment.

Model 2. Year, Price of Capital, Nonfarm Employment, and Total Agricultural Returns (agricultural returns plus government payments).

Model 3. Year, Price of Capital, Nonfarm Employment, Agricultural Returns, and Government Payments.

Model 4. Year, Price of Capital, Nonfarm Employment, and the Ratio of Government Payments to Agricultural Returns.

Results

The results of the analysis by region are presented in Table 1. Two regression models are presented for each region except for the Northeast. Each of the 4 models was examined for each region but not all are presented to avoid duplication. The basic equation (Model 1) without the agricultural return variables is retained in Table 1 for all regions. Equation 4 which includes the ratio of government payments to commercial agricultural returns is shown for most regions. Agricultural earnings act in a capital-labor substitution manner (high agricultural returns results in less operator labor) in all regions except the Lake States and Corn Belt (Northeast is inconclusive). The nature of the difference in how commodity programs perform (cyclical vs. counter cyclical) is highlighted by the sign differences among regions on the return ratio variable.

Northeast

The dominance of the nonagricultural return variables is exhibited with only Equation (1) presented in Table 1 for this region. The hypothesized effects for year (positive) and the price of capital (negative) can be noted, however the nonfarm employment variable was positive. Earlier it was discussed that where nonfarm employment is either of such a large relative size or where nonfarm

employment has made very strong growth, a "pull" on farm operator labor can occur. This can be explained either by a shift (pull) in the labor supply of agriculture or from an increased opportunity cost relationship. In the Northeast over the time period studied the relative increase in nonfarm employment compared to other regions has not been large. Nevertheless, the nonfarm economy is large relative to the agricultural economy. This region is one of only two which exhibit the positive relationship of farm size to nonfarm employment.

In this region the relative increase in total agricultural returns constituted by government payments was high over the 1950-2000 period. Also, the program acts in a strongly counter cyclical manner in this region. Still, the agricultural return variables in various forms in Models 2-4 were not significant and consistent.

Lake States

The price of capital was found to not be significantly related to farm size in this region. As discussed previously, this phenomenon can occur under certain types of agriculture and/or where demand functions of capital are relatively inelastic. Nonfarm employment is negatively related to farm size although the response is relatively low. The changes in level of government payments to agricultural returns is high in the Lake States region and the program operates in a counter cyclical manner. Here, as hypothesized as a substitution process, farm returns and government payments are both positively related to farm size.

Corn Belt

The Corn Belt similar to the Northeast and Lake States region, is impacted relatively less by time than most other regions. The Corn Belt is also not significantly influenced by the price of capital similar to the Lake States region. While negative and significant, the impact of nonfarm employment

is relatively less than for other regions. The commodity program operates in a counter cyclical manner in the Corn Belt and commodity program payments changes have been relatively greater than total agricultural returns changes compared to other regions. Thus, as with the Northeast region, farm size is positively related to the ratio of commodity program payments to commercial agricultural returns.

Northern Plains

The Northern Plains has unique farm size structural characteristics. The nonfarm employment variable was large and strongly significant. As with the Lake States and Corn Belt regions, the price of capital was not found to be significantly related to farm size. Commodity program payments also have increased relative to total agricultural returns in the region more than other regions and the program operates in a cyclical manner. A negative impact on farm size of the ratio of government payments to agricultural returns occurs.

Appalachian

The Appalachian region is the only other region than the Northeast which has a positive relationship between farm size and nonfarm employment changes. It also shows the slowest impact of time on farm size among all regions. Commodity program payments have only increased moderately relative to total agricultural returns in the Appalachian region but their performance has been counter cyclical. Thus farm earnings are positively related to farm size but government payments are negatively related to farm size.

Southeast

Estimated coefficients in the Southeast demonstrate high significance and all their levels are moderate relative to other regions. Also, all impacts are the usually hypothesized impacts. The

relative increase in the level of government payments compared to the change in commercial returns is the lowest of all regions and the nature of commodity payments (cyclical or counter cyclical) is inconclusive. Thus, as farm returns increase farm size also increases a demonstration of the substitution of capital for labor relationship.

Delta

The impacts of the hypothesized variables in the Delta region are observed to be similar to the Southeast region. However, the nonfarm employment variable is not significant. The commodity program's relative increase and its counter cyclical characteristics are very similar to the Southeast and the variable representing the ratio of government payments to agricultural earning performs in a similar manner.

Southern Plains

The major structural difference of the Southern Plains relative to other regions is the strong influence of the price of capital. Except for the Mountain region, its influence is higher than any other region. This again demonstrates the substitution phenomenon of capital for farm labor. The nature of commodity program is inconclusive. However, the positive effect of the farm return variable underscores the capital labor substitution impact.

Mountain

The levels of each estimated coefficient are large in the Mountain region. Also, the statistical significance of all variables are high and perform with expected performance. Government payments have increased in a relatively low manner compared to other regions relative to total agricultural returns and their cyclical performance is inconclusive. The positive nature of the farm earnings variable again is consistent with a capital-labor substitution phenomenon.

Pacific

The variables of the analysis explain farm size changes less than for other regions as demonstrated by the R^2 . In this region all variables demonstrate the usual hypothesized impacts. Interestingly, commodity payments have increased relatively little relative to total agricultural returns compared to other regions and have been cyclical in nature (high when commercial agricultural returns are high). Thus, both return variables are positive.

Conclusions

The panel econometric analysis examined by region changes in farm size as influenced by changes in the price of capital, nonfarm employment changes, and returns in agriculture (both commercial returns and government payments). This analysis attests to the wide variation in agriculture in the U.S. and the variability in the influence of the nonfarm economy by region.

As expected farm size was positively related to time in all regions. This variable represents unquantifiable factors of technological change as well as an income growth incentive for farm operators to expand farm size. Except for two regions (Northeast and Appalachian) nonfarm economic employment increases were found to decrease farm consolidation. For the Northeast the relative change in nonfarm job opportunities has not been large but the size of the nonfarm economy is. Still, the growth in nonfarm employment opportunities may have acted as a "pull" on the agricultural labor supply function. For other regions except the Appalachian region the effect on farm size of nonfarm employment growth as significantly negative particularly in the Northern Plains and Mountain region.

The price of capital was found to be important in all regions except the Lake States, Corn Belt, and Northern Plains. Otherwise, the substitution of capital for labor resulting from declining

real capital prices led to farm size expansion. It is not completely clear why the lack of influence of the capital price variable in the Lake States, Corn Belt, and Northern Plains. Their agriculture is similar but the use of only one capital price variable used in all regions could be the reason.

The influence of returns in agriculture as well as the nature of commodity programs demonstrated differential impacts among regions. For all but three regions (Northeast, Lake States, and Corn Belt) the agricultural labor return acted in a capital-labor substitution manner. That is, as labor returns rise, capital is substituted for labor and farm size increases. For the Northeast, the impact of variables representing agricultural returns was inconclusive. For the Lake States and Corn Belt the results indicate a "target income" or opportunity cost phenomenon whereby as agricultural returns increase pressures for farm expansion are reduced. Depending upon the relative changes in commodity program payments by region and the nature of how commodity program payments are executed (relatively constant, counter cyclical, or additive) the commodity payment variables were found to operate consistently with the overall results (target vs. substitution) determined for the farm return variable.

Table 1. Estimated Relationships for Farm Size, t Values (Parenthesis), and R² for 10 U.S. Regions.

Region	Equation	Year	Price Capital	Nonfarm Employment	Farm Earnings	Government Payments	Total Agricultural Returns	Ratio Government Payments to Farm Earnings	R ²
Northeast	(1)	3.45 (23.92)	-1.03 (23.59)	.01 (4.15)					.9278
Lake States	(1)	3.77 (8.44)	-.10 (.93)	-.02 (2.24)					.9355
	(4)	3.45 (7.97)	-.08 (.82)	-.02 (1.95)				166.54 (3.85)	.9418
Corn Belt	(1)	3.83 (13.67)	-.07 (.93)	-.014 (3.31)					.9420
	(4)	3.66 (12.89)	-.06 (.83)	-.012 (3.01)				68.22 (2.64)	.9436
Northern Plains	(1)	17.04 (35.58)	.05 (.35)	-.59 (23.81)					.9899
	(4)	17.24 (33.48)	.03 (.21)	-.59 (23.24)				-40.91 (1.09)	.9900
Appalachia n	(1)	2.54 (16.41)	-.47 (10.05)	.012 (6.06)					.9136
	(4)	2.72 (17.36)	-.50 (10.85)	.011 (5.22)				-138.42 (4.02)	.9190
Southeast	(1)	7.04 (25.94)	-.95 (11.03)	-.05 (26.75)					.9593
	(4)	7.34 (25.78)	-1.05 (11.52)	-.05 (27.17)				-135.62 (2.93)	.9610

Region	Equation	Year	Price Capital	Nonfarm Employment	Farm Earnings	Government Payments	Total Agricultural Returns	Ratio Government Payments to Farm Earnings	R ²
Delta	(1)	8.04 (14.53)	-1.03 (7.59)	-.011 (.68)					.9170
	(4)	8.40 (14.80)	-1.04 (7.73)	-.02 (1.08)				-106.67 (2.28)	.9199
Southern Plains	(1)	12.39 (13.01)	-2.92 (9.65)	-.008 (2.09)					.9211
	(2)	11.01 (10.41)	-2.52 (7.65)	-.013 (3.07)			.000008 (2.65)		.9266
Mountain	(1)	86.10 (21.15)	-22.55 (17.26)	-.93 (10.60)					.9567
	(2)	79.78 (18.10)	-20.89 (15.20)	-.99 (11.20)			.00013 (3.47)		.9580
Pacific	(1)	15.22 (21.66)	-4.22 (19.28)	-.010 (4.75)					.8354
	(3)	14.00 (18.64)	-3.96 (17.92)	-.02 (5.16)	.000008 (2.72)	.00014 (3.88)			.8512

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