How Economic Conditions Changed the Number of U.S. Farms, 1960-88

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Abstract *The annual net decline in the number of farms is explained by using the lagged number of farms to account for the longrun trend and several variables representing economic conditions The trend provides most of the explanatory power during 1960-74, while prices, land values, and interest rates explain deviations from the trend during 1975-88 Projections of farm numbers need to take into account both longrun trends and shortrun variability in economic conditions to produce meaningful estimates*

Keywords *Number of farms, prices, interest rates land values, time series*

What role is played by economic conditions in influencing changes in the number of farms? Has this role taken on increased importance in recent years as the farm economy has become more integrated into nonfarm and world economies? This article addresses these questions by estimating a time series regression model to explain changes in the number of farms during 1960-88 I used a trend component and several variables which represent economic conditions in the farm economy

A number of recent studies has analyzed changes in the distribution of farms in different size classes (*2,5,6,10*) [1] These studies have given little attention to the effects of economic variables, while using census data from 2 or 3 census years and focusing on the transition of farms among different size classes, as well as farm entry and exit

While these studies identify structural trends and examine hypotheses regarding firm size and growth, they fail to consider the effects of economic conditions which affect the relative profitability of farming The studies are primarily cross-sectional, containing insufficient variation in many price and policy variables to discern statistically their effects on the number of farms

The present study complements these more detailed studies by using annual observations over a 28-year period to estimate a regression model that explains changes in farm numbers The data are less detailed and may be less reliable than the census data (see appendix), but they permit consideration of the effects of year-to-year variations in shortrun economic variables on the number of farms I am less concerned with considering in detail the longrun structural forces focused on by previous studies than the attempt to identify the role played by shortrun economic conditions

Regression Model of Changes in Farm Numbers

In any year t, the number of farms is determined jointly by longrun structural forces and by shortrun influences appearing as deviations from the longrun trend The change in the number of farms between year t and t-1 is expressed as a first-order difference equation to represent the longrun trend plus a deviation, D_t

$$F_t - F_{t-1} = A(F_{t-1} - F_n) + D_t, \qquad (1)$$

where F_t is the total number of farms in year t, and α and F_n are constant parameters with the restrictions, $-1<\alpha<0$, $F_n>0$ The trend component with the restrictions given above states that the number of farms will decline each year by some fixed proportion α of the difference between the number of farms in the previous year and some fixed constant F_n [2] This implies a continuous decrease in farm numbers at a declining rate which converges toward F_n from above This model is chosen simply because it fits the data well, a theoretical model of the longrun decline in farm numbers is not attempted here This longrun trend could result either from some dynamic adjustment process, a longrun trend in relative prices, or a change in technology

Economic theory suggests that net entry to a competitive industry like farming will be influenced by the expected profitability of farming relative to prospective earnings in other activities The profitability of farming is, in turn, affected by changes in economic conditions The deviation from the longrun trend in farm numbers, D_t, is therefore expected to be

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[1] Italicized numbers in parentheses cite sources listed in the References section at the end of this article

[2] The observed percent change in the number of farms $\delta_t = (F_t - F_{t-1})/F_{t-1}$ is equal to $\alpha - \alpha(F_n/F_{t-1})$ Thus a α is not identical to δ_t unless $F_n=0$ in fact $|\alpha| > |\delta_t|$ and δ_t is not constant over time approaching zero as F_{t-1} approaches F_n

influenced by variables representing economic conditions, X_t, expressed as a linear function of these variables

$$D_t = b_0 + \sum_{j=1}^{K} b_j X_{jt} + e_t, \qquad (2)$$

where the b_j are parameters to be estimated, and e_t is a random disturbance

Substituting equation 2 into equation 1, expressing the X_{jt} as deviations from their means,[3] and rearranging slightly, equation 3 is obtained

$$F_t - F_{t-1} = (-\alpha F_n) + (\alpha F_{t-1}) + \sum_{j=1}^{K} b_j X_{jt} + e_t \qquad (3)$$

Equation 3 expresses the change in the number of farms as a linear function of the lagged number of farms and K economic variables with intercept $(-\alpha F_n)$

This equation can be estimated with regression analysis techniques The estimates of the coefficients b_j are estimates of the effects of the economic variables on changes in the number of farms A positive b_j will be found for variables associated with increased net entry of farms,[4] and negative b_j will be found when a variable is associated with less net entry The variables actually used are discussed in the following section Failure to reject the joint hypothesis that

$$b_1 = \quad = b_k = 0, \qquad (4)$$

suggests that the change in the number of farms may be explained using only the longrun trend

The estimated coefficient on the lagged number of farms yields an estimate of α, and, given the estimate of α, F_n can be obtained by dividing the intercept by $-\alpha$ Note the special case where the coefficient on the lagged number of farms is equal to zero and the intercept is nonzero This would suggest a linear trend in farm numbers and, consequently, no tendency for the decline in farm numbers to slow down

[3]This forces the intercept b_0 to equal zero which facilitates the recovery of the parameter F_n from the intercept in equation 3

[4]Net entry of farms, F_t-F_{t-1}, has been negative for most of the past 50 years An increase in net entry means that the negative number will move closer to zero This is a decrease in net exit

Data on the Number of Farms

The model discussed above is applied to the official USDA estimates of the number of farms, which peaked during the 1930's and fell continuously until the end of the 1970's when 2 years of very small increases were recorded (fig 1) (see appendix) This study considers the years 1960-88, during which the extremely rapid decline that began in the 1950's appears to have gradually slowed down, with the number of farms approaching approximately 2 million by the end of the period This decline appears to represent a completion of the structural shifts of the 1950's which showed little sign of slowing down as labor migrated out of agriculture and average farm size increased The period ends with the farm boom-and-bust years of the 1970's and 1980's, when the decline in farm numbers slowed to zero and became briefly positive before returning to rapid decline during the early 1980's

The rate of change in farm numbers declined steadily in absolute value from 1960 until about 1974 (fig 2) After this time, the rate of change in farm numbers did not follow a predictable pattern as it had during the 1960's and early 1970's, but rather fluctuated around a mean of about minus 1 percent The peak in figure 2 in 1979-80 corresponds to the farm "boom" years of the late 1970's when exports and land values were increasing, real interest rates were low, and farming was believed to be an attractive investment The trough coincides with the "bust" years of declining exports and land values and high real interest rates in the 1980's This pattern leads the author to consider whether economic conditions have exerted greater influence during recent years than in earlier years when the longrun trend appears to have been the dominant influence

Specification of Explanatory Variables

The regression model includes variables that influence the relative profitability of farming and which fluctuate from year to year, in addition to the lagged number of farms which is intended to capture the longrun trend The variables include prices of farm output and inputs, land values, interest rates, and the ratio of nonfarm wages to farm income

Prices are believed to play a key role in determining entry to and exit from a competitive industry The ratio of the index of prices received by farmers to the index of prices paid by farmers represents the ratio of

Figure 1
Number of U.S. farms, 1910-88

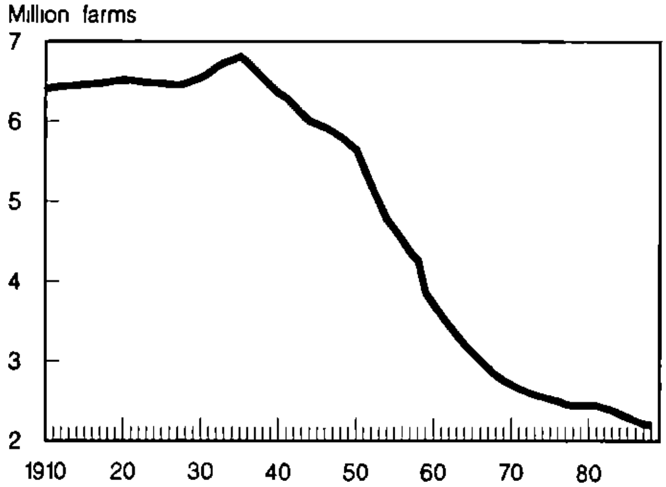
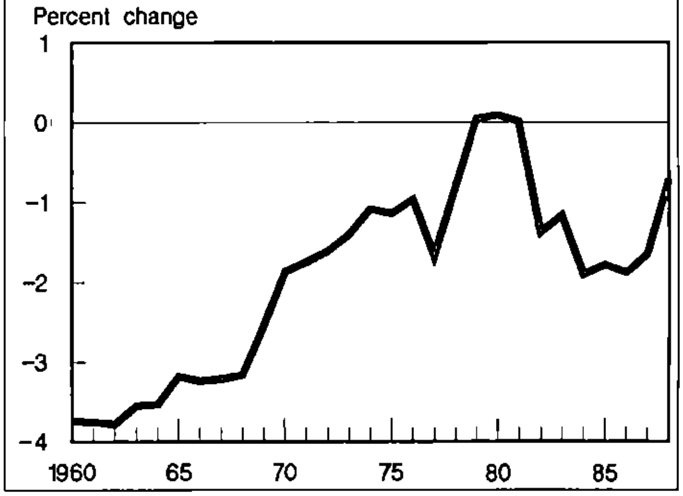


Figure 2
Rate of change in farm numbers, 1960-88



output prices to input prices A higher value of this ratio is expected to lead to greater net entry of farms, thus its coefficient is expected to be positive

Current prices may not reflect expected future profitability of farming Land values are, therefore, included as an explanatory variable since land values are determined by expected future returns from farming [5] Increases in the value of farmland should be associated with greater anticipated returns in farming and the greater net entry of farms Land is also an important asset in the farm portfolio, so changes in its value can affect the financial viability of farm operations Increases in land values increase the attractiveness of farmland as an investment and should lead to greater net entry, while decreases in land values result in financial stress and lead to less net entry The measure of land values used here is the USDA average value per acre of farm real estate deflated using the GNP deflator

Real interest rates influence the price of credit, important to entering farmers, and can affect the degree of financial stress Higher real interest rates may reduce net entry by making farm borrowing more expensive and increasing financial stress The real interest rate was computed by subtracting actual inflation, as measured by the GNP deflator, from the prime rate charged by banks

An increase in the ratio of nonfarm wages to farm income is expected to reduce net entry (increase net exit), since this will enhance the attractiveness of nonfarm employment over farm employment Annual nonfarm income was obtained by multiplying private agricultural average gross weekly earnings in 1977 dollars by 50 Farm income was obtained by dividing net farm income in 1977 dollars by the number of farms [6]

Estimation and Results

The results were obtained using the Yule-Walker procedure for correcting first-order autocorrelation of the error terms to achieve efficient estimates (*3,8*) An instrumental variable is created for the land value variable (because it is not exogenous and likely to be correlated with interest rate) by using predicted values from the following regression

$$\text{Land value}_t = 172\ 1 + 0\ 014\ X_t + 13\ 38\ R_t \quad (28\ 83)\ (0\ 003)\ (5\ 86)$$
$$+ 23\ 99\ I_t,\ R^2 = 0\ 90, \quad (6\ 67)$$

(standard errors in parentheses) where X_t is exports of farm products deflated by the prices received by farmers index, R_t is the real interest rate, and I_t is actual inflation as measured by the GNP deflator

Table 1 presents the results of two regressions estimated for 1960-88 An F-test rejects the hypothesis that the coefficients on the economic variables are

[5]Barkley (*1*) included land values in a model that explained migration of labor out of agriculture and found a positive association

[6]This measure does not take into account the fact that many U S farmers supplement farm income with income from off-farm sources

Table 1—Regression results annual change in number of U S farms, 1960-88[1]

Variable[2]	(1) Full model	(2) Reduced model
Intercept	133,486 * (28,760)	162,128 * (38,882)
Number of farms {t-1}	- 07 * (01)	- 08 * (01)
Ratio of prices received to prices paid by farmers {t}	53,683 * (27,282) [93]	
Average value/acre of farm real estate (1977 dollars) {t-1}	112 81 * (28 95) [1 07]	
Real interest rate {t-1}	-3,432 * (1,395) [18]	
Ratio of nonfarm earnings to real farm income {t-1}	2,525 (5,282)	
Durbin-Watson statistic	1 05	47
Adjusted R^2	90	57

[1]These estimates were obtained by using a procedure to correct for autocorrelation of the error terms

[2]The dependent variable is the change in the number of U S farms between time t and time t 1 { } = Time subscript ( ) = Standard errors [ ] = Elasticities computed at values * = Significance at the 5-percent level with a one-tailed test

jointly equal to zero (equation 4), indicating that these variables do add explanatory power to the model Three of the four economic variables are significant and have the expected signs, with the ratio of nonfarm wages to farm income being the only nonsignificant variable The model that includes the economic variables explains 90 percent of the variation in the change in farm numbers, while the model using only the lagged number of farms explains only 57 percent of the variation

The estimate of α is minus 0 07 in the full model (column 1), suggesting that the number of farms falls each year by 7 percent of the difference between the number of farms and the value of F_n The value of F_n implied is 1,906,943 This agrees with the data of figure 1, which suggested that the number of farms has been approaching 2 million asymptotically over time

The ratio of output to input prices has a significant positive coefficient, as does the coefficient on land values These results suggest that as the output-input price ratio and land value rises (falls), thus increasing (decreasing) the profitability of farming and its attractiveness as an investment, net entry increases (decreases) The real interest rate has a negative effect, suggesting that as real interest rates rise, the price of credit rises, deterring new entry, and possibly resulting in greater financial stress among current farmers, leading to increased exits The final result is less net entry

The computed elasticities are approximately equal to one for the coefficients on prices and land values, and 0 18 for the interest rate, indicating that the magnitude of the price and land value effects is much greater than that of the interest rate An increase in the ratio of prices received by 0 10 will increase net entry by 5,368, an increase in land value of $100 will increase net entry by 11,281 An increase in the interest rate of 1 percentage point will reduce net entry by 3,432

The data were divided into two subperiods to test for differences over time in the importance of the economic variables and in the trend found in the data The 1960-74 period appeared to be dominated by the longrun trend toward fewer farms at a declining rate (fig 2) During this early period, changes in farm numbers showed much less year-to-year variation than during 1975-88, perhaps suggesting that shortrun economic conditions exerted less influence than in recent years, or that economic conditions were less volatile I estimated separate regressions over the two time periods to detect differences in the parameters between the periods

The results of the regressions show significant differences between the two periods (table 2) A Chow test (*4*, p 87) rejects the hypothesis that the parameters of the models, including the economic variables, are equal between the two subperiods with an F-statistic of 4 0 compared with a critical F(*6,16*) at the 5-percent level of 2 74

The economic variables have much greater importance in the later period, with all except the income ratio being significant The land value coefficient is significant in the early period, but an F-test fails to reject the hypothesis that the coefficients on the economic variables are jointly equal to zero The regression using only the lagged value of farms for 1960-88 explains 87 percent of the variation in the change in farm numbers This reduced model has no explanatory power at all during 1975-88, however, while the model including the economic variables had an R^2 of 0 95

Table 2—Regression by subperiod annual change in number of U S farms[1]

Variable[2]	1960-74 (1) Full model	1960-74 (2) Reduced model	1975-88 (3) Full model	1975-88 (4) Reduced model
Intercept	106,897 * (37,778)	182,746 * (29,805)	702,403 * (97,807)	-37,631 (154,981)
Number of farms {t-1}	- 063 * (012)	- 087 * (009)	- 305 * (041)	004 (065)
Prices received/ prices paid by farmers {t}	46,077 (34,469)		189,063 * (56,060) [6 29]	
Average value/ acre farmland (1977 dollars) {t}	234 03 * (99 36) [1 14]		267 04 * (38 17) [7 06]	
Real interest rate {t-1}	-2,258 (2,438)		-5,725 * (2,141) [91]	
Ratio of nonfarm to farm income {t-1}	28,500 (23,894)		7,815 (5,303)	
Durbin-Watson statistic	1 23	46	2 93	90
Adjusted R^2	98	87	95	0

[1]These estimates were obtained by using a procedure to correct for autocorrelation of error terms Columns 1 and 2 were estimated using data for 1960 to 1974, columns 3 and 4 were estimated using data for 1975 to 1988

[2]The dependent variable is the change in the number of U S farms between period t and t-1 { } = Time subscripts ( ) = Standard errors * = Significance at the 5-percent level using a one-tailed test

When the economic variables are included in the 1975-88 model (column 3) the intercept and the coefficient on the lagged number of farms are significant, the value of α being 0 305 and the value of F_n about 2 3 million, while both of these parameters are nonsignificant in the reduced model (column 4) The decline in farm numbers at a decreasing rate can be detected in the 1975-88 data when one accounts for the effect of the economic variables, although the value of α is larger than that for 1960-74 (0 06 to 0 09)

The effects of prices, land values, and interest rates appear to be of much greater magnitude during 1975-88 than during 1960-74 The coefficient on land values is not statistically different between the two periods, but the proportional effect is much larger in the later period (an elasticity of 7 versus a value of 1 for the early period) because the number of farms is much smaller in the later period The price variable had an elasticity of 6 29 during 1975-88 and was nonsignificant during 1960-74 The interest rate was also nonsignificant in the early period, with an elasticity of 0 93 in the later period The point estimates, however, are not statistically different between the two periods As in the 1960-88 model, the proportional effects of prices and land values during 1975-88 are about equal to each other and much larger than the effect of interest rates

The implication of these results is that economic variables have taken on an increasingly important role in recent years in influencing changes in farm numbers while in previous years changes were mainly due to longrun structural forces Table 3 shows coefficients of variation for the variables under study for 1960-74 and 1975-88 The large coefficients of

Table 3—Descriptive statistics by subperiod

Variable	1960-74 Mean	1960-74 Coefficient of variation	1975-88 Mean	1975-88 Coefficient of variation
Number of U S farms	3,054,361	13 99	2,366,450	4 99
Annual change in number of U S farms	-87,271	-44 57	-27,961	-68 62
Percentage change in number of U S farms	-2 76	-34 68	-1 19	-70 45
Ratio of prices received to prices paid by farmers	1 17	6 85	93	13 57
Average value/acre of farm of real estate (million 1977 dollars)	439	14 97	740	22 18
Real interest rate	2 11	45 15	4 67	76 46

variation in 1975-88 indicate that prices, land values, and interest rates have shown much greater volatility during the more recent period, as have changes in farm numbers The results suggest that the greater fluctuations in farm numbers experienced in recent years result both from greater sensitivity to economic conditions and from greater variability in economic conditions

Implications for Modeling Farm Structure

This increasing importance of fluctuations in economic conditions has important implications for the modeling of farm structure, which is normally studied with the use of census data from a limited number of years Estimating Markov chain models meant using this type of data which were, until recently, mainly extrapolations of historical trends The results of this study, however, suggest that variation in economic conditions may cause the probabilities of entry and exit to vary from year to year, so the transition probabilities may not be appropriate for forecasting future farm structure when economic conditions are changing

Some recent work has emphasized that the transition probabilities[7] estimated in Markov chain analysis of farm structure are nonstationary over time (*7, 10*) The data available have permitted only cross-sectional analyses which are not able to estimate the effects of variables such as prices, land values, and interest rates on the transition probabilities The greater sensitivity of farm numbers to these shortrun influences makes this problem particularly acute

Smith (*10*), for example, projects farm numbers to 1986 using Markov models estimated from 1974 to 1978 census data His model overpredicts farm numbers from 1978 to 1986 because 1974-78 was a period when the economic environment of farming was relatively favorable (hence the probability of exit, say, was unusually low), and the model could not take into account the declines in prices and land values and increases in real interest rates that occurred in the 1980's and triggered drastic reductions in farm numbers[8]

Until models can incorporate economic variables that vary from year to year into nonstationary analysis, results obtained from them may be of limited temporal generality, and the projections made from such models should be used and interpreted carefully It may become possible to incorporate these variables into

[7]The probability that a farm in class i at time t will move to class j at time t+1 The classes are usually discrete size classes plus a nonfarm class which allows for entry and exit

[8]Admittedly a time series model such as the one estimated in this article could not have made the prediction unless it could have anticipated the changes in prices

nonstationary Markov models as the length of the census longitudinal file (*2,7,9,10*) is increased to include additional years, allowing more variation in prices and policies

Conclusion

This study showed by means of regression analysis that economic variables, including prices, land values, and interest rates, have a significant influence on changes in the number of farms The influence of these variables also appears to have increased in recent years, where in earlier years the number of farms evolved in a more deterministic manner, falling at a decreasing rate When I controlled for the influence of these variables, I found the trend in the number of farms still to be present in recent years

It is important to understand the operation of these influences given the increasing integration of the farm sector into the general economy of the Nation and into the world economy An understanding of these influences is essential for guiding discussions about farm policy, where influences on farm numbers are often a central point Future models of farm structure and projections of the number of farms should consider both the longrun trends and the influence of shortrun fluctuations in economic variables, since these two effects operate in tandem to determine the number of farms

Appendix

The data on farm numbers are annual estimates produced by USDA and published in August issues of *Crop Production* (*11*) and various statistical bulletins (*12,13,14*) The estimates are linked to the census counts, and for noncensus years the number of farms is estimated using information from the USDA June enumerative survey While the accuracy of the estimates may be open to question, the numbers do represent USDA's official estimates of the number of farms The total number of farms does not tell the complete story about farm structure, since it does not reveal anything about relative changes in size classes

A change in the definition of what is considered to be a farm occurred in 1974, resulting in a discontinuity in the published series A farm had previously been defined as a place of more than 10 acres and at least $50 of sales of agricultural products or a place of 10 acres with sales of at least $250 The cutoff was changed to $1,000 regardless of acreage under the new definition Numbers were published for 4 years under both the new and old definitions, and a comparison revealed that the new and old estimates differed by about 245,000 farms The old and new series were spliced together by subtracting 245,000 farms from all pre-1975 numbers While this works on the unlikely assumption that the number of farms with sales of less than $1,000 remained constant over the entire period, a more sophisticated adjustment scheme was not possible Another distortion results from inflation which tends to push more very small farming operations into the "farm" definition as prices rise, increasing the value of sales for a given quantity of production

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