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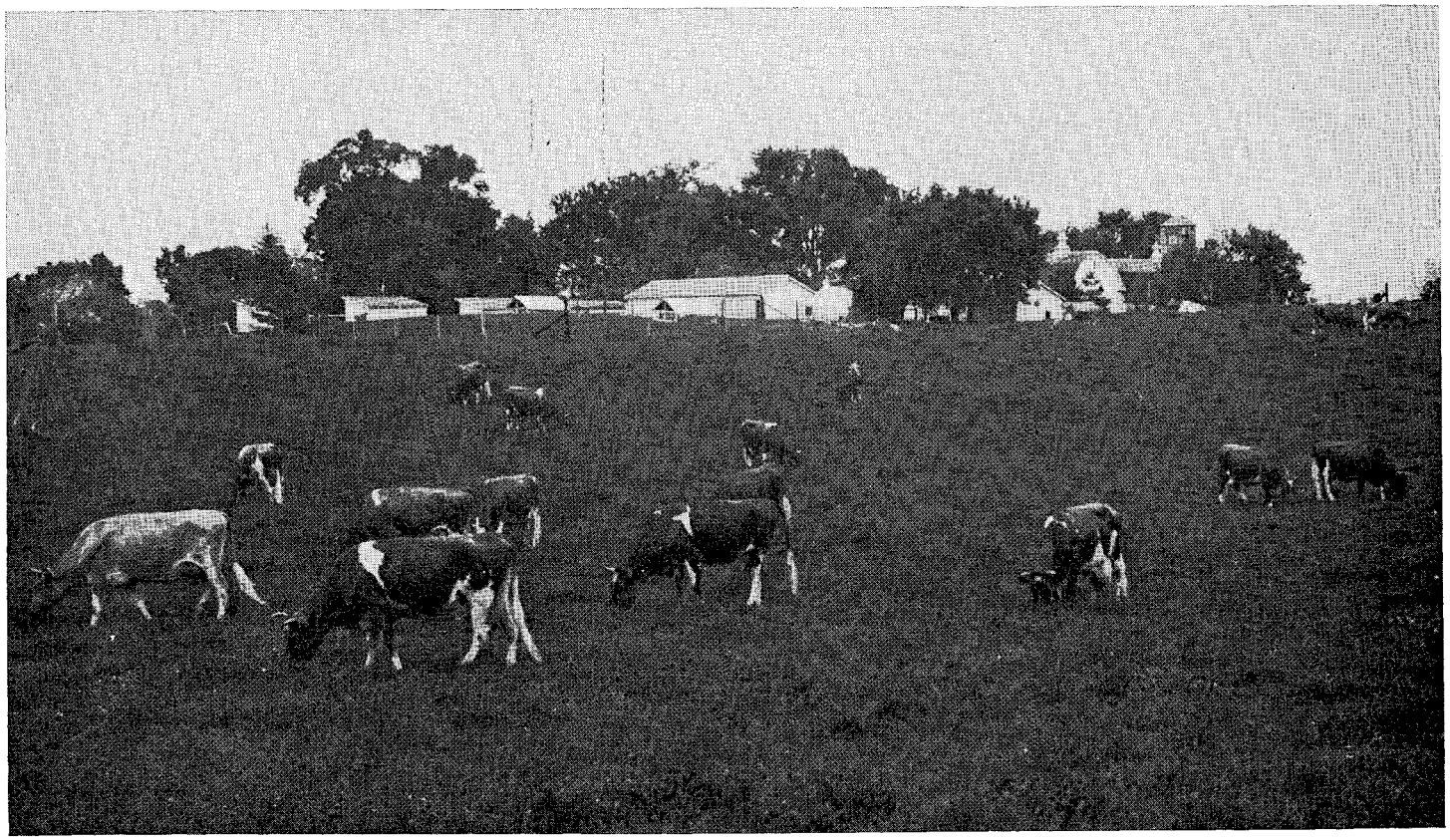

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Contents

Use of a Producer Panel to Estimate Changes in Agricultural Production in Minnesota's Dairy Belt

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Much effort has been directed to projecting changes in the structure of U.S. agriculture generally and to predicting the supply of specific farm commodities.[1] The objectives of this report are (1) to discuss briefly the merits and problems of two conventional procedures for predicting agricultural supply—profit-maximizing (normative) analysis and time-series analysis—and (2) to discuss the potential use of a third procedure, a producer panel, both as an independent estimator of supply and as a supplement to other procedures. The empirical portion of this report deals exclusively with objective two, with focus on estimating milk supplies in Minnesota's dairy belt.

Introduction

Profit-Maximizing Analysis

The two most common forms of supply analysis based on a profit norm are equating the marginal value productivity-cost ratios of resources in alternative uses via production function analysis and budgeting or programming a specified but limited set of resources to provide an income maximizing level of enterprise operation and/or farm organization. In either case, input-output data may be developed by one of several procedures, including synthesis from engineering-economic data and statistical estimation from data acquired from sample farm firms. These analyses usually are conducted without the benefit of time and risk discounting and almost always without consideration of equilibrium price-quantity relationships for resources and products.

Results provided by normative analysis probably are most often used as recommendations for expansion, contraction, or reorganization of farm resources (individually or in the aggregate) to enhance farm profits. Thus they have primary value in a farm or aggregate resource management planning context. They do, however, have an alternative use in setting a probable upper bound to economic production response (supply) possibilities and in determining the direction of likely changes in supply under alternative price assumptions. Also, they can provide useful information relative to assessing the competitive position of different size and different type farm firms.

These analyses are not useful for predicting the magnitude of future supplies (particularly shortrun supplies) of agricultural products. There always has been a detectable gap between resource organizations estimated to be optimal and actual realized organizations of farm resources. Furthermore, there is no convincing evidence that such a gap will not exist in the future, even though a higher proportion of total agricultural production is expected to come from commercial (profit and/or efficiency oriented) producers than has been the case historically. Supply elasticities

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[1] Some insight into these efforts can be obtained by a review of recent literature. Lengthy bibliographies can be found in these reports:

Marc Nerlove and K. L. Bachman. "The Analysis of Changes in Agricultural Supply: Problems and Approaches." *J. Farm Econ.* Vol. XLII. Aug. 1960. pp. 551-54.

W. B. Sundquist et al. *Equilibrium Analysis of Income-Improving Adjustments on Farms in the Lake States Dairy Region, 1965.* Univ. of Minn. Agr. Exp. Sta. Tech. Bull. 246. Oct. 1963. pp. 10-11.

Earl O. Heady et al. *Agricultural Supply Functions—Estimating Techniques and Interpretations.* Ames: Iowa State Univ. Press. 1961.

for some commodities computed from supply functions based on profit-maximizing analysis tend to be larger than those actually realized and/or those computed from time-series data. This phenomenon is particularly evident when these computed production elasticities are applied in situations where reversibility (contraction) of production is projected.[2]

Recently, considerable effort has been devoted to improving the predictive ability of these analyses by conditioning the possible rate at which new technology may be adopted or at which changes in enterprises or resource use are permitted.[3] The feasibility of this supply estimation procedure will be discussed in relation to this study later in the report.

Time-Series Analysis

Time-series analysis has been used with varying degrees of success to predict supplies of specific agricultural commodities. The usual formulation has been to estimate supply as a function of commodity price and the prices or price ratios of competing commodities. Other variables associated with supply often are included in such time-series analyses. Such analyses have utilized both current and time-lagged data series.

Rapid changes in the structure of American agriculture have tended to make supply estimation with time-series analysis a hazardous procedure for a number of farm products. For example, between 1954 and 1959 over a million U.S. farmers, representing about 23 percent of the total entrepreneurial units, left agriculture. At the same time, farmworkers declined in number from 8.7 to 7.3 million. In Minnesota, some 116,230 farmers kept milk cows in 1955. By 1959, only 4 years later, this number had declined to 90,170 or about 78 percent of the 1955 total. Meanwhile, the number of cows per farm increased rapidly. Numerous similar situations of rapid structural change in U.S. agriculture can be cited.

To have statistical significance, time-series projections must be based on data series with a considerably longer time span than 4 or 5 years. Yet using a longer time span introduces major structural changes, and attempting to take cognizance of changes in structure via specification of new or dummy variables is not typically very successful. Even when successful statistically, the results lack interpretation and the procedure uses up already limited degrees of freedom as well. As in the case of normative analysis, there are problems in using a common time-series predictor for periods of both supply expansion and contraction. Rapid changes in farm production technology have changed substantially the cost to price ratios for most farm products, thus changing the effects of absolute variances in cost and price time series. A second effect of technology changes has been to change the production potential of individual farm firms for any product price. Also, the incidence of and change in government farm programs have been affecting both input use in agriculture and production of agricultural commodities. Because these programs vary in their provisions over time, their effects on supply of agricultural commodities cannot easily be incorporated into time-series analyses.

Additional Supply Analysis Needs

The above discussion of the shortcomings of conventional procedures is not intended as criticism per se but is included to point up additional supply analysis needs. Some shortcomings might be remedied by up-to-date and broad-based supplementary information on changes in the structure of producing firms (size, resource base, technology employed, etc.). Consideration of important nonprice and nonincome variables that affect supply also is needed. Farmers' responses to such factors as risk and internal capital rationing and their farming experience, personal preferences, age, family responsibilities, and production expectations should be included in such a consideration.[4]

All the above needs can be best evaluated first at the individual firm or producer level. Attempts to evaluate them solely at an aggregate level are likely to mask the effects of microlevel variables. Research needs are apparent both at the conceptual level to understand decision-making by producers[5] and at the operational or method of prediction level. The latter need is for specification of measurable variables that depict producer response and determination of a valid method for collecting data.

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[2] See Willard W. Cochrane. *Farm Prices: Myth and Reality.* Minneapolis: Univ. of Minn. Press. 1958. and Glenn L. Johnson. "Supply Function—Some Facts and Notions" in Heady et al. *Agricultural Adjustment Problems in a Growing Economy.* Ames: Iowa State Univ. Press. 1958.

[3] See particularly Richard H. Day. *Recursive Programming and Production Response.* Amsterdam: North-Holland Publishing Co. 1963. and W. Neill Schaller. *A Recursive Programming Analysis of Regional Production Response.* Unpub. Ph.D. thesis. Berkeley: Univ. of Calif. 1962. The procedure discussed in these articles also is being used in a national model of production response currently being developed in the Farm Production Economics Division, ERS, USDA.

[4] Glenn L. Johnson. "Stress on Production Economics." *Australian J. Agr. Econ.* Vol. 7. No. 1. Pp. 22-23 are particularly relevant. A preliminary formulation of relevant variables can be found in the contribution of L. M. Day and H. R. Jensen to the Chicago Conference on Agricultural Supply Functions reported in Heady et al. *Agricultural Supply Functions.* op. cit.

[5] One extensive attempt to probe into the decision-making process was made by researchers in the North-Central Region and is reported by Glenn L. Johnson et al. in *Managerial Processes of Midwestern Farmers.* Ames: Iowa State Univ. Press. 1961. Although this study provided valuable insights into the decision-making process, it did not, nor was it intended to, provide an operational basis for solving the problem.

The Study

An Uncharted Research Area

A farmer's planned supply response involves estimates of the future that he can know only imperfectly. Little is known about what these future estimates are, how a farmer constructs them, and how he integrates them into future plans. It is known that as he formulates his production plans he is faced with imperfect knowledge about numerous variables such as prices, technology, yields, institutions, and people. But it is not known how or to what extent he considers such variables in his planned supply response.

Perhaps variables such as the subjective fixity of production factors, his age, family composition, equity position, desire for leisure, and level of income are the variables that substantially condition or determine a farmer's planned supply response. Moreover, since a farmer's planned supply response involves estimates of the future, his estimates are subject to error. Little is known about the resultant gap between planned and realized supply response. Too, a study of farmers' planned supply responses may uncover areas of supply response that are unplanned, i.e., some of the changes in supply response may be due to random variation. Because of the lack of information in this area, the research reported here sought both to test some hypothesized relationships and to point out relationships with potential predictive capabilities.

Prediction of the future supply of important agricultural commodities is of interest. However, it was decided to assess farm production changes in a general way initially and then to focus primarily on milk production. Relative to most agricultural commodities, a large share of milk production costs results from relatively "fixed" investments. As a result, milk production might be expected to be less responsive to shortrun prices[6] than would be the case with a product such as soybeans. To the extent that this hypothesis holds true, consideration of nonprice variables is a particularly important aspect of supply analysis for milk.

Variables Related to Supply

It was hypothesized that a number of variables were related to the decisions Minnesota farmers make about what products to produce and in what quantity. A list of these variables and explanations for hypothesizing that they had an effect on the supply of farm products follow.

1. Shortrun and Longrun Price Expectations for Crops, Livestock, and Livestock Products. It was hypothesized that, other things being equal, farmers would increase production of those farm products for which high shortrun and longrun prices were expected. It was further hypothesized that shortrun and longrun price expectations should be considered in separate categories because of the possibility that the two expectations might be different or that farmers might respond differently to each. For example, although farmers might anticipate a near future decrease in milk prices, they might increase cow numbers in anticipation of secular improvements in milk prices.

In this study, the shortrun planning span was set at 1 year and the longrun planning span at 5 years. To avoid respondents' inability to project longrun prices in absolute values, price expectations were evaluated as price relatives (milk prices favorable relative to those for beef, beef prices unfavorable relative to those for hogs, etc.), using current prices for comparison. Because the farms in this study were largely feed-grain, dairy, or other livestock types, only corn, milk, beef, and hog price expectations were developed.

2. Land Resources. It was assumed, other things being equal, that production could be expanded most readily on those farms with large cropland bases, because of the land base requirements for crops and for most livestock, particularly dairy.

3. Labor. Increased farm production, particularly of dairy products, was hypothesized to be related positively to the amount of farm labor available to man the production process.

4. Income Level and Equity Position. It was hypothesized that, because of ready financing, farmers with high incomes and/or good equity positions would be more likely to increase production than would other farmers. Several income and equity ratios were considered to be positively related to production changes. These ratios were: total capital to total debt, real estate capital to real estate debt, and operating capital to short-term debt.

5. Propensity to Use Credit. It was hypothesized that the more willing farmers were to borrow money when needed, the more likely they were to increase farm production. Absolute dollar value of the volume of credit a farmer would use if he thought it profitable was hypothesized to be a reasonable measure of his propensity to use credit.

[6] The results of empirical work done by a number of analysts would appear to bear out this expectation. See particularly H. W. Halvorson. "The Response of Milk Production to Prices." *J. Farm Econ.* Vol. 40. Dec. 1958. and R. Barker. *The Response of Milk Production to Price: A Regional Analysis.* Unpub. Ph.D. thesis. Iowa State Univ.: Dept. of Econ. and Soc. 1960.

6. Age and Family Composition. It was hypothesized that age (particularly of farm operators 50-55 years or older) would be negatively related to increases in farm production principally because older farmers would desire to reduce their workload. Conversely, the number of sons 12 years of age or older a farmer had was thought to be positively related to production increases, since farmers with sons this old would have increasing family labor supplies.

7. Current Size of Livestock Enterprises. Because of the enterprise experience already available and the trend toward increased specialization and size of enterprises, it was assumed that increased production might occur in greatest quantity on those farms that already had substantial enterprises.

8. Excess Capacity. It was assumed that livestock enterprises particularly would increase most rapidly on those farms with excess building capacity and feed supplies.

9. Off-farm Employment. The amount of off-farm employment of farm operators was hypothesized to be negatively related to changes in farm production. This reasoning was based on the premise that farm production and off-farm employment would compete for the operator's labor and managerial resources.

10. Personal Preferences. Because some farmers disliked certain farm enterprises and preferred others, it was hypothesized that farmers would increase most the production of those products for which they had indicated an enterprise preference. This premise was thought to be a particular consideration in dairying because of the dislike many operators expressed for the "lack of freedom" associated with the enterprise. Others were thought to prefer the steady income and lack of risk associated with the enterprise.

Other variables and relationships were devised and tested after the survey data were acquired. A number of other factors, such as weather conditions and government programs, also were thought to be related to production decisions and supply levels, but specific relationships were not hypothesized before acquisition of survey data.

Use of a Producer Panel

To provide meaningful information on the variables listed above, two research requirements appeared necessary. First, it was decided that data should be acquired from a representative sample of farmers to permit valid generalization of supply estimates for a specific population of producers and to permit accurate checking of this inference against other data sources. Second, it was decided that data should be acquired over a period of several years to obtain information on price stability and production expectations and to determine why farmers make year-to-year changes in resource use and production. Also, a time lapse was needed between initial data acquisition for several of the variables and final measurements of production to allow change to take place and to provide a basis for estimating relationships between variables.

The Minnesota Producer Panel

In 1959, a survey was made of 327 farmers from 35 counties encompassing the major dairy belt of Minnesota. Farmers were sampled randomly and represented about 0.55 percent of the farm operators in the area who (1) grossed over $1,200 of farm income in 1958 and (2) were neither specialized poultry nor truck crop farmers. This survey provided data for the 1958 farm business operation. Subsequent surveys were made in March 1961, 1962, and 1963. The sample size diminished somewhat after 1959 because some farmers decided to quit farming or to refrain from providing information asked of them in personal interviews. Effective sample size for different years will be discussed along with specific data and analyses later in this report.

In addition to its use for the "prediction oriented" analysis discussed here, the 1959 survey was used as the basis for profit-maximizing analysis and supply response of farmers from 24 different representative farm situations. These situations were delineated on the basis of soil type, farm size, and type of milk market. Results of the profit-maximizing analysis are available for comparison with the results from the study reported here.[7]

Other Characteristics of Panel Participants

Because of random selection, characteristics of the original 327 panel members were widely different.

[7] Results of this analysis were reported in Univ. of Minn. Agr. Exp. Sta. Bulls. 459, *Profitable Adjustments in Farming in East Central Minnesota;* 460, *Profitable Adjustments in Farming in Central Minnesota;* 466, *Income-Improving Farm Adjustments in Southeastern Minnesota;* 473, *Income-Improving Adjustment Alternatives on Grade A Dairy Farms in Minnesota;* and in Univ of Minn. Agr. Exp. Sta. Tech. Bull. 246, *Equilibrium Analysis of Income-Improving Adjustments on Farms in the Lake States Dairy Region, 1965.*

Cropland acreage varied from 0[8] to 639 acres, with an average of 132 acres. The labor force on farms (estimated in man-months) varied from 0.6 to 36 months, with an average of 15.7 months. The typical farm operation was a one-man farm with some family labor available. Of the 327 farmers, 273 had a dairy enterprise in 1958. Of the 273 dairymen in the sample, 38 produced milk for fluid use, 210 sold grade B whole milk, and 25 sold cream only.

Dairy enterprises varied in size from 1 to 57 cows, with an average of 18 cows in the milking herd. Only seven farms had a milking parlor-loose housing dairying system at the beginning of the study period. The remainder had conventional stanchion barn dairy operations.

Of the 327 farms, 29 had beef enterprises, 196 had hog enterprises, and 14 had no livestock enterprise at all.

The age of panel members in 1958 ranged from 21 to 77, with an average age of 46 years. Fifty-two of the farmers were engaged in some type of off-farm employment ranging from 3 to 12 months per year and averaging slightly more than 5 months.

Analysis of Production Adjustments

The analysis reported in the ensuing sections of this report centers on a diagnostic assessment of production changes during the 5-year study period. The major study objective was to relate these changes to measurable characteristics of the farm operator, including his expectations, his family, and his farm business. The major focus of inquiry was to assess the extent of and reasons for changes in dairy production. However, an attempt was made to include crop production, livestock, and livestock products in this assessment and then to focus narrowly on dairy production.

Net Production Changes on Producer Panel Farms

The dependent variable chosen for the general assessment of net production changes was the change in work units from 1958 to 1962. This variable was defined as the change in all farm enterprises converted into work units according to the index used to measure cooperator productivity in the Minnesota Farm Management Recordkeeping Association.[9]

The panel included a number of farmers who were not very concerned with making changes in their farm business because their off-farm employment provided some family income, and they didn't have enough family labor left to make any substantial increases in farm business volume. Consequently, farm operators who earned more than $250 per year doing off-farm work were sorted out of the sample, and their production changes were analyzed separately.

A second group in the sample that did not appear very receptive to making production changes was the group of farmers over 60 years old, many of whom were willing to maintain their farm businesses about as they were. So the sample was further sorted on an age basis. The older group and the off-farm income

[8] One farm operator had no cropland but had a sizable drylot livestock operation. This type of operation, although rare in this particular study, represents an increasingly prominent type of organization in U.S. livestock agriculture. However, it is one that time-series data are particularly unsuited to cope with.

[9] The total work units for any one farm are a measure of the size of that farm business. A work unit as used in this report is the average accomplishment of a farmworker in a 10-hour day, working on crops and productive livestock at average efficiency or 10 hours of work off the farm for pay. The number of work units for each class of livestock and each acre of crop is:

Item	*Number of work units*	*Item*	*Number of work units*
Dairy cows	10.00 per cow	Small grain	0.50 per acre
Other dairy cattle	3.50 per animal unit*	Sugarbeets	1.50 per acre
Beef breeding herd	3.50 per animal unit*	Corn, husked	0.70 per acre
Feeder cattle	0.25 per 100 pounds	Corn silage	1.00 per acre
Hogs	0.20 per 100 pounds	Alfalfa hay	0.60 per acre
Soybeans for grain	0.50 per acre		

* Animal unit represents alternately one dairy cow or bull, two other dairy cattle, one and one-fourth beef cows or bulls, one feeder steer or heifer, three and one-third other beef cattle, two and one-half hogs or five pigs.

This or any similar work unit suffers from being in one sense an input, rather than an output unit. It does, however, provide a gross measure of the latter. For more discussion, see T. R. Nodland. *1964 Annual Report of the Southeastern Minnesota Farm Management Service.* Dept. of Agr. Econ. Rpt. No. 280. Univ. of Minn. June 1965. p. 21.

group were added back into the sample when prediction of changes in cow numbers was considered.

Changes in Farm Work Units

The main emphasis in the following analysis centered on those farmers without substantial off-farm income who were 59 years of age or younger. This group included a large portion of the original sample and was expected to include most of those operators making production adjustments that resulted in an increased supply of farm products.

To identify variables related to changes in production (work units), an equation was constructed and regression coefficients estimated utilizing 42 independent variables (see table 1).[10] This equation was found to be reliable by the F test; 93 percent of the variance in the dependent variable was associated with the independent variables used. Many of the variables, however, were not significant and some variables were removed to derive a useful a priori estimating procedure. Equation 1 included variables determinable only after the test period had begun.

A formulation that included only variables measured at the beginning of the study period appears as equation 2 in table 1. Some additional variables were highly interrelated and were removed for that reason.[11] Using this equation with 21 independent variables, 40 percent of the variance in the change in total work units was explained. Though a much smaller portion of total variance was explained in equation 2 than in equation 1, equation 2 was statistically significant. Since some of the least useful variables had been removed, it was a useful equation for examining the relation between the dependent variable and some of the independent variables considered.

In equation 2, the ratio of total assets to total liabilities was a useful indicator of changes in work units, though it was not useful for indicating the absolute value of assets. The dependent variable also was affected significantly by the levels of livestock enterprises in the initial study year. The number of feeder cattle and feeder pigs in 1958 both had a significant effect on changes in total work units; the regression coefficients for both of these variables were negative. Estimates were significantly affected by the willingness of operators to borrow additional capital funds. Adjustments in work units as indexes of change in the farm business apparently were not responsive to measurable price expectations of specific enterprises in either the longrun or shortrun. The shortrun price expectations from 1961 were used in this analysis since they were completely recorded for that year only.

No simple reason was apparent for the negative regression coefficients of feeder cattle and feeder pigs. One hypothesis, however, was that major production adjustments on farms with large nondairy enterprises in 1958 already had been made when the study began.

The same variables used in equation 2 were included in formulating equation 3, shown in table 2. Sample size was increased, however, from 89 to 130 by substituting the sample mean for missing variables. Information on no more than three missing variables was added for any single farmer; most lacked only one or two. Using the same variables as in equation 2 for these 130 observations, the results in equation 3 (table 2) were recorded. This increase in sample size did not produce better statistical results than were obtained with the small sample. But the increase did result in a better representation of the total group of farmers sampled.

Additional stratification was performed by geographical location in an attempt to make the study area homogeneous. Farms from the 11 northernmost counties in the test area were excluded on the basis that their soils were somewhat different and less readily adaptable to nondairy farming than soils in the other counties. The results of the regression analysis performed on the remaining study area were not greatly different from the preceding equations. The amount of explained variance did not increase as compared to equation 2, and the effect of individual variables was about the same. Consequently, this formulation was not reported in equation form.

An additional postsampling stratification procedure was used in an attempt to improve results from the estimating equation. The sample was sorted on the basis of the market for dairy products. The largest group of producers sold grade B milk; a few were grade A producers. Two additional groups were delineated: those farmers who had no dairy enterprise and those who sold cream. Only the first two of these strata were analyzed by regression analysis, since the latter two contained only a few individual producers.

The analysis performed on the stratum of grade B producers did not produce a stronger estimating equation than that obtained for the sample in equation 2. The explained variance was about the same, but the effects of individual variables were somewhat different. The milk price expectation of grade B producers appeared to be a significant variable in their decisions to make adjustments, though this variable had no explanatory value in other strata.

Only 25 grade A producers provided adequate information for regression analysis. The resulting estimating equation was not reliable at the 95-percent confidence level and is not reported here.

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[10] In subsequent equations, the sample size varies with the number of variables used. Unless otherwise indicated, complete information on all variables was a requirement for inclusion. Complete information was not obtained from all respondents.

[11] Since the major objective of the statistical formulation was that of prediction, intercorrelation between independent variables was not of major consequence. If two independent variables were highly intercorrelated and the coefficient on one was small and nonsignificant, no useful purpose was served by including it.

Table 1. Regression equations with change in farm work units between 1958 and 1962 as the dependent variable

Item	Equation 1* Regression coefficient	Equation 1* T value	Equation 2* Regression coefficient	Equation 2* T value
Equation number	1*		2*	
Number of independent variables	42		21	
Number of observations	89		95	
Table value of T	1.96		1.96	
Explained variance	93 percent		40 percent	
Computed F	12.60		2.34	
Table value of F	1.69		1.75	
Constant term	—63.60	.....	43.29	.....
Excess dairy capacity (cows)	—1.49	1.21	—1.38	0.71
Gross income ($100)	0.05	0.24	.....	.....
Cropland (acres)	—0.35	1.30	.....	.....
Tenure (owner, part owner, renter)	—18.92	2.43	.....	.....
Net worth ($100)	0.9	0.76	—0.10	1.52
Real estate assets ($100)	—0.09	0.73	.....	.....
Non-real estate assets ($100)	—0.26	1.76	0.31	1.75
Total assets ÷ total liabilities	0.14	0.50	0.56	2.46
Real estate assets ÷ real estate liabilities	—0.04	0.16	.....	.....
Non-real estate assets ÷ non-real estate liabilities	0.09	0.69	.....	.....
Age of operator (years)	—2.94	1.07	—8.87	1.60
Education (years)	—1.33	0.27	0.43	0.05
Off-farm work (months)	—1.92	0.44	—4.63	0.75
Off-farm income ($100)	—0.04	0.04	.....	.....
Dairy cow numbers, 1958 (head)	—9.55	6.86	0.31	0.20
Longrun price expectation for milk (price relative)	13.08	1.04	—4.19	0.20
Dairy cow numbers, 1962 (head)	10.99	11.23	.....	.....
Cows expected next 5 years, 1963 (head)	0.01	0.02	.....	.....
Beef calves born in 1958 (head)	2.03	1.03	—2.40	1.39
Beef cows expected next 5 years, 1963 (head)	0.44	0.04	.....	.....
Feeder cattle in 1958 (head)	—0.69	1.76	—1.14	2.90
Feeders expected next 5 years, 1963 (head)	0.06	0.23	.....	.....
Pigs farrowed in 1958 (litters)	—3.50	4.17	—1.59	1.34
Longrun price expectation for hogs (price relative)	—7.45	0.78	—28.70	1.53
Pigs expected next 5 years, 1963 (litters)	2.05	3.22	.....	.....
Family labor supply (months)	1.49	0.65	.....	.....
Sons at home (number)	0.90	0.32	.....	.....
Longrun price expectation for beef (price relative)	—3.36	0.35	—24.84	1.37
Time operator intends to farm (years)	0.83	1.43	1.02	0.96
Change in net worth, 1958 to 1962 ($100)	—0.03	0.77	.....	.....
Change in dairy cows, 1958 to expected 1963 (head)	—0.17	0.21	.....	.....
Change in beef cows, 1958 to expected 1963 (head)	2.66	1.55	.....	.....
Change in hog numbers, 1958 to expected 1963 (litters)	0.82	1.22	.....	.....
Change in off-farm employment, 1958 to 1962 (months)	1.75	0.50	.....	.....
Change in off-farm income, 1958 to 1962 ($100)	0.29	0.21	.....	.....
Feeder pigs purchased, 1958 (head)	0.03	0.08	—0.75	2.44
Change in feeder pigs purchased, 1958 to 1962 (head)	0.45	3.84	.....	.....
Expected price for milk, 1961 ($)	0.68	0.04	—7.54	0.23
Expected price for hogs, 1961 ($)	2.72	0.09	3.60	0.67
Expected price for cattle, 1961 ($)	0.37	0.02	1.88	0.43
Willingness to borrow ($100)	0.105	1.71	0.213	2.54
Cropland ÷ labor	6.88	1.32	—0.13	0.04

* Includes all farmers under age 60 with less than $250 off-farm income in 1958 and who reported information on all independent variables included in the regression.

Table 2. Regression equations with change in farm work units between 1958 and 1962 as the dependent variable

Item	Regression coefficient	T value	Regression coefficient	T value
Equation number	3*		4*	
Number of independent variables	21		11	
Number of observations	130		139	
Table value of T	1.98		1.98	
Explained variance	36 percent		20 percent	
Computed F	2.84		2.86	
Table value of F	1.66		1.91	
Constant term	151.95	.....	16.99	.....
Excess dairy capacity (cows)	—1.90	1.15	1.08	0.81
Cropland (acres)	.....	.....	0.01	0.05
Net worth ($100)	—0.01	1.19	—0.04	1.04
Non-real estate assets ($100)	0.12	0.91	.....	.....
Total assets ÷ total liabilities	0.38	1.94	0.35	1.90
Age of operator (years)	—16.12	3.24	—15.05	3.79
Education (years)	—11.08	1.24	.....	.....
Off-farm work (months)	—3.94	0.71	.....	.....
Dairy cow numbers, 1958 (head)	0.49	0.44	1.33	1.59
Longrun price expectation for milk (price relative)	—7.76	0.51	7.35	0.61
Beef calves born in 1958 (head)	—2.12	1.75	.....	.....
Feeder cattle in 1958 (head)	—0.22	0.89	.....	.....
Pigs farrowed in 1958 (litters)	—2.27	2.75	.....	.....
Longrun price expectation for hogs (price relative)	—4.16	0.31	.....	.....
Family labor supply (months)	.....	.....	—0.30	0.23
Sons at home (number)	.....	.....	2.65	0.72
Longrun price expectation for beef (price relative)	—12.70	1.00	.....	.....
Time operator intends to farm (years)	0.74	0.76	.....	.....
Change in off-farm employment, 1958 to 1962 (months)	.....	.....	—2.68	0.92
Feeder pigs purchased, 1958 (head)	—0.53	4.47	.....	.....
Expected price for milk, 1961 ($)	—6.48	0.25	.....	.....
Expected price for hogs, 1961 ($)	0.18	0.04	.....	.....
Expected price for cattle, 1961 ($)	—10.57	0.48	.....	.....
Willingness to borrow ($100)	0.001	1.50	0.001	1.90
Cropland ÷ labor	6.88	1.32	.....	.....

* Includes all farmers under age 60 with less than $250 off-farm income, with information on no more than three independent variables missing for any farmer. The mean value for all observations was substituted when a farmer failed to report data on a variable. In most cases, only one or two variables were incomplete.

Analysis With a Reduced Number of Variables

In equation 4 (table 2), a reduced number of variables was used to predict changes in work units. Included were variables that had influenced the estimate in previous equations and some that were regarded as factors influencing farmer production decisions. The equation was shown to be reliable by the F test at the 95-percent confidence level. The influence of individual variables did not change appreciably from previous equations where a large number of variables was used. However, the variables used explained only about 20 percent of the variance in the dependent variable.

A T value of at least 1.98 should be exhibited for regression coefficients to be significant at the 95-percent confidence level. Only age of operator exhibited this large a T value. Willingness of an operator to borrow and his ratio of total assets to total liabilities were very close to this level.

To this point, only equation 1 had both a significant F ratio (as evaluated at the 95-percent confidence level) and a reasonably high explained variance, indicating a strong estimating equation. However, the equation contained a number of variables not observable at the start of the test period. When these and all other defective variables were removed, the proportion of variance explained was much reduced. Thus, it was concluded that the variables measured may serve to predict aggregate production changes over a short period quite well, but they do not have adequately reliable predictive power over a period of 4 or 5 years.

Production Changes in the Dairy Enterprise

Producers Without Dairy Cows in 1958

In 1958, the producer panel had a number of farmers who had no dairy cows. These farmers were considered as a separate stratum to determine the effect they as a group had on the supply of dairy products. There were 54 nondairy farmers in the sample in 1958, but only 22 of them contributed information in the final survey year. Of these 22 farmers, only 1 had started in the dairy business by 1962. Several others gave up farming between 1958 and 1962. Thus, all available information indicated that almost all milk production increases were from farmers who already were in the dairy business in 1958.

A tabular examination of the nondairy farmer group indicated a high incidence of off-farm employment among them. The group averaged $540 in off-farm income in 1958 and $1,482 by 1962.

The nondairy farmers experienced a slight average increase of 10 work units per farm over the study period, but individual farmers recorded very high levels of changes in work units, both positive and negative. The largest group (farmers less than 60 years old with less than $250 of off-farm income) had an average increase of 37 work units per farm over the test period. The figure does not include work unit changes as a result of off-farm employment.

Of the farmers who had no dairy cows in 1958, three were 60 or older. Their average age was 48, compared to 46 for the entire panel.

Farmers without dairy cows had larger average croplands—185 acres—than other panel members, who averaged 132 acres and had less total labor available. Also, the former group had more feeder cattle and fewer hogs on their farms than did the panel as a whole.

Farms With Older Operators

An examination of production changes in the producer panel suggested that those operators age 60 and older in 1958 did not account for much of the expansion in dairy production. There were 22 farmers in this age group who still were participating in the panel in 1963; they were examined as a separate stratum. Farmers in this group experienced an average reduction of 18 work units per farm over the test period. They owned an average of 11 dairy cows in 1958, compared to 18 cows for the whole panel; by 1962, they had an average of only 7 dairy cows.

Farmers in the 60 and older group owned little livestock other than dairy cows, except for several who had small hog enterprises. The group had a cropland acreage average of 94.5 acres, compared to 132 acres for the entire panel. Although these farmers had a labor supply per farm as large in man-months as for the whole panel, it might be concluded that their capacity for physical labor was somewhat less, since they were substantially older than the other panel members.

Operators With Off-Farm Income

Forty-three farmers with off-farm incomes of at least $250 were still participating in the producer panel in 1963. Individual farmers within this group reported large adjustments in production, measured both in work units and dairy herd size, over the test period, but as a group their average changes were very low. They averaged a reduction of 1.6 work units over the test period and reduced their dairy herd size by an average of one cow.

Farmers in this group averaged 16 cows in their dairy herds in 1958, a number not much lower than the panel average of 18 cows. An average of 18 litters of pigs was farrowed on their farms per year, but only a few farmers had beef cattle or purchased feeder pigs.

The average age of farmers in this stratum was 44.5 years as compared to 46 for the whole panel.

Production Changes on Farms That Left the Panel

One difficulty in analyzing production changes in the producer panel was that information was incomplete for farms whose operators left the panel before the study ended. For those farms included in the study only 1 year, essentially no information about adjustments was available, but for those that dropped out in subsequent years, some year-to-year changes could be examined. See table 3 for a comparison of resources and enterprise levels between farms not included in the study after 1 year and those that were included longer.

By the time of the second survey (covering 1960), 77 farmers dropped out. In the next survey (covering 1961), another 21 farmers departed from the sample, and in the final survey (covering 1962), schedules were obtained from 20 fewer farmers. Thus, year-to-year changes on farms whose operators dropped out of the panel are based on a small sample.

Farmers who left the sample were slightly older, had less average labor and cropland, and had fewer dairy cows than farmers who stayed in the study. The greatest proportionate difference between these two groups was in dairy cow numbers, particularly on those 77 farms not included in the sample after 1 year.

Table 3. A comparison of farms whose operators left and farms whose operators remained in the producer panel

Item	Unit	Farms included in 1962	Farms that dropped out, all years	Farms that dropped after 1959 survey	Farms that dropped after 1960 survey	Farms that dropped after 1961 survey
Number of farms	Number	209	118	77	21	20
Age of operator in 1958	Years	45.16	48.00*	50.60*	43.40	44.00
Cropland acreage in 1958	Acres	143.00	112.00*	106.24*	112.42	135.37
Dairy cow numbers in 1958	Number	17.28	11.00*	9.97*	15.24	12.60
Off-farm work in 1958	Man-months	0.52	1.32*	1.19*	1.52	1.62
Changes in dairy cow numbers:						
1958 to 1960	Number	0.35	.....	.....	0.57	0.10
1960 to 1961	Number	0.99	.....	.....	.....	1.70
1958 to 1961	Number	0.97	.....	.....	.....	1.45
1958 to 1962	Number	1.2	.....	.....	.....	.....

* Values are significantly different from the same measures for the group of farms included in the survey in 1962. Tests for statistical significance were conducted using the T test at the 95-percent probability level.

Farmers who left the sample averaged more off-farm work than those who remained. This phenomenon held true in the aggregate for farmers who left the sample as well as for any group that left the panel in any single year.

The Major Stratum of Producers

A large group of the 1963 panel participants (126 farmers) was not included in the four strata previously discussed (i.e., older farmers, those without dairy enterprises, those with substantial off-farm income, and those who left the panel before 1963). This remaining stratum of producers was considered to be the group most likely to make positive adjustments in dairy production. Regression analysis was used in an effort to determine what variables were related to changes in dairy cow numbers when the above groups were removed. The results are presented in equation 5 (see table 4). Note that equation 5 is not a strong estimating equation since only 23 percent of the variance in the sample could be explained by the independent variables used, and the equation did not pass the F test for reliability. Two of the independent variables that passed the T test for reliability at the 95-percent level were age of operator and number of feeder pigs purchased in 1958, both of which bore a negative relationship to changes in dairy cow numbers. A feeder pig enterprise was not found on many farms; the low value for the regression coefficient on this variable indicated its effect on the estimate was slight, though it did pass the T test.

Since the above attempt at prediction was unsuccessful, the 126 farmers were further sorted on the basis of changes they made in dairy herd size over the test period. It was hoped that some distinctive characteristics could be isolated for those producers who increased dairy production substantially and those who did not. The farmers were grouped into three strata: those who increased herd size by at least five cows; those who decreased herd size by at least five cows; and those who made changes involving fewer than five cows or who made no changes at all. Of course, this division could not have taken place at the beginning of the test period. It was a procedure introduced after the study had begun to determine which variables, if any, were related to positive (or negative) changes in herd size.

Farmers Who Made Negative Changes

The stratification disclosed that the group that reduced dairy cow numbers by more than five head was by far the smallest of the three groups. Consequently, those farmers over age 59 and those with off-farm income who made negative changes involving more than five cows were included to obtain a large enough sample to examine by regression analysis. The stratum of farmers who made large negative changes contained 28 farmers, 10 of whom were in the group with off-farm income and 8 of whom were in the group with operators age 60 and over.

The results of the regression analysis performed on the farms with negative changes in herd size are shown in equation 6 (see table 4). The variables used explained 81 percent of the variance in changes in dairy cow numbers, but the F test for reliability was not met at the 95-percent level.

Farmers Who Made Positive Changes

The group of farmers who realized dairy herd increases of more than five head from 1958 through 1962 contained few operators who were over age 59 or who had substantial off-farm income; these individuals were not included when the group was analyzed

by regression analysis. Results of this analysis are shown in equation 7 (see table 5). This equation was statistically significant at the 95-percent level and 80 percent of the variance in changes in dairy cow numbers was explained by the independent variables used. Several of the variables used exhibited a computed T greater than 2.1, the value necessary for significance at the 95-percent level. The largest of these values was for the ratio of cropland to labor.

The number of beef calves born in 1958 had a high positive effect on changes in dairy herd size, though the reason for this effect was not evident.

Number of sons in the family had a negative effect on changes in herd size, though this variable might have been expected to act similarly to the labor supply. An operator's longrun price expectation for hogs also had a negative effect on changes in herd size, suggesting possible competition between the hog and dairy enterprises.

An operator's willingness to borrow had a T value approximating the value needed for significance at the 95-percent level, but the small regression coefficient indicated that this variable had little effect on changes in dairy cow numbers.

Farmers Who Made Little or No Change

This third stratum contained 76 farmers, more than the preceding two added together, indicating that farmers in a large segment of the sample experienced little or no change in herd size during the test period. Since change in herd size was the dependent variable and since variance in this factor had not been highly realized in a large part of the sample, the regression equation calculated for this sample was not statistically significant. Only 33 percent of the variance in the dependent variable could be explained by the independent variables used (see equation 8, table 5).

Table 4. Regression equations with change in dairy cow numbers between 1958 and 1962 as the dependent variable

Equation number	5*		6†	
Number of independent variables	22		22	
Number of observations	126		28	
Table value of T	1.98		2.57	
Explained variance	23 percent		81 percent	
Computed F	1.42		0.99	
Table value of F	1.66		1.84	
Item	Regression coefficient	T value	Regression coefficient	T value
Constant term	—0.02	.....	—17.92	.....
Excess dairy capacity (cows)	0.0004	0.002	0.02	0.09
Gross income ($100)	0.02	0.88	—0.07	0.94
Tenure (owner, part owner, renter)	0.78	0.73	—2.72	0.61
Non-real estate assets ($100)	—0.007	0.70	0.07	2.34
Total assets ÷ total liabilities	0.0005	0.33	0.0008	0.15
Age of operator (years)	—1.15	2.86	0.19	0.14
Education (years)	—0.48	0.77	0.69	0.25
Off-farm income ($100)	—0.23	1.65	0.56	1.31
Dairy cow numbers, 1958 (head)	0.006	0.05	0.73	1.57
Longrun price expectation for milk (price relative)	0.06	0.04	0.87	0.16
Beef calves born in 1958 (head)	—0.11	0.86	0.46	1.09
Pigs farrowed in 1958 (litters)	0.07	0.85	0.16	0.49
Longrun price expectation for hogs (price relative)	0.43	0.33	1.87	0.61
Family labor supply (months)	0.09	0.57	0.06	0.15
Sons at home (number)	0.10	0.12	1.44	0.41
Longrun price expectation for beef (price relative)	—0.04	0.04	—0.45	0.14
Feeder pigs purchased, 1958 (head)	—0.03	2.02	0.04	1.38
Expected price for milk in 1961 ($)	—0.76	0.32	—2.21	0.48
Expected price for hogs in 1961 ($)	0.33	0.86	—0.14	0.14
Expected price for cattle in 1961 ($)	—0.07	0.32	0.63	1.82
Willingness to borrow ($100)	—0.003	0.49	0.007	0.34
Cropland ÷ labor	0.40	1.69	0.82	0.86

* Includes farms with operators less than 60 years of age and with less than $250 off-farm income and with at least some dairy cows in 1958.
† Includes those farms where dairy cow numbers were decreased by at least five cows between 1958 and 1962.

Table 5. Regression equations with change in dairy cow numbers between 1958 and 1962 as the dependent variable

Equation number	7*	8†
Number of independent variables	22	22
Number of observations	41	76
Table value of T	2.10	2.02
Explained variance	80 percent	33 percent
Computed T	3.35	1.16
Table value of F	2.19	1.84
Stratum	*	†

Item	Regression coefficient	T value	Regression coefficient	T value
Constant term	0.91	.....	—11.80	.....
Excess dairy capacity (cows)	0.40	1.38	0.04	0.43
Gross income ($100)	0.04	1.12	0.01	0.84
Tenure (owner, part owner, renter)	—1.20	0.98	0.53	1.19
Non-real estate assets ($100)	—0.02	1.21	—0.004	0.92
Total assets ÷ total liabilities	—0.001	0.53	—0.0002	0.32
Age of operator (years)	—0.44	0.52	—0.22	1.43
Education (years)	—0.04	0.04	—0.15	0.56
Off-farm income ($100)	0.18	0.77	—0.07	1.17
Dairy cow numbers, 1958 (head)	0.29	1.54	—0.03	0.73
Longrun price expectation for milk (price relative)	—1.17	0.59	0.83	1.32
Beef calves born in 1958 (head)	1.09	3.59	—0.01	0.21
Pigs farrowed in 1958 (litters)	—0.06	0.70	—0.03	0.79
Longrun price expectation for hogs (price relative)	—4.03	2.65	1.06	2.04
Family labor supply (months)	0.05	0.31	—0.03	0.41
Sons at home (number)	—3.21	3.49	0.68	1.36
Longrun price expectation for beef (price relative)	—2.48	1.34	0.23	0.47
Feeder pigs purchased, 1958 (head)	0.00	0.00	—0.01	1.70
Expected price for milk in 1961 ($)	2.87	1.02	3.32	2.47
Expected price for hogs in 1961 ($)	—0.51	0.99	—0.11	0.60
Expected price for cattle in 1961 ($)	0.66	1.04	—0.02	0.02
Willingness to borrow ($100)	0.0002	2.07	0.002	0.69
Cropland ÷ labor	1.37	4.37	0.002	0.02

* Includes those farms with operators less than 60 years of age with less than $250 of off-farm income in 1958 who increased dairy cow numbers by at least five cows between 1958 and 1962.

† Includes those farms with operators less than 60 years of age with less than $250 of off-farm income in 1958 who made changes in cow numbers (positive or negative) involving fewer than five head between 1958 and 1962.

Aggregation of Producer Panel Data

Preceding analyses and discussion have focused on a diagnostic evaluation of producer panel data. The following section represents an attempt to utilize these and related findings to predict changes in dairy cow numbers in the geographical area represented by the producer panel sample.

Changes in Dairy Cow Numbers

In 1958, members of the producer panel had 4,951 dairy cows on 327 farms. The panel was drawn to be representative of the main dairy belt of Minnesota. The area included 35 counties in which farmers kept an estimated 875,000 dairy cows in 1958 and 947,000 cows in 1962.[12] These estimates were exogenous to the producer panel data and represented an increase of about 8 percent in cow numbers over the test period. It was against this change in dairy cow numbers that estimates from the producer panel were compared and evaluated.

On the basis of findings shown in earlier sections

[12] *Minnesota Agricultural Statistics*. Minn. State-Federal Crop and Livestock Rpt. Serv. 1959. pp. 56-57. Ibid. 1962. pp. 46-47. It should be remembered that since these data also are based on a sample of respondents, they too are subject to sample and reporting error.

of this report, producer panel members were stratified into two major groups, those who had no dairy cows in 1958 and those who had one or more. The bases for this stratification were: (1) the absence of new dairy enterprises during the test period and (2) the indiscernibility of other stratification schemes that were consistently reliable estimators of producer changes.

All variables observed in 1958 were included in an estimate of dairy cow number changes on the 180 farms with dairy cows and for which data were available for all 4 survey years. The resulting equation proved unreliable and is not reported here.

In equation 9 (table 6), some variables were removed in an attempt to improve predictive ability. The variables removed were either not well expressed numerically or had only a very slight effect on estimates of change in dairy cow numbers. In this case, an estimating equation reliable at the 95-percent level was obtained. Age of operator and shortrun price expectation for milk were variables that had a significant effect on the dependent variable at the 95-percent level.

Equation 10 (table 6) contains the six independent variables that appeared to have the most value in predicting changes in dairy herd size. T values ranged from 1.39 to 3.32.

The procedure used in estimating aggregate changes in dairy cow numbers for the study area was: (1) to apply equation 10 to all farms with dairy cows in 1958 and (2) to assume there was no milk production on farms with no cows in 1958. Using this procedure, a predicted increase of 276 dairy cows on producer panel farms from 1958 to 1962 was indicated. The panel contained 0.55 percent of the farmers in the 35-county test area in 1958. Using this as a samp-

Table 6. Regression equations with change in dairy cow numbers between 1958 and 1962 as the dependent variable

Equation number	9*		10*	
Number of independent variables	23		6	
Number of observations	180		180	
Table value of T	1.96		1.96	
Explained variance	21 percent		15 percent	
Computed F	1.82		5.17	
Table value of F	1.61		2.175	
Item	Regression coefficient	T value	Regression coefficient	T value
Constant term	—13.36	.....	—9.91	.....
Excess dairy capacity (cows)	—0.06	0.48	.....	.....
Gross income ($100)	—0.0002	0.01	.....	.....
Cropland (acres)	0.003	0.10	.....	.....
Net worth ($100)	—0.002	0.18	.....	.....
Real estate assets ($100)	—0.001	0.12	.....	.....
Non-real estate assets ($100)	0.007	0.54	.....	.....
Total assets ÷ total liabilities	0.005	0.14	.....	.....
Real estate assets ÷ real estate liabilities	—0.003	0.11	.....	.....
Non-real estate assets ÷ non-real estate liabilities	0.005	0.32	.....	.....
Age of operator (years)	—0.83	2.39	—0.83	3.32
Off-farm income ($100)	—0.05	0.69	—0.12	1.58
Dairy cow numbers, 1958 (head)	—0.17	1.67	.....	.....
Beef calves born in 1958 (head)	—0.08	0.48	.....	.....
Feeder cattle in 1958 (head)	—0.02	0.20	.....	.....
Pigs farrowed in 1958 (litters)	0.05	0.64	.....	.....
Longrun price expectation for hogs ($)	.....	.....	1.34	1.57
Family labor supply (months)	0.19	0.84	.....	.....
Sons at home (number)	.....	.....	0.77	1.39
Time operator intends to farm (years)	0.006	0.008	.....	.....
Feeder pigs purchased, 1958 (head)	—0.02	1.50	.....	.....
Expected price for milk in 1961 ($)	3.12	2.72	.....	.....
Expected price for hogs in 1961 ($)	0.031	0.18	.....	.....
Expected price for cattle in 1961 ($)	0.09	1.15	0.28	1.66
Willingness to borrow ($100)	—0.002	0.47	.....	.....
Cropland ÷ labor	0.42	0.86	0.31	2.22

* All farms with dairy cows whose operators contributed continuous data for all 4 survey years are included in the stratum for which equations 9-12 inclusive were estimated.

Table 7. Regression equations with total dairy cow numbers on individual producer panel farms in 1962 as the dependent variable

	11*	12*
Equation number		
Number of independent variables	14	6
Number of observations	180	180
Table value of T	1.96	1.96
Explained variance	72 percent	71 percent
Computed F	30.65	69.34
Table value of F	1.67	2.10

Item	Regression coefficient	T value	Regression coefficient	T value
Constant term	—5.02	.....	—3.34	.....
Excess dairy capacity (cows)	0.03	0.23	.....	.....
Cropland (acres)	—0.007	0.30	.....	.....
Total assets ÷ total liabilities	0.008	0.59	.....	.....
Age of operator (years)	—0.99	3.53	—0.96	3.79
Off-farm income ($100)	—0.11	1.50	—0.15	1.96
Dairy cow numbers, 1958 (head)	0.91	11.81	0.97	1.72
Longrun price expectation for milk (price relative)	—1.92	1.79	—1.53	1.52
Family labor supply (months)	0.21	1.02	.....	.....
Sons at home (number)	0.91	1.47	1.19	2.10
Longrun price expectation for beef (price relative)	—0.99	1.18	.....	.....
Expected price for milk in 1961 ($)	—0.66	—0.36	.....	.....
Expected price for cattle in 1961 ($)	0.37	2.12	0.35	2.02
Willingness to borrow ($100)	—0.002	0.49	.....	.....
Cropland ÷ labor	0.56	1.25	.....	.....

* All farms with dairy cows whose operators contributed continuous data for all 4 survey years are included in the stratum for which equations 9-12 inclusive were estimated.

ling factor for expansion, the predicted increase in cow numbers was 50,400.[13] The actual increase in cow numbers for the test area was 72,400.[14] Though the estimate was somewhat lower than the actual increase, it was well within the large confidence interval associated with the estimate. However, the large error of estimate made any prediction a tenuous one.

Predicting Total Cow Numbers in 1962

As demonstrated earlier, the dependent variable, changes in dairy cow numbers from 1958 to 1962, was of very small magnitude (for both positive and negative changes) for many farms in the sample population. Consequently, it was not suprising that the alternative estimating procedures used did not result in statistically adequate predictions of herd size changes.

When the absolute value of dairy herd size in 1962 was used as the dependent variable, this dependent variable had greater variance from the mean than was the case when changes in dairy cow numbers was the dependent variable.

The results of regression analysis to estimate total cow numbers in 1962 are presented in table 7. Equation 11 was used to screen and select the set of variables that appeared to be most useful in estimating total cow numbers; equation 12 was used in making this estimate. Equation 12 was applied to all farms with dairy cows in 1958 to estimate dairy cow numbers in the sample area in 1962.

Seventy-one percent of the variance in cow numbers in equation 12 was associated with variance in the six independent variables included. It was estimated that panel farmers would have 5,564 dairy cows in 1962. Aggregating this sample resulted in an estimate of 1,016,070[15] dairy cows in the 35-county test area by 1962, compared to the reported number of 947,400 cows.[16]

[13] Because the standard error of estimate used for predicting changes in cow numbers (equation 10) was about three times as large as the predicted change, the standard error associated with the predicted increase is of the same proportion.

[14] *Minnesota Agricultural Statistics.* Minn. State-Federal Crop and Livestock Rpt. Serv. 1962. pp. 46-47.

[15] Since this estimate was subject to a standard error of estimate of ± 359,000 cows, the reported number (947,400) was well within the confidence limits of the predicted number of cows.

[16] *Minnesota Agricultural Statistics.* op. cit. 1962.

Evaluation of Procedure and Results

The major objective of this study and of the analyses presented here was to devise a procedure for estimating changes in dairy production over an intermediate period of 4 to 5 years, a planning period important both to producers and to policymakers. The study was undertaken because of the shortcomings of conventional time-series and profit-maximization analyses to accurately predict such changes. The intermediate time period was a critical one researchwise because (1) cow numbers, production per cow, and near-term milk, beef, and feed prices are good variables for predicting only short-term (1 year or less) changes in milk production, and (2) production in a length of run longer than 5 years probably is influenced substantially by technology and other variables not determinable so far in advance. It was an assumption of the analyses that if changes in cow numbers could be reliably determined, independently determined trends in production per cow could be applied to predict changes in milk production.

Prediction of intermediate length of run changes in dairy cow numbers from the producer panel data was somewhat less than completely successful. Yet some insight into the use of the procedure was found.

Significant Findings

The prediction equations formulated in the preceding analyses were in general either (1) unique to the group of farms represented and the time period considered or (2) too inadequately reliable statistically to be used as the sole basis for estimating future changes in dairy cow numbers in the sample area.

In the diagnostic exploration of variables, however, a number of variables which at one time or another appeared significantly related statistically to changes in farm work units and/or changes in dairy cow numbers were encountered. This group of variables (the first three of which are somewhat interdependent) and their influence on production adjustments were:

(1) Dairy Herd Size in 1958. The larger the initial herd size was in 1958, the larger was the increase in production through 1962. In other words, large enterprises got even larger during the study period. A large cropland acreage usually accompanied increases in dairy herd size.

(2) Absence of a Dairy Enterprise. Virtually no farmers who did not have a dairy enterprise in 1958 were planning to or actually did add one during the study period. So 1962 milk production was almost entirely that of farmers who were in the dairy business in 1958.

(3) Excess Dairy Building Capacity. Unused dairy capacity in 1958 was negatively related to changes in dairy cow numbers from 1958 through 1962. Operators of farms with unused capacity apparently already had decided to curtail or eliminate the dairy enterprise and were willing to let facilities stand idle.

(4) Off-farm Employment. Many farmers engaged in or planning off-farm employment already had reduced or planned to reduce their livestock enterprises, particularly dairy, by the time the study began.

(5) Age of Operator. As a farmer's age increased, rate of expansion on his farm decreased. This negative relationship was true over the entire age range of farmers studied. Few farmers past age 50 planned or actually made any expansion in dairy cow numbers from 1958 through 1962. Generally, they planned to curtail cow numbers to ease their workloads.

Other variables, such as relative longrun price expectations for milk and animal products, asset-liability ratios, and willingness of a farm operator to borrow money, were sporadically significant, but their influence was not adequately consistent to provide a general basis for assessing production changes.

Additional data acquired on price and production expectations and personal preference of farmers for livestock enterprises did not provide reliable relationships to changes in cow numbers.

A finding of positive importance was that a large proportion of the producers changed cow numbers negligibly during the 4-5 year study period. Identification of those producers who exhibit a high degree of stability of production is important for two key reasons. First, it establishes the source and quantity of a major component of future supplies. Secondly, it permits the study of change to focus on those producers or producer groups most likely to change their production level.

Assessment of the Procedure

As indicated at the outset of this report, it was intended that the producer panel be appraised both as an independent estimator of supply and as a supplement to other procedures. Results suggest that it might best be used in the latter capacity. It appears that the variables cited above might be utilized better in one of the following procedures:

1. A General "Comparative Statics" Type of

SUPPLY ASSESSMENT. Such an assessment at various points in time could utilize stratification of farms on the basis of the variables cited above and provide evaluation at specific points in time of the effects of changes in the size and proportion of resulting strata on milk supplies.

2. A CONVENTIONAL TIME-SERIES ANALYSIS where data on the key variables would be reported on as broad a population basis as are other variables traditionally included in such an analysis.

3. A NORMATIVE ANALYSIS where information on this set of variables would be used to establish adjustment alternatives and restraints on maximum or minimum adjustments considered to be feasible.[17] This alternative is based on the hypothesis that a price-profit basis for projecting milk supplies would be adequately accurate only if this analysis was tempered by proper stratification of producer groups and if nonresponsive producer groups could be delineated. Also, some empirical basis would be needed for discounting adjustment rates and levels for lags associated with time, risk, and tradition considerations.

A comparison of change in cow numbers for the study area was made via three methods: (1) projections from the producer panel study, (2) a normative linear programming analysis using the same adjustment period base, and (3) estimates made by the Minnesota State-Federal Crop and Livestock Reporting Service.

A comparison between the first and last of these sources can be found on page 16 of this report. Compared to the linear programming results at the most comparable set of milk and livestock prices assumed for the analysis, the producer panel estimate of cow numbers is substantially (some 30 percent) lower and much closer to the enumerative, sample-based estimate made by the Crop and Livestock Reporting Service. Inspection of the results showed that one major reason for the difference was the allowance in the normative analysis for establishment of dairy enterprises on farms with no dairy enterprise in 1958. This phenomenon did not occur in actual practice, but did occur in some of the programming results. Also, farmers were permitted the alternative of dairy herd expansion regardless of their age, though advanced age deterred such expansion for many farmers. Another important difference arose because of the absence of off-farm employment alternatives in the normative analysis. This alternative turned out to be one that was exercised by a number of farmers in the producer panel.

It might be concluded, therefore, that a continuous and broad report of age distribution of producers, changes in the incidence of off-farm employment, number of farms with dairy enterprises, and of the size distribution of dairy herds would be of help in predicting future milk supplies. This information would facilitate the stratification useful either for a time-series analysis or for a normative analysis for predictive purposes.

It also might be concluded that a statistical formulation of supply based on data acquired from a limited sample of producers will leave substantial unexplained variance for a number of reasons. Of particular importance are the limited variance in production on many farms (despite variance in factors affecting production on others), competition from off-farm employment opportunities, and uncontrolled personal or environmental factors.

[17] The latter procedure currently is being used on a gross statistical basis by a team of researchers in the Economic Research Service of the U.S. Department of Agriculture. For examples of this procedure, see the works of Richard Day and Neill Schaller cited earlier in this report.