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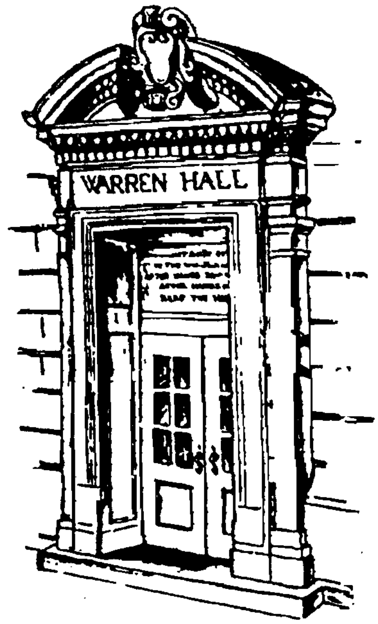

Staff Paper

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DO NEW YORK DAIRY FARMERS MAXIMIZE PROFITS?

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Abstract

Varian's Weak Axiom of Profit Maximization was used to determine whether each of 49 New York dairy farms displayed behavior consistent with profit maximization. The results indicate that most were only moderately successful in maximizing profits. Characteristics of the farms did not strongly differentiate those that were better at maximizing profits.

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Do New York Dairy Farmers Maximize Profits?

The ability of farmers to maximize profits is of paramount importance in applied economic analysis. In these analyses, it is typically assumed that farmers not only try to maximize profits, but that they are successful. This is the underlying assumption in derived output supply and input demand functions which are used in price and welfare analysis. Deviations from successful profit maximization can bias empirical results.

Do farmers attempt to maximize profits and are they successful? With perfect information, most economists would accept profit maximization as an important, if not the primary, objective of most farmers. In a nonperfect world with uncertainty, Simon, among others, has argued for alternative theories, which generally fall under the concept of bounded rationality (Stiglitz). Farmers are rational, but since they do not have perfect information their decision results deviate from the profit maximizing paradigm.

The purpose of this research is to determine how close a group of New York dairy farms comes to displaying profit maximization behavior. This will be tested using the nonparametric approach to production analysis championed by Varian. If these farmers do not display behavior consistent with profit maximization, as determined by their selection of input and output quantities, it can be concluded that either they are not very successful at maximizing profits or that profit maximization is not their objective. Recent applications of nonparametric production analysis in agriculture include work by Fawson and Shumway, Chavas and Cox. Those efforts used aggregated regional or U.S. data, rather than firm-level data as used here.

Nonparametric Production Theory

Much of the recent interest and development in the nonparametric approach to production analysis is attributed to Varian (1984), but the initial effort was formalized by Afriat. In that work, they specify what empirical evidence would support the hypotheses of profit maximization behavior.

Define the netput vector for period i as $Y^i = (y_1^i, \ldots, y_n^i)$, $i=1, \ldots, m$, where y_k^i is an output if $y_k^i > 0$ and an input if $y_k^i \leq 0$. An associated price vector is defined as $P^i = (\rho_1^i, \ldots, \rho_n^i)$, where each $\rho_k^i \geq 0$ denotes the price associated with each respective element of Y^i.

If we observe a set of price vectors, ρ^t and netput vectors, y^t, for $t=1, \ldots, T$, then the hypothesis of period-by-period profit maximization can be tested. A necessary condition for these data to be consistent with profit maximization is that $\rho^t y^t \geq \rho^t y^s$, for all s and t.

This inequality states that the profit using the price and netput vectors from any given year must be at least as great as using the price vector from that given year and the netput vector from a different year. It tests whether given the price vector for a given year the firm was successful in selecting the input and output quantities that maximized profits. Varian (1984) refers to this as the Weak Axiom of Profit Maximization (WAPM). It is a test that imposes no functional form on the data.

Although the data used can be cross-sectional, with firms operating in different markets, and thus facing different price vectors and choosing different netput vectors, most analyses utilize time series data. The difficulty with using time series data is that technological change is a factor. As Varian (1990) states, if most violations of WAPM indicate that the firm would be better off at time t making a choice that was made at some later date, then technological progress or learning-by-doing may be involved; the more profitable choices were not made at time t because they were not available. However, if we go backwards and find those netput vectors are more profitable, then we must conclude that the firm did not maximize profits at time t.

Varian (1990) indicates that his WAPM is a "sharp" test in that either the data pass the test exactly, or they do not pass. The test does not allow for an "error term." It may be that in profit maximization, as in horseshoes and grenade throwing, "close" may be good enough. Thus, Varian (1990) proposes a goodness-of-fit measure that measures the percent of extra profit the firm could have made at the base price vector if an alternative netput vector had been chosen rather than the base netput vector.

Empirical Application

Varian's Weak Axiom of Profit Maximization (WAPM) was tested individually for each of 49 New York dairy farms over an 11-year period. These farms participated in the New York Dairy Farm Business Summary for each year from 1977 through 1987. Therefore, for a price vector in any given year there were ten alternative netput vectors to test WAPM. Since each of the 11 years was used as a moving base, a total of 110 tests for each firm was available, with half of the total netput vectors from years previous to the 11 base years and half from years after the base years.

These data include complete receipt and expenditure data for each farm but very limited price data. Therefore, price data were taken from annual published price indices for New York dairy farms (New York Agricultural Statistics Service, 1977=100). Price indices are available for feed, purchased animals, fuel and energy, fertilizer, seed, machinery, building and fencing supplies, farm services and rent, agricultural chemicals, farm wage rates, property taxes, and milk sold.

The expenditure categories from the farm data were more extensive than the price indices, and it was necessary to combine selected items as shown in Table 1. Many of the business summary expenditure's assignment and aggregation are obvious, such as dairy feed purchased and other feed purchased under the price index of feed. Others are less apparent, but placement was in the closest related price index. Aggregation of the various expense items into a single expenditure was done using a geometric average with individual firm cost shares for each input as weights. After aggregation, expenditures and milk receipts were converted into quantities by dividing by annual price indices. These quantities then became the netput vector for each firm for that year.

Results

Over the 11 years, there were a total of 55 years behind the moving base year and 55 years ahead. There was not a single farm where every past year was less profitable than the base year using base year prices and past year quantities. The best any farm did was 13 percent. The average for the 49 farms was 36.9 percent (Table 2).

Table 1. Data Categories.

Variable	Price index	Business summary expenditures aggregated
Feed	Purchased feed	Dairy feed Other feed
Animals	Purchased animals	Livestock purchases Interest on livestock (3%) Other livestock expenses
Fuel	Fuel and energy	Fuel Electricity
Fertilizer	Fertilizer	Fertilizer
Seed	Seed	Seed
Machinery	Machinery	Machinery depreciation (10%) Interest on machinery (3%) Other machinery expenses Miscellaneous expenses
Buildings	Building and fencing supplies	Building depreciation Interest on real estate (3%) Building and fence repair
Services	Farm services and rent	Breeding fees Veterinarian expenses Marketing expenses Telephone Insurance Machinery hire expense Cash rent
Chemicals	Chemicals	Spray and other crop expenses
Wages	Wage rates	Value of operators' labor & mngmt. Value of unpaid family labor Hired labor
Taxes	Property taxes	Real estate taxes
Milk	Milk	Milk sales Change in feed and crop inventory Dairy cattle sales Other livestock sales Miscellaneous crop sales Machinery rental Government payments Miscellaneous receipts

Table 2. Percent of Years Netput Vector Other than Base Year Netput More Profitable Using Base Year Prices for 49 New York Dairy Farms.

	Past netput more profitable at base year prices		Future netput more profitable at base year prices
		--- Percent of Years ---	
Average	36.9		61.8
Std. deviation	12.8		12.6
Maximum	62		85
Minimum	13		38
Correlation		-.98	

Of the 55 years ahead of the base year, on average, over the 49 farms, 61.8 percent of those years it would have been more profitable using those future years' quantities, given base year prices. The minimum for any farm was 38 percent. Thirty-seven of the 49 firms had a larger percentage of successor than prior years more profitable than the base years, supporting Varian's assertion that technological change or learning should be exhibited. With any price vector, firms appear to be more profitable each succeeding year. The fact that the correlation of the past and future year's profitability percentage was almost perfectly negative (-.98) implies technological change and learning are significant factors. An obvious thought would be to try to correct or adjust for technological change. Unfortunately, the procedures to derive a total factor productivity measure assumes successful profit maximizing behavior, which is being tested. Any single-input productivity measure, such as production per cow, is a biased measure of productivity.

Because of technological change, one would expect that more future than past years would be more profitable than any base year. However, these farm data are subject to stochastic events and data measurement error. There were some previous years when crops were better and milk yield was greater even under nonregressive technological change.

Table 3 shows the percent of the 49 farms where the base year netput was less profitable than other year netputs at base year prices. Given nonregressive technological change and profit maximization but stochastic events, one would expect the percentage of farms to increase as the base year is approached, and continue to increase after the base year. This trend should be populated with stochastic spikes. This is illustrated in a plot (not shown) of the data in Table 3. The general trend of that plot is upward, with obvious stochastic events such as 1977, the first point of each line, an upward event, and 1987, the last point of each line, a downward event.

What is missing yet from the results is any concept of how close these farms came to maximizing profit. What has been shown is whether the profit has been greater or less than the base year. Table 4 corrects for that by showing the average deviations in net profit from the base year for the 49 farms. These could be converted into percentage deviations, as Varian suggests, using the base year profits shown on the bottom of the table. In interpreting these profits, it is important to realize that the opportunity costs of the operator's labor, management, and capital are included as inputs. Also, the prices used are indices (1977=100), so profits are real values. As can be seen, most of the deviations in prior years are negative and increasingly so the further they are from the base year. In contrast, most of the deviations in the forward years are positive and increasingly so the further they are from the base year. This further supports Varian's claim that the data are expected to show technological change and learning.

Table 3. Percent of 49 New York Dairy Farms Where Base Year Netput Less Profitable Than Other Year Netputs at Base Year Prices.

Quantities of inputs and outputs	Prices of Inputs and Outputs										
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1977	0	65	71	55	39	49	35	41	39	35	39
1978	37	0	45	31	27	29	33	22	20	16	27
1979	27	55	0	31	29	29	22	24	18	10	27
1980	41	69	69	0	35	49	33	29	29	18	35
1981	57	73	73	65	0	53	49	45	39	29	45
1982	49	69	71	53	43	0	41	43	37	22	41
1983	65	69	78	65	49	59	0	51	53	31	45
1984	61	76	76	67	49	59	49	0	45	27	47
1985	61	78	80	67	55	63	47	53	0	39	53
1986	67	86	88	71	69	73	65	67	61	0	59
1987	61	76	76	63	53	59	53	49	47	39	0

Table 4. Deviations in Net Profit from Base Year Using Various Year Netputs and Prices, Mean Values for 49 New York Dairy Farms.

Quantities of inputs and outputs	Prices of Inputs and Outputs										
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1977	0	9782	11661	4613	-899	228	-8697	-5403	-10013	-13720	-5126
1978	-9632	0	1004	-7313	-13890	-12735	-22055	-18943	-22607	-26059	-17238
1979	-11206	-1374	0	-8604	-15448	-14122	-24062	-21303	-24837	-28660	-19720
1980	-5334	4930	7586	0	-6389	-5707	-15570	-13063	-17443	-21345	-12374
1981	-825	9743	13031	5911	0	228	9408	-7115	-12450	-16442	-7598
1982	-528	9814	12379	4847	-1072	0	-9810	-7293	-12023	-16102	-7279
1983	6449	17273	20726	13992	8807	9712	0	2389	-3124	-7368	1494
1984	4906	15465	18386	11282	6064	7120	-2507	0	-5494	-9704	-942
1985	8772	19918	23196	16247	11187	12680	2717	5165	0	-4225	4842
1986	11526	23025	26300	19532	14652	16596	6371	8892	4206	0	9349
1987	4077	15617	18378	10758	4949	7197	-3903	-1605	-5327	-9642	0
--- Computed Average Net Profits Each Year ---											
	8600	765	-723	3377	7751	8496	13343	7053	10363	11868	3382

These accounting data were obtained from the New York Dairy Farm Business Summary which also collects characteristic data on these farms and the farmers who operate them. Although previous attempts to relate these characteristics to firm profitability or efficiency have not been successful, an attempt is made here to relate ability to maximize profits to farm and farmer characteristics (Tauer and Belbase; Tauer). Specifically, a logit model was estimated where the dependent variable was the percent of years the past netput was more profitable. A model using future netputs gave similar results and is not reported. The model estimated, using ordinary least squares, was:

$$\ln\left(\frac{P}{1-P}\right) = \alpha + \beta X$$

where P is the percent of years the past netput was more profitable (column 2, Table 2), and X is the vector of characteristics (Table 5).

The dependent variable was generated from data over the years 1977 through 1987. Over that eleven-year period, many of the explanatory variables changed, some routinely, such as age of the operator, others, such as record type, changed nonroutinely. Thus, the values of the explanatory variables for the mid year of the data set were used (1982). The mean values are shown in Table 5.

The explanatory variables as a group only explained 16 percent of the variability in the dependent variable and only three variables were statistically significant: membership in the Dairy Herd Improvement Association (DHIA), the type of milking system, and the record-keeping system. The sign on the DHIA variable is negative, which implies that participation in that organization reduces the farmer's ability to choose

Table 5. Logit Regression of Percent Years Past Netput Was More Profitable.

Variable (1982)	Definition	Mean	Coefficient	t-Stat.
Constant			.48	.68
Age (first operator)	Years	49	-.02	-1.35
Business type	0 for sole proprietor 1 for other	.29	-.11	-.59
Dairy Herd Improvement Associations	0 for nonmember 1 for member	.84	-.68	-2.91
Education (first operator)	0 high school or less 1 post high school	.53	-.20	-1.08
Milking system	0 for stanchion 1 for parlor	.59	.39	2.25
Record type	0 for account book 1 for computer, other	.63	.37	2.20

Adjusted $R^2 = .16$.
F-statistic = 2.57.
Durbin-Watson = 1.95.
n = 49.

profit-maximizing inputs. This is perplexing since the purpose of that organization is to help farmers manage their farms. However, all but 8 of the 49 farms were members, so this result may be spurious. Also, this is a selective group, and membership in DHIA may not be necessary for good management for them. However, Tauer, using all 395 New York Business Summary Farms for 1990, found DHIA farms were also less efficient.

The farms with parlor systems appear to be better at selecting profit-maximizing inputs. The input mix for parlors is slightly different from those for stanchions, less labor and more capital, for instance, and it may be easier to select these optimal levels. The existence of a milking parlor may also be a proxy for managerial skills or the information system of the farm. This might appear to be the case because business records kept with a computer or other nontraditional format (recordbook) allowed farms to better maximize profits. Tauer and Belbase also noticed this, but stated that using alternative record systems other than an account book may mean more expenses are being correctly recorded rather than lost, biasing the results. It is interesting that neither age (experience) nor formal education had an impact on the farmer's ability to maximize profits, nor does operating as a multiple-owner business with more than one decision-maker.

Conclusions

Varian's Weak Axiom of Profit Maximization (WAPM) was utilized to determine whether a group of New York dairy farms displayed behavior consistent with profit maximization, as determined by their selection of input and output quantities. Although confronted with technological change, the results from these data of 49 dairy farmers indicate that they are only moderately successful in maximizing profits. As expected, some are better than others at profit maximization. The available characteristics of these farms, such as age and education, did not differentiate among those that are better at profit maximization. The few variables that were statistically significant were only weakly so, questioning the validity of their impact.

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