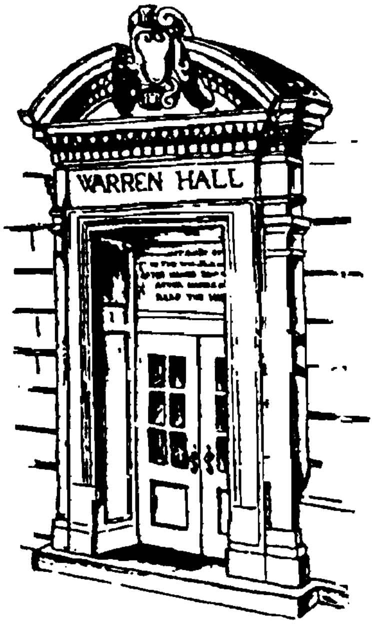

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SUCCESS IN MAXIMIZING PROFITS AND REASONS FOR PROFIT DEVIATION ON DAIRY FARMS

by

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Success in Maximizing Profits and Reasons for Profit Deviation on Dairy Farms

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Abstract

The Weak Axiom of Profit Maximization (WAPM) was used to test how successful each of 70 individual New York State dairy farms was in maximizing profits using nine years of data. The netput vectors were corrected for technological change using nonparametric indices that do not require the assumption of profit maximization nor any functional form for the underlying technology. These technology indices are consistent with the nonparametric assumptions used in the WAPM tests. The average negative WAPM deviation over the 70 farms was .20, indicating that on average these farms could have selected available netput vectors that would have increased profits by 20 percent of total receipts. A tobit regression showed that the available characteristics on these farms explained very little of the variability in their abilities to select the best netput vectors. Yet, increased age and additional education increased the ability to select the best netput vector.

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Success in Maximizing Profits and Reasons for Profit Deviation on Dairy Farms

I. Introduction

Profit maximization behavior is the paradigm taught in economic principal courses and used in much of economic research. Criticisms of this approach have centered on whether the firm's goal is to optimize profits and whether the firm has satisfactory knowledge of the production possibility set to choose optimal points from that set (Winter, 1991). Simon has suggested that a more appropriate behavior concept is "satisfying." Firms are rational, but they do not have perfect information that allows them to select optimal plans. Instead, they select plans that are satisfactory. Williamson and Winter further extend this notion into an evolutionary concept, and argue that firms do not search for alternative plans until current plans are clearly known as suboptimal, and then firms explore for alternatives that are not necessarily optimal, only better than current plans. Risk aversion or credit and other constraints may also lead firms to maximize some alternative goal other than unconstrained profit maximization.

Based upon the work by Afriat (1972) and Varian (1984), a number of researchers have used nonparametric, revealed preference procedures to test whether observed behavior is consistent with profit maximization or cost minimization behavior. Efforts in agriculture, using aggregated regional data, include those by Chavas and Cox (1988); Fawson and Shumway (1988); and Lim and Shumway (1992). Tests using individual agricultural firm data include Featherstone *et al.* (1995); Ray and Bhardra (1993); and Tauer (1995). Findings have been mixed, although Featherstone *et al.* (1995) and Tauer (1995) conclude that groups of U.S. farmers come much closer to minimizing costs than to maximizing profits. Although that is expected since cost minimization is required for profit maximization, the extent of the discrepancy in Featherstone *et al.* was significant. Their study used farmers from Kansas where both output quantities and output prices were more variable relative to the dairy farmers from

Tauer (1995). Cost minimization, but not profit maximization, is consistent with maximizing expected utility of wealth of a firm facing output price uncertainty, but even cost minimization is not consistent when production is uncertain (Batra and Ullah, 1974; Pope and Chavas, 1994). Profit maximization is the criterion used to generate agricultural market supply curves, and further tests of profit maximization behavior are warranted.

The purpose of this paper is to extend the work of Tauer (1995) on dairy farms by specifying and measuring profit deviations from the Weak Axiom of Profit Maximization (WAPM) as a censored variable, and to explain why some farmers are better at selecting inputs that will maximize profits. Data from 70 individual dairy farms over nine years will be used. To correct for technological changes over that period, Malmquist nonparametric indices will be used. These do not require the assumption of profit maximization, nor any functional form for the underlying technology, and thus are consistent with the assumptions used in WAPM tests. WAPM tests are specified as a censored variable, and the maximum negative deviation of actual profit from the most profitable alternative feasible netput vector is computed. Tobit regression will be used to relate successful profit maximization to characteristics of farms.

II. Weak Axiom of Profit Maximization (WAPM) and Malmquist Indices

The WAPM test is $V_i = P_o Y_o - P_o Y_i$, where the P vector is prices of the outputs and inputs, all positive, and the Y vector is the netput vector comprised of k members, either for the base year o, or the comparison year i, where y_{ik} is an output if $y_{ik} > 0$ and an input if $y_{ik} < 0$ (Varian, 1984). The technology set defined by Y is constant, nonempty, closed, bounded from above, and convex with free disposal. A negative value for V_i indicates that an alternative netput was more profitable than the base year netput at base year prices. This means that the firm could have made a larger profit, given the prices in a given year, if it had used the inputs and produced the outputs that it did during an alternative year. It implies that the firm did not maximize profits in a given year, since at least one alternative netput vector would have been more profitable to use that year. If V_i is positive for all i, then the base year netput was the most profitable netput to use of the netput vectors observed. Yet, nonobserved netput vectors that would have increased profit may still exist.

If a firm selected the correct netput in a given year such that V_i is positive for all i, it is not important how much more profitable that correct selection was compared to an alternative year, since the alternative year netput was suboptimal. What is important is if V_i is negative, then how far the firm was from a more profitable netput vector. These criteria are summarized by the following specification for a censored variable T_i that measures the indexed size of profit deviation:

$$\text{(1)} \qquad \text{If} \quad V_i = -(P_0Y_0 - P_0Y_i)/R_0 \geq 0, \quad \text{then } T_i = V_i$$

$$\text{If} \quad V_i = -(P_0Y_0 - P_0Y_i)/R_0 \leq 0, \quad \text{then } T_i = 0, \text{ for } i = 1, \ldots, n$$

where n is the number of netput vectors (years) and R_o is the total receipts of the base year (P_oY_o). The purpose of R_o is to index the WAPM tests based upon the size of the receipts in a given year. This allows interfirm comparison of firms of different sizes. It also measures the relative size deviation from profit maximization, whereas Varian's basic WAPM test only measures whether a specific netput vector chosen in the base year was the most profitable. Here revenue is used as the denominator rather than profit as suggested by Varian (1990), since profit may be close to zero, or even negative, producing significant swings in the statistic.

The next step is to find the maximum T_i value for each base year for each farm,

$$\text{(2)} \qquad \text{Max } T_i = \text{Max } \{T_i\}, \quad \text{for } i=1,\ldots,n.$$

This measures how far actual profit in the base year was from the most profitable netput vector.

An underlying assumption for the WAPM test is that the various netput vectors are selected from a constant technology set. A firm's failure to select the best netput vector implies that the firm is selecting netput vectors in the interior of the technology set (technical inefficiency), or on the boundary of the technology set, but not at the point necessary to maximize profits given prices (allocative inefficiency). Since the empirical draws for the netput vectors are the inputs and outputs that a specific firm actually used in any number of given years, the assumption of a constant technology set is typically violated because of technological change. Thus, it is necessary to adjust or correct for technology change in the WAPM test. Most adjustment procedures assume progressive technological change and only allow WAPM comparisons using alternative netput vectors that chronologically occur before the base year (Chavas and Cox, 1988; Varian, 1984). This, by definition, eliminates half of the observations and weakens the WAPM test because the base year netput vector could be the most profitable strictly because of technological change. One corrective approach that is consistent with the nonparametric characteristics of the WAPM test, and allows all observations to be used in the WAPM tests because the technology set is converted to a constant set, is to adjust the netput vectors for technological change using Malmquist indices from distance functions computed from nonparametric methods. That procedure was used by Tauer (1995).

An output distance function is defined as (Cornes, 1992):

$$(3) \qquad D_o^t\left(x^t, y^t\right) = \min\left\{\theta : \left(x^t, y^t / \theta\right) \in s^t\right\} = \left(\max\left\{\theta : \left(x^t, \theta y^t\right) \in s^t\right\}\right)^{-1}.$$

This essentially shows how much output(s) y can be increased given a quantity of input(s) x, such that x and θy remain in the production set. It is further necessary to define distance functions with respect to two different time periods as:

$$(4) \qquad D_o^t(x^{t+1}, y^{t+1}) = \left(\max\left\{\theta : \left(x^{t+1}, \theta y^{t+1}\right) \in s^t\right\}\right)^{-1}$$

and

$$(5) \qquad D_o^{t+1}(x^t, y^t) = \left(\max\left\{\theta : \left(x^t, \theta y^t\right) \in s^{t+1}\right\}\right)^{-1}.$$

The distance function specified by equation (4) measures the maximal proportional change in output required to make (x^{t+1}, y^{t+1}) feasible in relation to the technology at time t. Similarly, the distance function specified by equation (5) measures the maximal proportional change in output required to make (x^t, y^t) feasible in relation to the technology at time t+1. These distance functions are reciprocals to the output-based Farrell measure of technical efficiency and can be calculated for each firm using nonparametric programming techniques (Färe, *et al.*, 1994).

Technical change between year t and t+1 is measured as the geometric mean of the distance functions, which captures the shift in technology between periods evaluated at x^t and x^{t+1} (Fare, *et al.*, 1994):

$$(6) \qquad T_o^{t+1}\left(y^{t+1}, x^{t+1}, y^t, x^t\right) = \left[\left(\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)}\right) x \left(\frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^{t+1}, y^{t+1})}\right)\right]^{\frac{1}{2}}$$

, where D_o^{t+1} is the distance function measured at time t+1 using netput vectors at time t or t+1. Although each distance function used to measure T_o^{t+1} entails a proportional (radial) expansion or contraction of the output vector y^t or y^{t+1}, the single value index T_o^{t+1} reduces to the geometric mean of these two separate radial lines that may not coincide. As such, the measured technological change is not necessarily Hicksian neutral.

Although equation (6) adjusts for technological change that occurred over the period of the observed netput vectors, Varian (1990) states that WAPM tests may fail not only from technological change but also from learning by doing. Within the technology set, learning by doing might be measured by the change in technical efficiency between years, measured as:

$$(7) \qquad E_o^{t+1}\left(y^{t+1}, x^{t+1}, y^t, x^t\right) = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)}.$$

The Malmquist productivity change is the product of efficiency change and technical change, $M_o^{t+1}(.) = E_o^{t+1}(.) \bullet T_o^{t+1}(.)$, and can be used to correct the output quantities of the netput vector to generate a technology set that has constant technology and efficiency.

Tauer (1995) corrected netput vectors using the Malmquist productivity index. Here we elect to correct netput vectors only by the technological change that occurred. The failure to select the best netput vector, given a price vector, may partially be due to allocative inefficiency. Yet, inherent in the nonuse of an alternative netput vector may also be the inherent technical inefficiency known in utilizing that vector. Thus, for instance, a farmer may not have selected an alternative netput vector over a base netput vector because he realizes that he could be less efficient in using that alternative netput vector. That would be reflected as less profit. If that greater (or less) inefficiency of an alternative netput vector is removed relative to the base vector, then the change in profits that may have been realized by selecting the alternative vector would be overstated, relative to the actual profit the farmer would have experienced. Of course, the concept of implementing technological change and then the initial inefficiency in utilizing that new technology is inherent in the dynamic quasi-fixed factor adjustment cost models (Luh and Stefanou, 1993; Treadway, 1970).

III. Data

The data are from 70 farms that participated in The New York Dairy Farm Business Summary (NYDFBS) for each year from 1984 through 1993. Summary statistics for these farms are reported in Smith, Knoblauch, and Putnam. Since accrual procedures to collect these data first began in 1985, the year 1984 was dropped from the analysis. This leaves nine years of data. Rotating each of those years as the base year provides nine base years with eight comparison netput vectors for each of those nine base years for each farm.

These farms primarily produce milk (farms are excluded from the annual NYDFBS if crop receipts are over 10 percent of total receipts), so two outputs were defined: milk and other output. Other output mostly includes the sale of cull dairy cows, but various miscellaneous receipt items are included. Six inputs are defined: labor, feed, energy, crop, livestock, and real estate as summarized in Table 1.

Table 1. Data Categories

Variable	1993 Average (in 1993 dollars)
Labor input	59.1 (months)
Purchased feed input	$135,871
Energy input	$21,680
Crop input	$92,102
Livestock input	$110,402
Real estate input	$67,815
Milk output	36,837 (cwt.)
Other output	$84,125

Receipts and expenditures, except for milk and labor which are collected in physical quantities, were first converted into quantities by dividing by annual price indices published by the New York Agricultural Statistics Service (1984=100). This converts expenditures and receipts into 1984 dollars, assuming that all farms paid and received the same prices for each item in any given year. To the extent that some individual farm expenditures were greater because of higher prices paid for a quality input (feed for instance), dividing by the same price for all farms converts these inputs into a quality-adjusted input, reflected as a larger quantity of a constant-quality input. Input and output prices to perform the WAPM tests were those published by the New York Agricultural Statistics Service consistent with the data categories listed in Table 1.

The linear programming models used to compute the technical and efficiency changes for each year on these 70 farms over the nine years are discussed in Tauer (1996). The same outputs and inputs were used as for the WAPM tests. The average technological change over the nine-year period was 3.4 percent. The average productivity change, which is the product of technical change and technical efficiency change, was 2.6 percent. Since output distance functions were used, both the milk output and other output were corrected for technical change using the relevant annual indices computed for individual farms.

IV. Empirical Results

Varian (1990) stated that because of technological change and learning by doing, WAPM will more often be violated when the base year is compared to future rather than past years. That is the case here when the output vectors are not adjusted for technological change. The average WAPM violation over the 70 farms was 11.8 out of the 36 tests per farm using past netput vectors, with a much greater violation of 24.8 out of the 36 tests using future netput vectors. The null hypothesis of equal number of past and future netput vector violations was rejected at 1% significance level. When the output vectors were adjusted for technological change, the average WAPM violation using past netput vectors increased to 12.1 out of the 36 tests per farm, whereas the average WAPM violation using future netput vectors decreased to 24.3 out of the 36 tests per farm. The null hypothesis of equal number of past and future netput vector violations was rejected at 1% significance level. Similar statement can be made when the outputs were adjusted for productivity (technology and efficiency) changes. The average WAPM violation over the 70 farms was 12.2 out of the 36 tests per farm using past netput vectors, with a much greater violation of 24.3 out of the 36 tests using future netput vectors. The analysis that follows uses netput vectors corrected for technological change only.

For each firm and base year the alternative netput vectors were used to calculate the maximum T_i value for that base year. This value indicates, as a fraction of total receipts during the base year, how much net profit could have been increased by using the best alternative netput vector. Since there are nine base years, there are nine maximum T_i values for each firm. These values are summarized in Table 2, which shows the average of the nine maximum T_i values for each firm, along with the standard deviation, and maximum value. There is considerable variation in results. Firm #19 has the lowest mean value of .08; firm #5 has the highest mean value of .61. This indicates that alternative netput vectors than the netput vectors actually selected by firm #19 over the nine years could have increased profits by 8 percent for firm #19; firm #5 could have increased its profits by 61 percent. The average over the 70 firms is .20, with most firms having values in the teens and twenties.

Tauer (1995) concluded that over half of the dairy farms from an earlier period of the NYDFBS data set were within 10 percent of minimum cost, but did somewhat worse in profit maximization. But since he averaged both negative and positive deviations, whereas we only average negative deviations here, the results are not comparable. Featherstone *et al.* (1995), using Kansas farms, found the mean amount of profit underage across 289 farms was 40.0 percent, and the average cost overage was only 11.0 percent. Although these reflect the negative deviations only, they implicitly correct for technological change by only permitting WAPM and WACM comparisons using past netput vectors, assuming progressive technological change. The WACM tests further require that $Y_i \geq Y_o$, additionally restricting observations for WACM such that the same netput vectors are not included in the comparison of WAPM and WACM.

Table 2. Summary Values of Maximum T_i for 70 Dairy Farms for Nine Base Years

Farm	Mean	Standard Deviation	Maximum
1	0.09	0.08	0.26
2	0.16	0.10	0.31
3	0.16	0.16	0.56
4	0.38	0.21	0.69
5	0.61	0.32	1.02
6	0.17	0.12	0.41
7	0.14	0.09	0.29
8	0.14	0.09	0.32
9	0.19	0.10	0.35
10	0.14	0.08	0.27
11	0.15	0.12	0.42
12	0.22	0.16	0.56
13	0.16	0.10	0.32
14	0.21	0.15	0.51
15	0.11	0.10	0.29
16	0.18	0.11	0.36
17	0.14	0.07	0.23
18	0.28	0.23	0.84
19	0.08	0.09	0.26
20	0.19	0.12	0.40
21	0.16	0.09	0.32
22	0.15	0.08	0.23
23	0.15	0.14	0.45
24	0.34	0.18	0.53
25	0.10	0.06	0.20
26	0.17	0.10	0.37
27	0.17	0.12	0.37
28	0.12	0.07	0.23
29	0.24	0.12	0.36
30	0.15	0.08	0.25
31	0.27	0.18	0.58
32	0.29	0.13	0.50
33	0.17	0.14	0.46
34	0.24	0.16	0.50
35	0.17	0.10	0.31
36	0.12	0.07	0.23
37	0.13	0.11	0.37
38	0.18	0.10	0.32
39	0.19	0.21	0.65
40	0.12	0.09	0.28

-continued-

Table 2. Summary Values of Maximum T_i for 70 Dairy Farms for Nine Base Years (cont.)

Farm	Mean	Standard Deviation	Maximum
41	0.23	0.15	0.50
42	0.09	0.06	0.19
43	0.18	0.11	0.34
44	0.29	0.20	0.56
45	0.24	0.14	0.43
46	0.19	0.12	0.40
47	0.25	0.21	0.61
48	0.18	0.09	0.30
49	0.17	0.12	0.37
50	0.14	0.08	0.25
51	0.32	0.19	0.58
52	0.15	0.12	0.36
53	0.11	0.09	0.26
54	0.11	0.09	0.29
55	0.24	0.13	0.43
56	0.29	0.15	0.50
57	0.50	0.39	1.30
58	0.16	0.14	0.40
59	0.21	0.12	0.45
60	0.30	0.15	0.54
61	0.20	0.14	0.38
62	0.29	0.12	0.45
63	0.14	0.07	0.27
64	0.21	0.13	0.38
65	0.09	0.07	0.21
66	0.17	0.12	0.37
67	0.22	0.18	0.55
68	0.16	0.13	0.38
69	0.15	0.11	0.34
70	0.13	0.10	0.29
Average	**0.20**	**0.13**	**0.41**

As expected, most firms with low averages also have low standard deviations, although a number of firms with relatively low averages still show large variation around that average. All but farms #39 and #65 show at least one of the nine base years as the most profitable netput vector, and even those two firms had a minimum value of Maximum T_i at .01, indicating that the alternative netput vector was not very much more profitable than the base netput vector. Yet, some of the maximum T_i values were very high, with firm #57 having a maximum value of 1.30. This indicates that an alternative netput vector than the netput vector actually selected that year would have increased profits by 130 percent of the total receipts that year. Firm # 42 showed the lowest maximum at .19.

Some farms are better at selecting optimal netput vectors, and obviously something unique exists on those farms. Since the T_i values are restricted to be equal or greater than zero, where the zero values are due to the truncation process on the WAPM test shown in equation 1, a tobit regression model was estimated to determine if characteristics of these farms could explain the variation in their abilities to select the best netput vector. The NYDFBS collects limited characteristic data on farms, emphasizing financial data, but information on age, education, and some business characteristics are available.

The tobit model is defined as:

$$y_i = B'X_i + u_i \text{ if } \text{RHS} > 0$$

$$y_i = 0 \text{ otherwise}$$

where B is a kx1 vector of unknown parameters; X_i is a kx1 vector of known constants; u_i are residuals that are independently and normally distributed, with mean zero and a common variance sigma squared (Maddala). Because this is a censored regression model, the log likelihood function is:

$$\log L = \sum_0 \log(1 - F_i) + \sum_1 \log\left(\frac{1}{\left(2\Pi\sigma^2\right)^{1/2}}\right) - \sum_1 \frac{1}{2\sigma^2}(y_i - \beta' x_i)^2 .$$

Estimation was by GAUSSX using the Broyden-Fletcher-Goldfarb-Shanno algorithm using starting values from the OLS estimates. The ending tobit results were not significantly different from these OLS estimates, probably due to the small number of zero dependent variables, and the generally poor fit of the equation. The adjusted R^2 value on the OLS regression was only .07.

Higher values of T_i reflect a deterioration in the ability to select the best netput vector. With that in mind, table 3 shows that experience, as reflected by age and education, increases the ability to select the best netput vector, as indicated by the negative signs on those estimated tobit regression coefficients. Apparently two heads (or more) are not better than one, since multiple-owned farms appear to do a worse job of choosing the best netput vector. Being larger, as measured by the number of cows, appears not to have any impact on the ability of a farm to select the best netput vector, although many larger farms also tend to be multiple-owned operations. Yet, given the poor overall statistical fit, factors other than those available from the NYDFBS are much more responsible for the ability of a farmer to select the best netput vector.

Table 3. Tobit Regression of Maximum T_i on Age, Education, and Operation Type

Variable	Coefficient	t-Statistic
Constant	.4353	12.94
Age of principal operator (years)	-.0047	-7.01
Education of principal operator (1 if post high school, 0 otherwise)	-.0796	-5.14
Operation type (1 if multiple operator, 0 otherwise)	.0438	2.91
Number of cows	-.0000	-0.20
Sigma	.0305	15.35
N=630		

V. Conclusions

The Weak Axiom of Profit Maximization (WAPM) was used to test how successful each of 70 individual dairy farms were in maximizing profits using nine years of data (1985 through 1993). The netput vectors were corrected for technology change using Malmquist indices computed from nonparametric estimated distance functions. Negative deviations of the WAPM test indicate that an alternative netput was more profitable than the base year netput at base year prices. These negative deviations were indexed by the total receipts of the base year, permitting inter-firm comparison.

The average negative WAPM deviation over the 70 farms was .20, indicating that, on average, an alternative netput vector, rather than the netput vector actually selected during base years, would have increased profits by 20 percent of the total receipts of the base year. Yet, all but two farms showed that at least one of the nine base year netput vectors was the most profitable netput vector. This relative success at choosing netput vectors to maximize profits is greater than the few other farm samples reported in the literature.

Some farms were better at selecting optimal netput vectors. A tobit regression model was estimated to determine if characteristics of those farms could explain the variation in their abilities to select the best netput vector. Although little of the variation was explained, increased age and additional education increased the ability to select the best netput vector, while more than one owner-operator had a detrimental impact.

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