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Factors Affecting Production Efficiency in a New Alternative Enterprise: The Case of the Ratite Industry

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ABSTRACT

Technical efficiency measures are calculated for ratite producers using data envelopment analysis. Regression analysis is then used to determine producer characteristics that are likely to lead to higher technical efficiencies. Results indicate that the most technically efficient ratite producers in Louisiana are not producing at the benchmark efficiency level advocated by the industry. Producer experience with other livestock, specialization, and labor are factors likely to lead to higher technical efficiency. These results are expected to hold for most new, alternative livestock enterprises.

Key Words: data envelopment analysis, ratite, technical efficiency.

The ratite[1] industry has rapidly expanded in the U.S. since South Africa relaxed export constraints on ostrich breeding stock in the early 1980s. Feathers, meat, and hides are recognized as marketable ostrich products and have been produced commercially in South Africa since the late 1800s. The U.S. ostrich industry began in the 1980s as a pure breeder market. To expand the U.S. market, a significant volume of animals was needed. Many producers with small acreage viewed ostrich production as an opportunity to utilize unused acreage and/or diversify their existing farm operations. This enterprise, which requires relatively low capital input in facilities and little land, had a high expected payoff in the short run, and the potential for a larger slaughter market in the long run. By 1996, it was estimated that there were up to 10,000 ostrich producers in the U.S. (van Zyl). The U.S. emu industry arose shortly after the ostrich industry with the anticipation of producing breeder birds for the subsequent sale of meat, hides, and oil.

During the 1980s and early 1990s, very little was known in the U.S. about how to produce ratites. However, prices for breeder birds were very high, with $20,000 per pair being common. Since production costs represented only a small percentage of the revenue from the sale of breeder birds, production efficiency appeared to be of little importance.

A rapid fall in breeder bird prices and a

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[1] Ratites include four species of birds—cassowary, emu, ostrich, and rhea. Only emu and ostrich are considered in this study, as they represent the majority of the ratite population raised for slaughter in the southeastern United States.

slow emergence of ratite product markets occurred during 1994–95 as the two industries moved from breeder to mixed breeder/slaughter markets. While markets for domestically produced ostrich products have slowly emerged, those for emu remain few in number and sporadic in volume. The resulting squeeze on producer margins, as discussed in a costs and returns analysis by Gillespie, Taylor, and Schupp, has called for ratite producers to more closely examine production efficiency and profitability. The 90th percentile Louisiana ostrich producer did not make a profit in 1995, due largely to low production efficiencies and high feed prices. However, Gillespie, Taylor, and Schupp concluded that ostrich production would be profitable if producers decreased feed costs and increased production efficiencies.

Given that higher production efficiency will be required for ratite operations to become profitable, several questions arise for these low-input, alternative livestock enterprises. How efficient are the most efficient producers? How different are these producers' efficiencies from efficiencies that industry promoters suggest should be obtained? What are the characteristics of farmers who are achieving the highest efficiencies? The objectives of this study are to: (*a*) determine the technical efficiencies of a sample of ratite farms, and (*b*) identify some of the factors that determine whether or not a ratite farm is technically efficient. Results of the study will lend insight into the farm situation under which inclusion of this alternative enterprise is likely to be successful.

Technical Efficiency Analysis

Technical efficiency analysis offers a method for examining the relative efficiencies of producers. Most agricultural industries which have been examined using technical efficiency measures have been established industries with prescribed management practices resulting from extensive research, such as Cloutier and Rowley on Quebec dairy farms. In these industries, the most efficient producers attain efficiencies that are commensurate with best management practices. In the case of ratites, U.S. production potential is largely unknown, though some research has been conducted in South Africa. Many industry advocates discuss a benchmark annual production level of 40 slaughter birds per breeder pair per year. However, only one of 331 surveyed producers in Louisiana was producing at this level in 1995. Many others did not produce one bird per pair per year. Some research of management practices currently is being conducted at experiment stations in the U.S. (e.g., Satteneni and Satterlee; Blue-McClendon and Bailey), but few recommendations are yet available to producers.

Measures of economic efficiency, including allocative and scale efficiency, are well suited to established industries. However, they are less suitable for newly established or recently emerging industries when product prices are extremely volatile and market outlook is uncertain. Markets have only recently been established for ostrich. With emu, markets are sporadic and limited. Since most ratite operators are producing below potential production levels and many are unprofitable, increasing technical efficiency should be a goal of ratite producers.

An appropriate method for analyzing technical efficiency is the data envelopment analysis (DEA) method (Sexton). This method is useful in situations where (*a*) there are multiple outputs and multiple inputs, and (*b*) there is not an objective way to determine the efficiency of a firm based upon one efficiency index formula. In such cases, more than one firm may be technically efficient while producing different amounts of products and using different input levels. Sexton states that, using DEA, the efficiency of a firm or organization is the "ratio of its total weighted output to its total weighted input" (p. 10). Firms have considerable flexibility in determining the weights to be used in evaluating their efficiencies, allowing firms to use different combinations of inputs to produce different combinations of outputs according to their preferred weights. Therefore, more than one firm can be technically efficient.

The objective function of the linear programming formulation for determining technical efficiency for a firm using DEA (as presented in Sexton, and in Cloutier and Rowley) is expressed as

$$\text{Maximize } h_k = \frac{\sum_{r=1}^{s} u_{rk} Y_{rk}}{\sum_{i=1}^{m} v_{ik} X_{ik}}.$$

This is a fractional objective function where firm k maximizes its technical efficiency h_k, the ratio of total weighted output by total weighted input. The term u_{rk} represents the output weights for output r and firm k, and Y_{rk} denotes output r produced by firm k. $X_{ik} > 0$ is the amount of input i used by firm k, and v_{ik} is the unit weight placed on input i by firm k. The firm chooses the weights u_{rk} and v_{ik} subject to a constraint that no other firm j will have a technical efficiency measure greater than one if it uses the same weights, such as:

$$\frac{\sum_{r=1}^{s} u_{rk} Y_{rj}}{\sum_{i=1}^{m} v_{ik} X_{ij}} \leq 1, \qquad j = 1, \ldots, n.$$

The selected weights cannot be negative; thus:

$$u_{rk} \geq 0, \qquad r = 1, \ldots, s;$$

$$v_{ik} \geq 0, \qquad i = 1, \ldots, m.$$

The fractional linear program is transformed into an ordinary linear program such that objective function (1) is maximized subject to constraints (2), (3), (4), and (5):

(1) $$\text{Maximize } h_k = \sum_{r=1}^{s} u_{rk} Y_{rk}$$

subject to:

(2) $$\sum_{r=1}^{s} u_{rk} Y_{rj} - \sum_{i=1}^{m} v_{ik} X_{ij} \leq 0, \qquad j = 1, \ldots, n;$$

(3) $$\sum_{i=1}^{m} v_{ik} X_{ik} = 1;$$

(4) $$u_{rk} \geq 0, \qquad r = 1, \ldots, s;$$

(5) $$v_{ik} \geq 0, \qquad i = 1, \ldots, m.$$

Firm k maximizes its weighted output subject to the above constraints: (2) that other firms' weighted outputs are not greater than their weighted inputs, (3) that firm k's total weighted inputs sum to 1, and (4)–(5) that individual input weights are greater than or equal to zero.

Weights are determined by the individual firms. With the DEA technical efficiency method, the firm is not penalized for diversifying its operation or specializing in the production of a certain output. Likewise, the firm is not penalized if it decides to use an alternate set of inputs. For instance, some ratite firms may decide to utilize another firm's facilities for incubating eggs rather than investing in incubation facilities of their own. A linear program is solved for each firm to determine its relative technical efficiency. After technical efficiency measures are estimated, regression analysis may be utilized to identify the important factors in determining a firm's technical efficiency.

In a case such as ratites, a producer may specialize in ostrich or emu, the grow out of slaughter birds, the incubation of eggs, or a combination of these. Thus, a variety of different types of firms are candidates for efficient farms. The DEA procedure is also useful for ratites because it allows a comparison of firms to one another without assuming that the most efficient firm is producing at its full potential. While other methods to estimate technical efficiency exist, such as using regression analysis to estimate technical efficiencies given generalized frontier production functions (e.g., Battese; Johnson, Zapata, and Haegler), DEA does not constrain firms to produce along an estimated production function of a particular functional form, nor does it constrain the analysis to one measure of output.

Methods

In February 1996, a survey was mailed to 95 ostrich and 236 emu producers in Louisiana. This survey requested information on the numbers of birds produced, input usage, and socioeconomic data associated with the producer. A 41% return rate was obtained, and 57 of the surveys were complete.[2] Of the 57 usable surveys, 22 respondents were ostrich producers, 33 were emu producers, and two were producers of both species. All were members of their respective state ratite commodity organizations. The completed surveys were assumed to be a representative sample of Louisiana ratite farms in terms of bird production and input usage. All producers were breeding ratites to produce eggs and/or mature birds.

Technical Efficiency Assessment

Producers of both emus and ostriches responded to the survey. Some of the facilities (e.g., incubators and hatchers) and other inputs that are used for emu can also be used for ostrich since the breeding, incubation, and hatching seasons for the two species do not coincide. Thus, for some situations, they are complementary enterprises. Products produced in our model include incubated emu and ostrich eggs and three-month-old emus and ostriches to be raised for slaughter. In this analysis, we assume that three-month-old emus and ostriches will reach slaughter weight and be sold at 12 months of age.[3]

Inputs used in the analysis include hours of labor used per week for the ratite operation, incubation capacity, number of acres devoted to the ratite operation, numbers of emu and ostrich hens, numbers of emu and ostrich roosters, amount of breeder feed used, and amount of feed used for slaughter birds. Thus, measures of labor, capital, land, breeding stock, and the major variable input are included.[4] All surveyed producers fed branded, bagged feed and none used forage as the principal feed component. However, some producers substituted, to a limited extent, acres in forages for mixed feed. The inputs and outputs are used in the DEA framework to determine distributions of technical efficiencies among firms. The linear programming software LINDO was used in the analysis. Fifty-seven linear programs were run, one for each firm.

Follow-up Regression Analysis

Measures of technical efficiency are used in a regression analysis to estimate those factors that are most important in determining a firm's technical efficiency. Equation (6) presents the regression equation that estimates the relationship between exogenous variables and technical efficiency:

$$(6) \quad TE = f(YEARS, LABOR, OSTDUM, BREEDHEN, COLONY, OTHLVSTK, PCTINC, INCOTH),$$

where *TE* represents the technical efficiency score and $f(\cdot)$ indicates the operator. Variables hypothesized to affect technical efficiency include: years in the ratite business (*YEARS*), labor used per breeder (*LABOR*), a dummy variable for ostrich production (*OSTDUM*), the total number of ratite breeder hens on the farm (*BREEDHEN*), the use of colony breeding (*COLONY*), the number of other livestock raised on the farm (*OTHLVSTK*), the percentage of household income that accrues from the ratite operation (*PCTINC*), and the utilization of incubation and hatching facilities for incubating and hatching other producers' eggs (*INCOTH*).

Economists have long recognized the effect of learning and experience on firm decisions (e.g., Rausser). *YEARS* is hypothesized to have a positive impact on a ratite firm's technical efficiency due to learning from past experiences. In a new industry with no prescribed management practices, those producers who have been involved in production longer should have higher technical efficiency scores. *YEARS* is measured as the number of years the

[2] The survey form was mailed to all respondents of an earlier ratite inventory survey. The near collapse of the breeder market had caused a number of producers to exit the industry. The large number of nonresponses and partial responses reflect the industry transition period.

[3] Ostriches and emus are commonly sold for slaughter at 12 months of age. Most death loss occurs from hatching to three months of age. We assume that three-month-old birds will eventually become slaughter birds.

[4] Gillespie, Taylor, and Schupp determined that feed costs accounted for 80–86% of total variable costs of ostrich slaughter bird production in 1995.

producer has raised ratites. The longest producing respondent in the survey had raised ratites for nine years.

LABOR is hypothesized to have a positive influence on technical efficiency. The collection, incubation, and hatching of eggs, and care of the young birds all require capable and observant labor. Producers who closely monitor breeders should have better technical efficiencies since they are more likely to conduct essential tasks, such as egg collecting, in a timely manner.[5] *LABOR* is measured as the number of hours of labor spent per breeder animal per week. A positive and significant sign on the *LABOR* estimate would provide evidence that labor is an effective input in increasing efficiency.

It is hypothesized that ostrich and emu will have different technical efficiencies; thus *OSTDUM* is measured. However, our model is not constructed to test which species is more technically efficient since (*a*) there are not enough years of data available to adequately address this issue, and (*b*) the animals breed in different seasons. Consequently, *OSTDUM* is interpreted simply as an intercept shifter.

BREEDHEN, the number of ratite breeder hens on the farm, is hypothesized to have a positive influence on technical efficiency. Positive significance would lend evidence that larger volume units might capture significant economies of size due to more efficient input usage.

It is hypothesized that *COLONY* has a positive influence on technical efficiency. Colony breeding refers to having greater than a one-to-one ratio of females to males in pens. Colony breeders are hypothesized to be more technically efficient since fewer males are required to breed females. Colony breeding could lead to significant economies of size for relatively small operations, particularly if one rooster breeds two or more hens as effectively as in a pair. Use of pairs has been the common practice in the early evolution of the U.S. industry. *COLONY* is measured through use of a dummy variable—those who utilize colony breeding versus those who do not.

The presence of other livestock on the farm is hypothesized to positively influence technical efficiency. Some of the husbandry practices used for other livestock also hold for ratites. Thus, economies of scope in information about livestock may be exploited in new animal production. *OTHLVSTK* is measured as a continuous variable, where the numbers of head of cattle, hogs, and sheep on the farm are included.

PCTINC is hypothesized to be positively correlated with technical efficiency. Those producers who acquire a larger percentage of their total income from the ratite operation are likely to be more efficient since the operation would be expected to be the primary concern of the producer. *PCTINC* is measured as the percentage of income from the ratite operation in 1995.

Those producers who incubate and hatch eggs for other producers are hypothesized to have higher technical efficiencies. *INCOTH* is a dummy variable indicating whether or not other producers' eggs are incubated and hatched. It is hypothesized that incubating another producer's eggs will lead to greater specialization in incubation, and thus a more efficient division of labor. Therefore, higher technical efficiency will result.

Two procedures are used to estimate the effect of producer characteristics on technical efficiency. Ordinary least squares (OLS) has been used in past technical efficiency studies (as prescribed by Sexton), and is used here. A censored two-limit tobit model (as discussed in Greene, and Madalla), with limits of 0 to 1 on the dependent technical efficiency variable, is also used. Results from the two models are briefly compared. LIMDEP is used to estimate the two-limit tobit model and SHAZAM is used to estimate the OLS model.

Results

Technical Efficiency Measurement

Results of the technical efficiency analysis are summarized in figure 1 for ratite, ostrich, and

[5] Under inclement weather conditions, it is highly important for eggs to be collected in a timely manner to prevent bacteria from entering the egg as it cools.

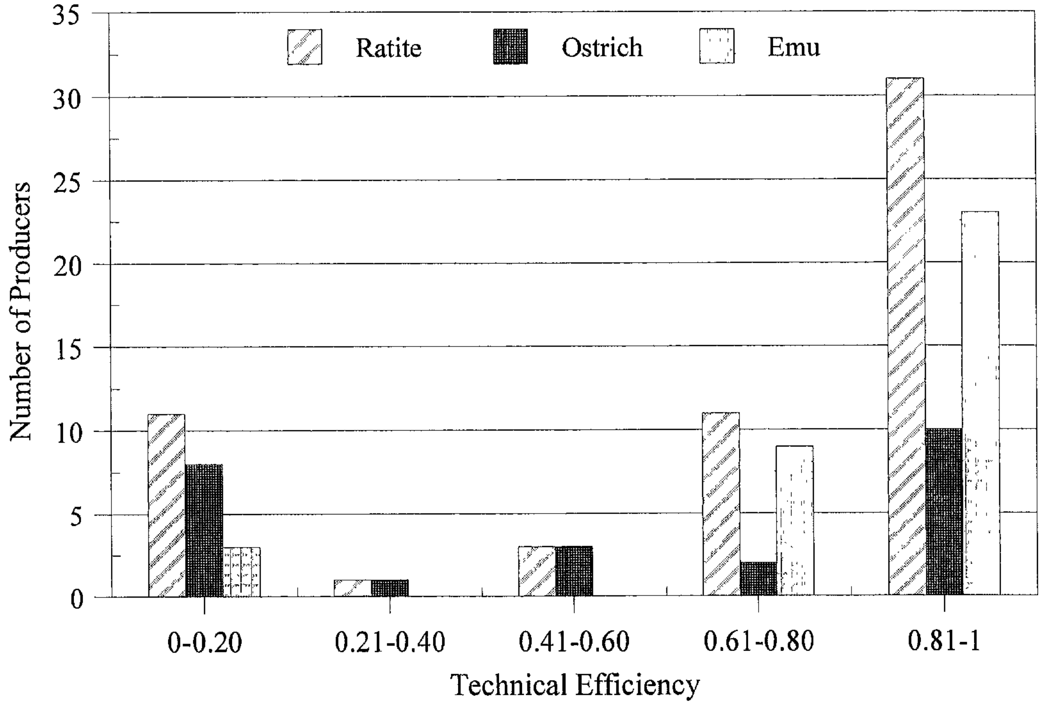

Figure 1. Technical efficiencies for Louisiana ratite, ostrich, and emu production, 1995

emu production. While there were more ratite producers in the 0.81–1 category, a significant number of producers had very low technical efficiencies, in the 0–0.20 range. Of the 57 producers, 31 were in the 0.81–1 category. Of these 31, 22 were technically efficient, with efficiency scores of 1. Eleven producers reported no eggs incubated or slaughter birds produced during 1995, indicating that 19% of the surveyed ratite operations produced no saleable output during 1995.

Of the 24 ostrich producers (figure 1), 10 were in the 0.81–1 category, with seven achieving an efficiency score of 1. Eight producers reported no eggs or slaughter birds produced during 1995. The average technical efficiency score for ostrich producers was 0.52. Of those ostrich producers with a technical efficiency score of 1, the average number of eggs per laying hen was 37, and the average number of slaughter birds per laying hen was 12. These numbers include one producer who had much higher productivity than the others, with 73 eggs and 49 slaughter birds per laying hen. Without his numbers in the averages, the average productivity of the producers with a score of 1 is 30 eggs and six slaughter birds per laying hen.

As shown in figure 1, 23 of the 35 emu producers were in the 0.81–1 category, and 16 had a score of 1. Only three emu producers reported no production in 1995, and the average technical efficiency score was 0.82. Of the producers with a technical efficiency score of 1, the average number of eggs per laying hen was 25, and the average number of slaughter birds per laying hen was 14.

These results for ostrich and emu indicate that most of the technically efficient ratite operations produced well below the benchmark of 40 slaughter birds per hen in 1995. Hence, even the most efficient producers need to raise their production levels if they are to reach the benchmark level.

Factors Affecting Technical Efficiency of Ratite Operations

Table 1 presents results of the OLS and maximum-likelihood two-limit tobit estimations. While most of the statistically significant vari-

Table 1. Results of OLS and Two-Limit Tobit Analyses: Factors Affecting the Technical Efficiency of Louisiana Ratite Farms, 1995

	Ordinary Least Squares (OLS)		Two-Limit Tobit	
Variable	Estimate	Std. Error	Estimate	Std. Error
Constant	0.5571***	0.1146	0.5592***	0.2407
YEARS	0.0283	0.0283	0.0660	0.0609
LABOR	0.0121*	0.0068	0.0193	0.0132
OSTDUM	−0.3580***	0.1014	−0.7058***	0.2215
BREEDHEN	0.0101	0.0087	0.0216	0.0189
COLONY	0.0009	0.1018	−0.1210	0.2062
OTHLVSTK	0.0039**	0.0020	0.0089**	0.0043
PCTINC	−0.0020	0.0023	−0.0073	0.0051
INCOTH	0.2460*	0.1338	0.7378**	0.3375
R^2	0.3315			
Log-likelihood			−45.12	

Note: Single, double, and triple asterisks (*) denote significance at the .10, .05, and .01 level, respectively.

ables in the OLS model are also significant in the two-limit tobit model, the *LABOR* estimate is significant at the 0.07 level in the OLS model, while it is not significant in the two-limit tobit model. The estimate for *INCOTH* has greater statistical significance with the two-limit tobit model than with the OLS model. The major difference in the results of the two models is the magnitude of the estimates. For instance, the estimate for *OTHLVSTK* for the two-limit tobit model is more than twice as large as with the OLS. Given that censoring is an appropriate assumption for technical efficiency measures, the two-limit tobit appears to be the preferred model.

We found no evidence to suggest that heteroskedasticity is a problem in either model. The Breusch-Pagan test yielded an estimate in the OLS run (B-P = 5.083, d.f. = 47) that did not lead to rejecting the null hypothesis of homoskedasticity. In the two-limit tobit model, multiplicative heteroskedasticity modeling was used to test for heteroskedasticity. For each variable, the likelihood functions were compared with the non-heteroskedasticity likelihood functions using the likelihood-ratio test. No evidence of heteroskedasticity was found.

The variable *YEARS* was of the expected sign, but not statistically significant.[6] Based on contacts with many producers in the industry, it appears there is much discussion among producers as to the effectiveness of different practices with which they are currently experimenting. This is to be expected in a new industry where cooperation in sharing information is mutually beneficial, given that one of the main goals of the current industry is to produce enough birds to form a significant slaughter market. While the information gathered through on-farm experimentation is limited, its diffusion appears to be relatively rapid, reaching not only those who have been producing for a few years, but also those who are relatively new in the business. Thus, while learning may be important in raising ratites, it is possible that the industry remains small enough and communication is open such that information diffusion is rapid, especially among members of the state ratite organizations. In this case, producers benefit from their own experiences as well as the experiences of others. Most of the surveyed producers identified "another producer" as their most important information source.

[6] Given that the industry is very new and few years of observations are available, producers continue in the experimental stage, where certain practices are quickly discontinued and others are considered for further observation. Some practices may have been confounded with poor growing conditions over the short history of the industry, leading to their premature discontinuation by some producers.

The amount of labor spent per breeder (*LABOR*) positively affected technical efficiency in both models. This suggests there is some evidence that those producers who frequently check pens for eggs and closely monitor for sick birds are likely to have higher technical efficiencies than those who spend less time. It appears that labor per breeder is an effective input.

Results indicate a difference in technical efficiency between ostrich and emu operations in 1995, as *OSTDUM* was significant in both models. *BREEDHEN* was not significant. Thus, this analysis does not provide evidence to suggest that significant economies of size currently exist in ratite production. Inclusion of detailed information on initial fencing costs may have led to *BREEDHEN* being significant. However, these detailed costs were unavailable. As the industry matures, it may be appropriate to conduct economic efficiency studies that can more adequately address the economies of size question.

The variable *COLONY* was not significant. While these results do not conclude that colony breeding leads to greater technical efficiency, research by Gillespie, Taylor, and Schupp suggests that if birds breed as well in colonies as in pairs, significant economies of size can be captured due to fewer breeding stock present in the operation. These results suggest that research is needed to determine whether the birds actually breed as well or better in colonies than in pairs.

The presence of other livestock on the farm (*OTHLVSTK*) has a positive influence on the technical efficiency of ratite farms. This finding provides evidence that producers with livestock experience are likely to have greater success in ratite production, indicating potential complementarity between the ratite and other livestock enterprises. Very little information about the production relationship and the factors affecting it is available to producers early in the evolution of an industry. Thus, experience with production processes in other species often leads to greater success in the new enterprise. An important implication is that early in the evolution of a new, alternative domestic livestock industry, significant economies of scope exist in producing these livestock along with other livestock that require many of the same production practices. These results suggest that the successful new ratite producers may be those who add the new enterprise as a diversification mechanism for existing livestock enterprises.

Percentage of income from the ratite operation (*PCTINC*) was not significant. Perhaps this is consistent with the *OTHLVSTK* variable; those who are also involved in traditional livestock enterprises have higher technical efficiencies, thus indicating that specializing in ratites does not lead to greater technical efficiency. Alternatively, this may show that producers with other sources of income have subsidized their ratite enterprises with higher quality breeding stock and facilities, the latter two factors increasing efficiency. Unfortunately, the input quality factor is difficult to measure in new alternative enterprises.

Incubating and hatching another producer's eggs (*INCOTH*) increases technical efficiency significantly since it utilizes resources that would otherwise go unused. Perhaps as important is that specialization in a production phase, such as incubation, leads to a more efficient division of labor, and thus greater efficiency. While the extent of the market (discussed by Stigler) has not been large enough to support completely specialized firms, these results lend evidence that movement toward specialization could lead to a more efficient division of labor, and thus higher technical efficiency.

Conclusions and Implications

Because the ratite industry did not exist in the U.S. before the mid-1980s, few of the producers who became involved in the industry had access to or knowledge of the most efficient practices for ratite production. The lack of information pertaining to raising ratites is one of the most striking challenges the industry faces. Information is a factor that would seem to be very important for technical efficiency in a new industry. Unfortunately, this is a difficult factor to measure in an industry where it is uncertain who has the most reliable information and whether the most reliable information has, indeed, been discovered.

While all producers in the sample were members of their respective state associations, producers also used a variety of other production information sources. Some producers reported that published materials were their primary information source, while most cited other producers. It is uncertain which source was the most reliable, given that the limited information which has been written about the industry may be better suited for another region of the country, or the world for that matter. Much of the published information is from South Africa, where dry conditions are much different than the humid climate of the southeastern U.S. A model run was conducted to test whether those producers whose primary information sources were publications were more technically efficient; however, it was not surprising that the variable was insignificant. Thus, as with most new alternative livestock enterprises, the source of the most reliable production information remains questionable. While producers are interested in increasing their efficiencies, information is limited primarily to discussions with other producers. As a result, technical efficiencies vary greatly as producers use different input mixes in experimentation. Because the industry remains in the producer experimentation stage, it is possible for the most recent entrant into the industry to be the most efficient.

While the futures of both the ostrich and emu industries remain uncertain, sparse information provides ample opportunities for research. It is possible that the inability to fully explain the variability in efficiencies among farms might be better explained if quality differences of breeder birds could be assessed. This raises opportunities for more breeding research and culling programs than are currently in place. Public research programs in the feeding, housing, and management of ratites also are warranted if the industries are to be successful.

Results of this study show that, while over one-third of ratite producers are technically efficient with a score of 1, nearly one-fifth have a technical efficiency score of zero, which is very uncommon in established agricultural industries. Also troublesome is that the average production of firms with a score of 1 was less than the number of eggs per hen and the number of slaughter birds raised per hen that many in the industry indicate should be produced.

Our results indicate that producers who spend more time with their breeders and have a general knowledge of animal production are likely to fare better in the industry than those who do not. It appears that management is a key factor in successfully operating a ratite farm. This is a finding that is likely to hold true for most new alternative farm enterprises. Ratite producers who are also producers of other livestock tend to be more efficient ratite producers. Thus, previous experience with animal production significantly improves a producer's chances of becoming an efficient ratite producer. As a result, ratite production may lead to significant economies of scope and may be a suitable alternative enterprise for diversification of domestic livestock operations.

This analysis was conducted during a critical transition period for the U.S. ratite industry. Many producers who had purchased expensive breeding stock and constructed costly facilities were faced with the realities of inadequate markets and serious financial losses. These efficiency results are likely representative of the development stage of new agricultural enterprises, such as slaughter goats, and reflect the uncertainties producers face as they experiment with ways to increase production and lower costs.

References

Battese, G.E. "Frontier Production Functions and Technical Efficiency: A Survey of Empirical Applications in Agricultural Economics." *Agr. Econ.* 7(1992):1–24.

Blue-McClendon, A., and C.A. Bailey. "Research on the Growth Rates of Ostrich Chicks." In *Conference Proceedings of the Association of Avian Veterinarians*, pp. 131–32, held in Reno NV, 28–30 September 1994.

Cloutier, L.M., and R. Rowley. "Relative Technical Efficiency: Data Envelopment Analysis and Quebec's Dairy Farms." *Can. J. Agr. Econ.* 41(1993):169–76.

Gillespie, J., G. Taylor, and A. Schupp. "Cost Estimates for Ratite Production." DAE Res. Rep. No. 706, Dept. of Agr. Econ. and Agribus., Louisiana State University Agricultural Center, Baton Rouge, December 1996.

Greene, W.H. *Econometric Analysis.* New York: Macmillan Publishing Co., 1990.

Johnson, J.L., H.O. Zapata, and A.M. Haegler. "Technical Efficiency in Louisiana Sugarcane Processing." DAE Res. Rep. No. 698, Dept. of Agr. Econ. and Agribus., Louisiana State University Agricultural Center, Baton Rouge, November 1994.

Madalla, G.S. *Limited Dependent and Qualitative Variables in Econometrics.* London/New York: Cambridge University Press, 1983.

Rausser, G.C. "Active Learning, Control Theory, and Agricultural Policy." *Amer. J. Agr. Econ.* 60(August 1978):476–90.

Satteneni, G., and D.G. Satterlee. "Factors Affecting Hatchability of Ostrich Eggs." Abstracted in *Poultry Sci.* 73, Suppl. 1 (1994):38.

Sexton, T. "The Methodology of Data Envelopment Analysis." In *Measuring Efficiency: An Assessment of Data Envelopment Analysis,* ed., R.H. Silkman. Josey-Bass Higher Education and Social and Behavioral Science Series, No. 32: New Directions for Program Evaluation. San Francisco: Josey-Bass Publishers, Winter 1986.

Stigler, G.J. "The Division of Labor Is Limited by the Extent of the Market." *J. Polit. Econ.* LIX,3(1951):185–93.

van Zyl, P. "A Global Perspective of the Ostrich Industry." *Amer. Ostrich* (August 1996):25–27.