2001

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N Sanneh

LJ Moffitt

DA Lass

Journal of Agricultural and Resource Economics 26(2):417–430

Stochastic Efficiency Analysis of Community-Supported Agriculture Core Management Options

Njundu Sanneh, L. Joe Moffitt, and Daniel A. Lass

The continued decline in both the number of and the acreage in small-scale farms and rural communities, as well as food safety and environmental concerns, has heightened interest in the community-supported agriculture (CSA) concept. Mean-variance, stochastic dominance, mean-Gini, and exponential utility/moment-generating function approaches to stochastic efficiency are employed to analyze three years of farm survey data on core management options for CSA farms. The core concept yields higher net income per acre than non-core management and, based on the stochastic efficiency analysis, should be regarded as the preferred management option for many CSA operators.

Key words: community-supported agriculture, farm management, stochastic efficiency analysis

Introduction

Community-supported agriculture (CSA), a concept of alternative agriculture (see, e.g., National Research Council; Moffitt), is gaining popularity in the northeastern United States and in the United States at large. The first CSA farming operation in the United States was begun in western Massachusetts during 1984. Today the number of CSA farms in Massachusetts stands at 39, and there are currently more than 1,000 CSA farms in the United States (Van En Center for CSA Resources).

Kelvin loosely defines CSA as a marketing arrangement in which farmers enter into an agreement with a group of local consumers to provide food for their families. Consumers agree to pay in advance for the food; most agreements require payment prior to planting, thereby providing the farmer with cash when it is most needed. Although each CSA operation has its own unique arrangements between farmers and shareholders, the farmer customarily is paid by the shareholders prior to the season for a weekly share of the harvest. CSA is a marketing approach that often brings together producers and consumers who share the same ideology toward food production and the environment. Shareholders in a CSA are generally interested in both the source of their food and the environment.

CSA presents an alternative management option for farmers, especially those operating small farms. A few earlier studies have focused on the economic viability of the

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Njundu Sanneh is a former research assistant, and L. Joe Moffitt and Daniel A. Lass are professors, all in the Department of Resource Economics, University of Massachusetts, Amherst. The authors thank an anonymous journal reviewer for helpful suggestions on an earlier version of this article. Funding support provided by the U.S. Department of Agriculture, Sustainable Agricultural Research and Education program under Grant No. 95LNE95-63, and the Massachusetts Agricultural Experiment Station under Project No. MAS00808 is gratefully acknowledged.

Review coordinated by Gary D. Thompson.

CSA concept as a farm management option (Suput; Lass, Rattan, and Sanneh; Kelvin). These studies have typically used enterprise budgets in analyzing the economic viability of existing CSA operations. While the assurance of economic viability is necessary for CSA to be sustainable, it is also important to keep the objective of many of these operations in perspective. CSAs, like many other "alternative agriculture" operations, historically have been strongly focused on the production of safer produce in an environmentally sensitive manner. In addition, CSAs are distinct in utilizing a marketing concept that places a great deal of emphasis on relations with the consumer. Even so, economic information concerning management options within the CSA concept is of interest to both existing and potential CSA operations.

In this study, we consider two aspects of a CSA farm operator's choice of management strategy. A CSA farm operator either can make all management decisions or can involve a core group of shareholders in the decision making. In a core-group management strategy, a group of shareholders participate in making operational decisions such as crop selection and the price of a share. We use stochastic efficiency analysis to compare net income per acre from core-group managed farms versus CSA farms in which the farmer makes all the decisions.

Background

Most CSAs in the northeastern United States market their shares during the winter months. The growing period and the provision of produce runs from about early May to November. Nearly all CSAs focus on providing a wide range of vegetable crops in their shares. Cooley and Lass reported that the three CSA farms in their study produced more than 70 vegetable and fruit crops. The shareholders purchase the shares during the winter season and, in so doing, secure a market for the farmer's produce and provide the farmer with financing for the operation. The farmer can then focus on production throughout the growing season.

The share prices are determined by the farm operator, in some cases with input from the shareholders. CSA operations sell various kinds of shares as a way of marketing their produce. Share types vary, but are generally classified as either working or nonworking. Shareholders pay "full price" for nonworking shares, which are categorized as full nonworking, half nonworking, and individual nonworking shares. Working shares are similarly designated as full working, half working, and individual working shares. For working shares, the shareholder contributes some form of labor to either production or marketing, or both, depending on the CSA operation. Other share types include "winter shares" and "group shares" sold mainly to institutions such as shelters and small restaurants. The full working share normally provides enough fresh produce for a family on a weekly basis. The commitment of funds by shareholders prior to the growing season relieves the farm operator of the need to secure financing for the seasonal operations. At the same time, the consumers' commitment ensures a secure market for the produce. The marketing of produce, which is a challenge for most small-scale farmers, is thus assured.

Agreements between farmers and consumers, whether verbal or by written contract, are not without problems. While Cooley found most consumers were happy with their CSA experience, concerns were raised about share content during the season. Most common was a concern expressed by shareholders about produce that they would rarely choose at a grocery. Few shareholders responding to Cooley's survey found the quantity of produce to be an issue. In fact, most estimated they wasted about 10% to 15% of their weekly shares.

Risks associated with the production activities of CSA operations are shared by the producer and the consumers. The resulting reduced marketing cost and risk sharing are luxuries enjoyed by CSA farmers that most small-scale farmers are not afforded. With the prefinancing of the operation by the shareholders, the farm operator also has more time to devote to farming activities than do other small-scale farmers. In addition, core-group shareholders' participation in budgeting often provides them an understanding of the farm operation and increases the likelihood of a positive image for the farm in the community. CSA farmers in some studies (Suput; Kelvin) have specifically identified the opportunity to educate others about farming and the relief from the sense of isolation felt by many small-scale farmers as additional benefits of the CSA concept.

For consumers, CSAs can serve as a source of locally grown, fresh foods at relatively lower prices (Cooley and Lass; Suput). In addition, the CSA concept gives consumers the opportunity to support local agriculture, make contact with nature, and, in the process, stems the decline in rural communities. CSA operations also provide shareholders an opportunity for social outings and greater involvement in the community—thereby transcending traditional agricultural activities and encompassing other social dimensions.

In terms of benefits to the community, the CSA concept has the potential to boost the local economy by allowing consumers to spend more of their disposable income on goods and services produced locally. This can be especially important in areas where a significant proportion of food is imported. Further, the CSA concept provides an alternative use of the land and slows the transformation of open landscapes in the community. Farmland can be placed in a trust for preservation purposes and can be used for CSA operations. Also, there is very little food spoilage with CSA operations because shareholders are willing to accept produce with minor blemishes. Finally, there is little packaging associated with CSA, and distribution costs are low (Van En and Roth).

Most CSA farms practice organic agriculture. Conventional farming practices have posed environmental, food safety, and socio-political challenges for policy makers, consumers, rural communities, and environmental groups. Such challenges include the pollution of groundwater through runoff of synthetic chemicals, a decline in rural communities as a result of the reduction of small-scale farms, and the potential for chemical residues in food. The alternative agricultural systems, including CSAs that have evolved in response to the problems of conventional agriculture, are generally small in size and have the potential to rekindle rural communities. CSA also has the potential to reduce the production risk as well as the marketing problems faced by small-scale farms. In so doing, CSA operations reduce the loss of farmland, and in particular farms with smaller holdings. In short, the CSA concept appears to have special potential for small-scale farmers who are interested in interacting with the community.

To realize this potential, it is important that economic analysis be utilized to identify efficient CSA management options. While enterprise budgets associated with different management options can be useful in describing an average outcome associated with a management option, such budgets do not provide criteria for choosing among options in a risky enterprise. The concept of economic efficiency used to evaluate different CSA management options should account for variability in economic returns in order to identify stochastically efficient options. In the next section, we provide a brief review of some popular methods for comparing the stochastic efficiency of management decisions. Each of the methods is used subsequently to compare different CSA management options.

Methods of Stochastic Efficiency Analysis

Stochastic efficiency analysis refers to comparison of a finite number of decisions that have uncertain outcomes to determine the efficient decisions. For example, for comparing CSA management options in a subsequent section, the uncertain outcomes are the net incomes per acre which follow from selection of different core management options. The desirability of stochastic efficiency analysis of farming decisions was noted by Anderson (p. 132):

> It is believed that whenever research is addressed to the development of new varieties and practices, etc. that are intended for adoption by 'risk-averse' farmers, the principles of stochastic efficiency are pertinent and indeed offer an important method for filtering out inefficient technological packages (i.e., packages that would not be preferred or adopted by those averse to risk) so that they are not extended to the farming community.

A number of stochastic efficiency criteria consistent with the expected utility hypothesis (von Neumann and Morgenstern) have been developed and used empirically to compare decisions in agriculture which involve uncertain outcomes. Well-known methods of stochastic efficiency analysis include (*a*) mean-variance (EV) analysis (Anderson, Hardaker, and Dillon); (*b*) stochastic dominance (SD) analysis (Hadar and Russell); (*c*) the exponential utility/moment-generating function (EUMGF) method (Yassour, Zilberman, and Rausser); and (*d*) mean-Gini (MG) analysis (Yitzhaki). All of these analytical methods possess strengths and weaknesses. For each, conditions sufficient for a decision to be efficient relative to another decision for a risk-averse decision maker can be based on the probability distribution of the outcomes. The outcome of interest here is the net income per acre, denoted by x, which is associated with a management option.

Mean-variance analysis is relatively easy to apply but may lead to inconclusive results, and is consistent with the expected utility hypothesis only if very restrictive conditions are satisfied—such as a quadratic utility function or a negative exponential utility function and normally distributed outcomes. Let F_i and F_j be the cumulative distribution functions associated with the uncertain outcomes of two distinct decisions. Under EV analysis, option i is efficient relative to option j if and only if:

$$(1) \qquad \int_a^b \left[F_j(x) - F_i(x)\right] dx \geq 0$$

and

$$(2) \qquad \int_a^b x^2\, d\left[F_i(x) - F_j(x)\right] + \left\{\int_a^b \left[1 - F_j(x)\right] dx\right\}^2 - \left\{\int_a^b \left[1 - F_i(x)\right] dx\right\}^2 \leq 0,$$

with at least one strict inequality.

Stochastic dominance analysis is generally regarded as the least restrictive method of stochastic efficiency analysis from an analyst's perspective, because it requires only very general assumptions about decision-maker preferences. A notable shortcoming of stochastic dominance analysis is the propensity for inconclusive results; that is, the likelihood that more than one alternative remains in the efficient set of alternatives following application of stochastic dominance rules. Under second-degree stochastic dominance analysis, option i is efficient relative to option j if and only if:

$$\int_a^x \left[F_j(t) - F_i(t)\right] dt \geq 0 \tag{3}$$

for all x, with strict inequality for at least one x.

Evaluation and comparison of certainty equivalents using the EUMGF method can identify a unique, efficient decision from among a set of possible choices involving uncertain outcomes. However, a comparison based on the EUMGF method is more restrictive than stochastic dominance in requiring use of a specific utility function for comparing decision alternatives. Under the EUMGF method, option i is efficient relative to option j if and only if:

$$\int_a^b -e^{-rx}\, d\left[F_i(x) - F_j(x)\right] > 0, \tag{4}$$

where the parameter r is the coefficient of constant absolute risk aversion.

A perhaps lesser known alternative to the EV, SD, and EUMGF approaches to stochastic efficiency analysis is based on the Gini mean difference associated with the distributions of uncertain outcomes. The MG method is known to be applicable in cases where the cumulative distribution functions associated with the uncertain outcomes of distinct decisions cross at most once, and may be useful in other cases (Yitzhaki; MacDonald, Moffitt, and Willis).

MG stochastic efficiency analysis may have some advantages over other approaches. First, the set of MG-efficient decisions may be a proper subset of the second-degree stochastic dominance efficient set. Hence, more conclusive findings may be permitted by this approach. Second, the MG approach does not require use of a specific utility function, and therefore does not involve the degree of restrictiveness associated with the EUMGF approach. Third, decisions identified by application of the MG approach are not dependent on outcome units as are the risk efficiency ranges identified by use of the EUMGF method. Finally, efficient decisions for risk-averse decision makers with absolute risk aversion confined to a left-most interval of constant absolute risk aversion are mean-Gini efficient (MacDonald, Moffitt, and Willis). Under MG stochastic efficiency analysis, option i is efficient relative to option j if and only if:

$$\int_a^b \left[F_j(x) - F_i(x)\right] dx \geq 0 \tag{5}$$

and

$$\int_a^b \left[F_j(x) - F_i(x)\right] dx - \int_a^b \left\{F_i(x)\left[1 - F_i(x)\right] + F_j(x)\left[1 - F_j(x)\right]\right\} dx \geq 0, \tag{6}$$

with at least one strict inequality.

Equations (1)–(6) can be used to compare decisions which result in uncertain outcomes. Following a discussion in the next section of the survey data underlying this study, CSA core management options are compared using EV, SD, EUMGF, and MG stochastic efficiency analysis.

Table 1. Number of Northeast CSA Survey Respondents by State, 1995–97

State	1995	1996	1997
Connecticut	2	2	2
Massachusetts	3	6	8
Maine	3	3	3
New Hampshire	0	1	3
New Jersey	1	1	2
New York	9	6	5
Pennsylvania	3	2	5
Vermont	1	4	4
Rhode Island	1	1	1
Total	23	26	33

Survey of CSA Operations in the Northeast

Data for this study were collected via a self-administered mail survey of CSA operations during the 1995–97 growing seasons. The response rate for the mail survey over the three growing seasons was 36%, and only two returned surveys were eliminated from the sample due to incomplete data. The mail surveys were sent to CSA operations in Connecticut, Massachusetts, Maine, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.

Table 1 reports the number of respondents by state for each year. In the sample, 14 farms participated in all three years, 11 farms participated in two of the three years, and 18 farms in just one year. The survey elicited data on the scale of CSA operations, including farm size and the proportion of acreage used for CSA operations. Operators were questioned about revenues from the CSA operations, other on-farm enterprises, and nonfarm sources of income. Questions were also asked about farm outputs, types and number of shares sold, and production information such as farm operating expenses, labor use, and weed, soil, and disease management. Finally, the respondents were asked to provide operator characteristics such as age, number of years of farming, CSA experience, and the operator's perceived benefits of the CSA to the farmer and to the community.

The CSA operations in our sample, like most organic farms in the region, were small-scale. Average CSA farm size and other characteristics of all farm operations in the survey are presented in table 2. The average farm size for the survey respondents was approximately 22 acres; of this total acreage, only about 50% was devoted to the CSA operation. The remainder of the land generally was devoted to more conventional agricultural marketing channels. All land on these operations was farmed under sustainable production methods, usually referred to as organic methods—reflecting the fact that the CSA phenomenon is relatively new in the United States and many operators are currently experimenting with the concept.

In addition to total cropland, table 2 also presents the various share types and their prices, number of full-weighted share equivalents, and the pounds of product per share. The various share types in the table were converted to a weighted index of full share equivalents. The weights for the nonworking shares were based on their price relative

Table 2. Farm Characteristics for the Average Northeast CSA Operation

Characteristic		1995	1996	1997
Total Cropland (acres)[a]		22.20	23.19	18.72
		(28.50)	(40.60)	(29.20)
CSA Cropland (acres)[a]		11.96	10.79	7.59
		(25.50)	(21.20)	(9.30)
Share Price by Type of Share ($/share):[b]				
▸ Nonworking:	Full	416.32	412.88	352.98
	Individual	326.00	298.29	270.56
	Half	243.75	247.00	273.35
▸ Working:	Full	260.67	248.89	246.39
	Individual	0.00	205.00	136.25
	Half	135.00	131.67	132.50
▸ Other (senior, etc.)		307.50	358.33	266.43
Full Share Equivalents (shares)		75.09	77.29	92.04
Product/Full Share (lbs.)		374.17	329.85	324.20

[a] Numbers in parentheses are standard deviations.
[b] Share types were converted to a weighted index of full share equivalents (refer to text narrative).

to the price of a full nonworking share, and those for the working shares were similarly based on the price of a full working share. For the "other" share type, the weights were based on the price of a full nonworking share.

Analysis of CSA operations in the survey focused on the core concept employed by some of the operations. The concept of a core group entails a group of shareholders taking part in the decision-making process of a CSA operation. For some CSAs, the presence of a core group occurs naturally, as the shareholders may form a CSA operation and hire an operator to take charge of the day-to-day farming activities. The extent of involvement of the core group in the decision-making process varies from operation to operation. For some operations, involvement may only be to the extent that shareholders have a say in what variety of produce the operation will provide. For others, the core may participate in deciding what crops and how much to produce, the amount of hired labor to use, and operator wages. The core group meets with the operator on a regular basis and is familiar with the budget for the farm. Objectives of the operation in terms of variety and volume of produce are discussed; the costs of achieving these objectives are assessed, and share prices are set to cover expenses.

About half the CSA operations had core groups. Survey information analogous to that shown in table 2 for all CSAs is presented for core and non-core CSAs in table 3. The CSA operations with core groups were on average more than twice the size of non-core CSAs. The number of full share equivalents is considerably higher for the core farms than for the non-core operations. For operations with core groups, the average price for a full share equivalent was $558.75, in contrast to $312.73 for those without a core group.

The core and non-core operations also show some differences in income, expenses, and net income. The last three rows of table 3 report average per acre income, expenses, and net income figures for core and non-core CSAs by year. In addition to higher average income per acre, the core operations typically also had higher average expenses per acre than their non-core counterparts. Net income per acre was variable for both the core and

Table 3. Northeast CSA Farm Characteristics, Core and Non-Core Management Options

	Core			Non-Core		
Characteristic	1995	1996	1997	1995	1996	1997
Number of Farms	11	11	16	12	15	17
Total Cropland (acres)	32.68	26.91	24.87	12.58	21.75	13.29
CSA Cropland (acres)	18.21	16.08	11.04	6.13	6.25	4.72
Shares by Type (shares):						
▸ Nonworking: Full	35.45	50.00	88.47	36.00	19.00	17.65
Individual	20.68	32.35	12.98	0.00	5.31	7.35
Half	26.28	25.04	15.85	6.48	9.75	15.16
▸ Working: Full	14.55	8.05	19.80	0.58	1.56	0.78
Individual	0.00	0.98	0.86	0.00	0.98	0.93
Half	0.58	0.25	0.97	0.28	0.00	8.09
▸ Other (senior, etc.)	0.89	0.18	3.18	2.46	3.85	1.23
Full Share Equivalents (shares)	98.43	116.85	142.11	45.80	42.43	50.31
Income ($/acre)	5,148	6,436	5,702	4,019	4,424	3,833
Expenses ($/acre)	4,264	4,817	3,436	3,927	2,667	2,457
Net Income ($/acre)	884	1,620	2,266	92	1,757	1,376

non-core operations over the three growing seasons. Core operations achieved higher net income per acre than non-core operations during 1995 and 1997, while non-core operations had higher average net income per acre during 1996.

Differences in the means were not statistically significant; however, test results reported in the next section reveal statistically significant differences in the net income distributions. In the survey, 12 non-core farms were operating at a loss as measured by negative net annual income per acre, while nine core farms were operating at a loss. The variability in net income underscores the need for a rational approach to management options with respect to risk. The survey data provide a foundation for conducting a stochastic efficiency analysis of core and non-core management options following estimation of probability distributions for net income per acre for core and non-core CSA management options in the next section.

Estimated Net Income Distributions

Table 4 presents some descriptive statistics of real net income per acre for the core and non-core CSA management options. Statistics in table 4 are calculated with net income expressed in 1997 dollars using the consumer price index for conversion. The stochastic efficiency criteria depicted in equations (1)–(6) depend on the probability distributions associated with net income per acre for the core and non-core management options. In this section we focus on estimation of these probability distributions. The time-series, cross-section data utilized for estimation and testing were pooled for purposes of this study. In preliminary regression analyses on both net returns and costs, tests of pooling could not reject the null hypothesis that the parameter coefficients were equal across the three years (Rattan).

Statistical tests for normality provided by D'Agostino, Belanger, and D'Agostino were calculated for both core and non-core observations on net income per acre. Test statistics

Table 4. Descriptive Statistics for Real Net Income per Acre, Northeast CSA, Core and Non-Core Operations, 1995–97

Statistic	Core	Non-Core	Statistic	Core	Non-Core
Number of Farms	38	44	Maximum ($/acre)	6,827	5,974
Mean ($/acre)	1,575	1,096	Skewness	0.260	-1.116
Std. Deviation ($/acre)	2,789	2,471	Gini Mean Diff. ($/acre)	3,147	2,788
Minimum ($/acre)	-3,826	-7,556			

Note: Statistics are calculated with net income expressed in 1997 dollars, using consumer price index conversion.

Table 5. Statistical Test Results for Observations of Real Net Income per Acre by CSA Management Option

	TEST		
Management Regime	Skewness	Kurtosis	Normality
Core	0.74 (0.23)	-0.78 (0.22)	1.15 (0.56)
Non-Core	-2.95 (0.001)	3.08 (0.002)	18.17 (0.0001)

Note: Numbers in parentheses are p-values.

for skewness, denoted $Z(\sqrt{b_1})$, and kurtosis, $Z(b_2)$, as well as the omnibus test statistic, K^2, were calculated. Results of the normality tests are reported in table 5. Normality can be rejected for net income per acre observations associated with the non-core management option, and pursuit of an alternative probability distribution for net income per acre for this management option is warranted.

While alternatives to the normal probability distribution, such as the gamma density and beta density, have been estimated and utilized in stochastic efficiency analysis (e.g., Moffitt et al.), the hyperbolic trigonometric (HT) density investigated by Taylor provides perhaps the most exceptional flexibility among available alternatives, as demonstrated in Taylor's examples. The HT density involves utilizing a polynomial expression in conjunction with the logistic probability density function to provide a very flexible functional form. The HT density estimated by Taylor employs a cubic polynomial of the form:

$$(7) \qquad ht(x) = 0.5(b + 2cx + 3dx^2)\text{sech}(a + bx + cx^2 + dx^3),$$

where sech is the hyperbolic secant function, and a, b, c, and d are parameters to be estimated. The HT density is regarded as a flexible form for approximating an unknown probability density function; hence, the parameters in (7) are not readily interpretable in terms of distribution moments or other statistical concepts. Taylor recommends maximum-likelihood estimation of the parameters in equation (7), where the log-likelihood function is given by $\Sigma \ln(ht(x))$. Maximum-likelihood estimates of the parameters in equation (7), with x denoting net income per acre for the non-core management option, are $\hat{a} = -0.4823$, $\hat{b} = 0.000388$, $\hat{c} = 1.181 \times 10^{-8}$, and $\hat{d} = 1.199 \times 10^{-13}$. Estimated standard errors associated with the estimates of a, b, c, and d are 0.139938, 0.000069, 1.19068×10^{-8}, and 1.49092×10^{-12}, respectively.

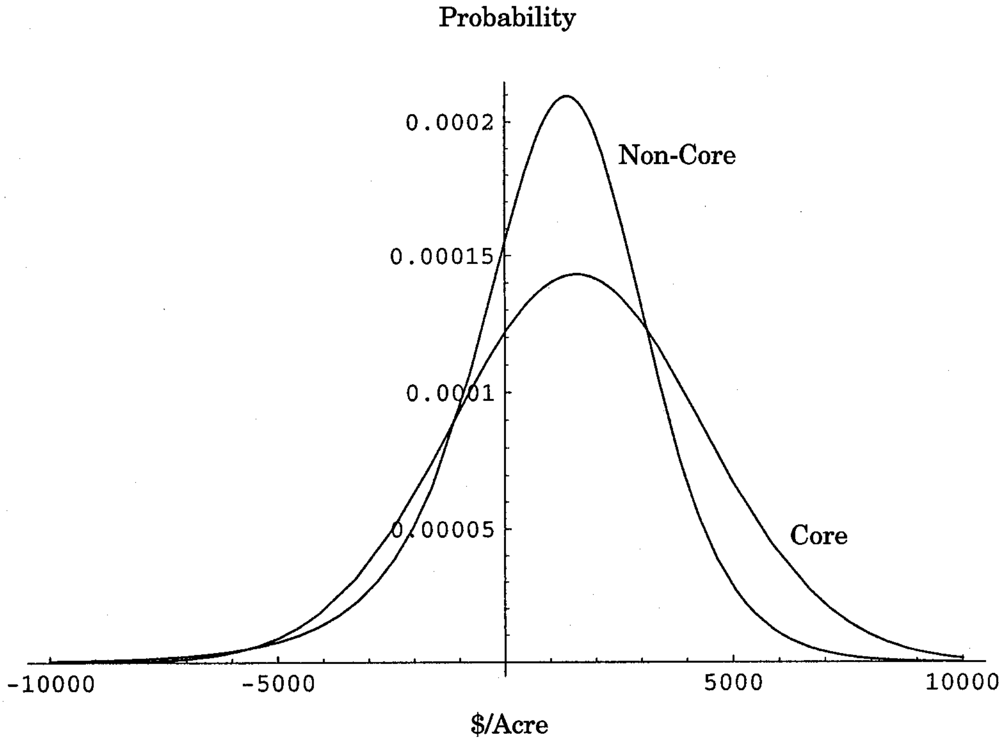

Figure 1. Estimated probability density functions for net income per acre, core and non-core CSA management options

Comparison of the fitted HT density to the normal density is pursued according to the Akaike information criterion (AIC). The criterion is used for model selection, not hypothesis testing. In this context, statistical models are regarded as approximating the true but unknown probability distribution, and the focus is on obtaining the model which provides the best approximation. The values of the AIC statistic for the HT density and the normal density were 810.83 and 815.348, respectively, suggesting that the HT density be selected over the previously rejected normal density for approximating the probability distribution of net income per acre associated with the non-core management option. The HT density was also estimated for core net income per acre, and the AIC was applied as well. In this case, the normal density was selected over the HT density, but barely—thus revealing the flexibility of the HT in approximating a normal curve.

The fitted normal density for core net income per acre and the fitted HT density for non-core net income per acre are shown in figure 1. The probability distributions depicted in the figure are used in a stochastic efficiency analysis of CSA core management options in the next section.

Table 6. Stochastic Efficiency of CSA Management Options

Stochastic Efficiency Criterion	Efficient Set of Options
Mean-Variance (EV)	Core, Non-Core
Stochastic Dominance (SD)	Core, Non-Core
Exponential Utility/Moment-Generating Function (EUMGF)	Core for $0 \leq r \leq 0.018$
Gini Mean Difference (MG)	Core

Stochastic Efficiency Analysis

Probability distributions of net income per acre for the core and non-core groups, $F_{CORE}(x)$ and $F_{NON\text{-}CORE}(x)$, respectively, where x is net income per acre, were inferred in the previous section with the normal distribution for $F_{CORE}(x)$ and the HT distribution for $F_{NON\text{-}CORE}(x)$. Stochastic efficiency analysis of core versus non-core management options by the various methods was conducted based on equations (1)–(6).

Table 6 shows the results of the stochastic efficiency analysis. Stochastic efficiency analysis by the EV criterion based on equations (1) and (2) is inconclusive. Hence, the relative efficiency of these options for the risk-averse CSA operator cannot be determined by EV analysis because the core has both a higher mean and variance than the non-core option. Similarly, as can be easily verified, the condition depicted by equation (3) for stochastic dominance analysis is not satisfied for the estimated probability distributions; the stochastic dominance approach therefore cannot discriminate between the core and non-core management options. The two management options are both in the efficient set, with neither strategy dominating the other.

The EUMGF approach to stochastic efficiency analysis also uses the estimated probability distributions for net income per acre in computing the certainty equivalent (CE) for each alternative strategy. The statistics in table 4 can be used in evaluating the CE for the core option under normality (Yassour, Zilberman, and Rausser), while the HT density can be used in conjunction with equation (4) to evaluate the CE associated with the non-core management option. The certainty equivalents are evaluated for various values of constant absolute risk aversion, r. For the estimated probability distributions, the core strategy is superior to the non-core strategy for nonnegative values of r less than 0.018. For $r \geq 0.018$, the two strategies switch and the non-core strategy dominates the core. The switching point for the two strategies can be observed in figure 2, which presents a graph of the core certainty equivalent minus the non-core certainty equivalent. Some risk-averse CSA operators prefer the core management option; only less risk-averse CSA operators ($r \geq 0.018$) will prefer the non-core over the core management option.

The mean-Gini approach to stochastic efficiency is based on the criteria described in equations (5) and (6). Given the statistics shown in table 5, only the core management option is in the MG efficient set. Note that the Gini mean difference in table 5 is interpreted as the average distance between two successive observations from the net income per acre density function, and is therefore a measure of dispersion in net income per acre. The MG stochastic efficiency analysis is known to identify decisions which are preferred by decision makers with absolute risk aversion, not necessarily constant, in a positive interval which includes zero (MacDonald, Moffitt, and Willis). Hence, the

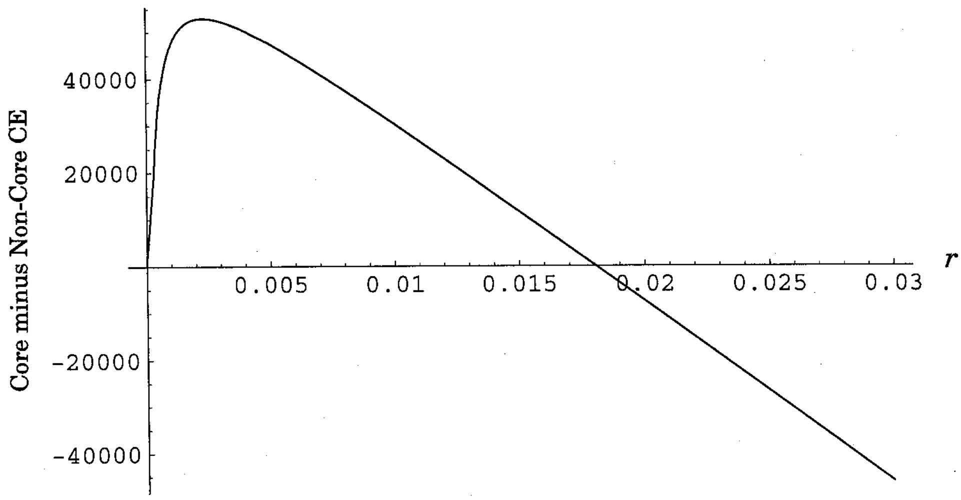

Figure 2. Difference in certainty equivalence (CE) for core and non-core management options as a function of constant absolute risk aversion (r)

results of the MG analysis suggest that risk-averse CSA farm managers with absolute risk aversion confined to a left-most interval of absolute risk aversion will prefer the core management option.

Using estimated probability distributions for net income per acre, the EV and stochastic dominance approaches failed to discriminate between the two management options as well. The core management option was identified as the unique, efficient management option by the MG approach. Under the EUMGF approach, the core management option was identified as the efficient strategy for perhaps many risk-averse farm managers. The non-core strategy was preferred by risk-averse CSA operators with a coefficient of constant absolute risk aversion (r) greater than 0.018. The stochastic efficiency findings suggest that many CSA operators, particularly more risk-averse ones, will prefer core to the non-core option.

Summary and Conclusions

The CSA concept has evolved in response to the search for alternative agricultural production systems that are economically viable and environmentally friendly. The continued decline in both the number of and the acreage in small-scale farms and rural communities, as well as food safety and environmental concerns, has heightened interest in the CSA concept in the northeastern United States. CSA not only serves as an alternative to the conventional agricultural system in the northeastern United States and the United States at large, but also advances other farm operator and consumer benefits that go beyond pecuniary objectives.

The mean-variance, stochastic dominance, mean-Gini, and exponential utility/moment-generating function approaches to stochastic efficiency were applied in undertaking stochastic efficiency analysis of the core and non-core management options for CSA farms. Based on the stochastic efficiency analysis, the core concept should be regarded as the preferred management option for many CSA operators. Cooley and Lass previously showed the potential of CSA operations to increase share prices to cover costs. More importantly, price increases to consumers could be made while the operations still charge lower prices to the consumer than do natural food supermarkets in the Northeast.

In view of the findings of this study, the management of the sale of shares and involvement of the shareholders through the core-management option is a further means by which CSA farms can achieve profitability for long-term sustainability. In weighing the impact of CSA operations, it is worth noting that there are other benefits which should be considered in arriving at a fair evaluation of the CSA concept. For example, the CSA as an alternative production system for small-scale farmers requires that the farm operator and consumers have similar objectives. Consequently, this farming system is recommended mainly for farmers who are interested in close interaction with consumers.

An important caveat to the conclusions of the stochastic efficiency analysis reported here concerns potential transactions costs which may differ for core and non-core management options and which were not quantified in this study. The core CSA management option involves farmer interaction with a group of shareholders who accept additional responsibility for management of the CSA operation. There are a number of possible roles for the core group. For example, the core group may take a limited role in management and act more as an advisory group, gathering periodically to provide some feedback to the farmer about the shares, share prices, and other activities on the farm. In this case, the transactions costs to the farmer would probably vary little from the non-core CSA management option, with the exception of the costs associated with periodic meetings. Additional transactions costs would be incurred in meeting with the core group, where costs become an increasing function of the frequency of meetings.

Alternatively, a more involved form of core-group management is possible. In such cases, the farmer incurs transactions costs in meeting with the core group prior to the winter marketing season to discuss the past season, share content, and share prices. Transactions costs may also be incurred during the preseason meeting through bargaining with the core group over share content and price. If the farmer then handles the subsequent sale of shares, additional transactions costs are incurred per contract as described above for the non-core CSA management option. Transactions costs may be incurred during the season with an active core group that meets several times during the season to discuss the CSA operation.

Transactions costs may differ between core and non-core CSA management options depending upon the level of involvement of the core group. The survey data used in this study identified CSA farms that utilized the core management option, but did not identify core-group activity levels. Even so, casual observation reveals the most common core-group models in use among the survey farms were those where the core group served primarily in an advisory role to provide input on the content and pricing of shares. Future research should quantify transactions costs for core and non-core CSA management options and compare the CSA concept to conventional farming. Also, given that long-term sustainability depends on the CSA farms maintaining sale of shares to cover operating expenses, further studies to identify means of satisfying shareholder needs appear warranted.

[*Received August 2000; final revision received June 2001.*]

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