



Effects of sample size on MOTAD and Target MOTAD solutions
by Clark Thomas Jones

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in
Applied Economics
Montana State University
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Abstract:

This study examines the effects of sample size on MOTAD and Target MOTAD solutions. Data sets based on historical observations are generated with a multi-variate normal random deviate generator.

A representative Montana dry-land grain farm supplied the historical data. Ten data sets of each sample size (10, 20, 30, 40, 50, and 70 observations per activity) are generated and input into both of the linear risk models.

All of the MOTAD models arrived at feasible solutions. Considerable instability was observed in the objective function values and basis activity levels for even the largest samples (at the lower deviation levels). However, as sample size increased the MOTAD results tended to be more stable.

Several of the Target MOTAD models were infeasible due to the specified deviation and/or target income levels. In the feasible Target MOTAD models, stability of the objective function values and basis activity levels was noted when sample sizes were 30 observations or larger. Feasible Target MOTAD models resulted in considerably larger objective function values than comparable MOTAD models. The feasibility problems of the Target MOTAD specification serve to illustrate theoretical problems of the traditional MOTAD model.

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MONTANA STATE UNIVERSITY
Bozeman, Montana

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of a thesis submitted by

Clark Thomas Jones

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citation, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

This study examines the effects of sample size on MOTAD and Target MOTAD solutions. Data sets based on historical observations are generated with a multi-variate normal random deviate generator.

A representative Montana dry-land grain farm supplied the historical data. Ten data sets of each sample size (10, 20, 30, 40, 50, and 70 observations per activity) are generated and input into both of the linear risk models.

All of the MOTAD models arrived at feasible solutions. Considerable instability was observed in the objective function values and basis activity levels for even the largest samples (at the lower deviation levels). However, as sample size increased the MOTAD results tended to be more stable.

Several of the Target MOTAD models were infeasible due to the specified deviation and/or target income levels. In the feasible Target MOTAD models, stability of the objective function values and basis activity levels was noted when sample sizes were 30 observations or larger. Feasible Target MOTAD models resulted in considerably larger objective function values than comparable MOTAD models. The feasibility problems of the Target MOTAD specification serve to illustrate theoretical problems of the traditional MOTAD model.

CHAPTER 1

OBJECTIVES

Risk is commonly included in farm management decision models. MOTAD and Target MOTAD linear programming farm management models incorporate risk by direct use of data associated with the risky element (returns) rather than parameters associated with the distribution of the risky element. Data may be limited due to availability or inconsistency of historical observations or the cost of obtaining additional observations. Therefore, it seems likely that these models may be used with small samples. Typical MOTAD models have included less than twenty observations. The objective of this research is to investigate the relationship between sample size and the stability (as indicated by the objective function level and basis activities) of MOTAD and Target MOTAD results.

Literature Review

As previously stated, many mathematical programming models have been utilized to include risk in agricultural research. Quadratic programming (QP) as developed by Markowitz (1959) was formulated as a means to incorporate risk in decision analysis. Later, Hazell (1971) offered MOTAD as a linear alternative to QP. Recently, researchers are questioning the theoretical basis of QP and MOTAD and offering alternative programming models. Literature that relates to the historical development of risk programming is reviewed within this section.

Quadratic Programming

Quadratic programming utilizes the mean and variance associated with the distribution of the risky element to estimate efficient portfolios of risky farm enterprises. In QP a quadratic objective function is optimized subject to linear constraints. QP is justified if the decision maker's utility function is quadratic or can be approximated by a quadratic function.

This quadratic utility function is of the general form (Markowitz 1959)

$$U(x) = a_0 + a_1 x + a_2 x^2 \quad (1)$$

where x is a risky portfolio and a_0 , a_1 , and a_2 are constants. By Taylor's theorem* (Chiang 1974) any n^{th} degree polynomial can be expanded** around any point $x_0 \neq x$ and expressed in another n^{th} degree polynomial form. Since a utility function defines only rank and a constant b can be defined as equal to a_2/a_1 , Equation 1 can be re-written such that

$$U(x) = x + bx^2$$

Further by the expected utility theorem

$$\begin{aligned} U(x) &= E(x + bx^2) \\ &= E(x) + b E(x^2) \end{aligned}$$

and if $M_k(x)$ is defined as the k^{th} moment $E[x - E(x)]^k$ about the mean it follows that

$$\begin{aligned} U(x) &= E(x) + b \{M_2(x) + [E(x)]^2\} \\ &= E(x) + b[E(x)]^2 + b M_2(x) \\ &= E(x) + b[E(x)]^2 + b V(x) \end{aligned}$$

* $U(x)$ must have a finite n^{th} derivative $U^n(x)$ for all x and $U^{n-1}(x)$ must be everywhere continuous.

**In this application to expand a function $U = f(x)$ means to transform that function into a polynomial form in which the coefficients of the various terms are expressed in terms of the derivative values $f^1(x_0)$, $f^2(x_0)$, etc., all evaluated at the expansion point x_0 .

where V is the variance of x and b is generally assumed to be negative such that the utility function demonstrates diminishing marginal utility.

The quadratic utility function ranks portfolios by two criteria: the expected income (E) and the variance of that expected income (V). An efficient set* of portfolios based on on E - V criterion can be estimated using a parametric QP algorithm. E - V analysis can be represented diagrammatically as in Figure 1. QP can lead directly to a utility maximizing portfolio (point C) if a unique utility function is specified. The more common approach is to determine the E - V efficient set of portfolios (line ZB) using QP. From the efficient set the individual decision maker can select an optimal portfolio (point C).

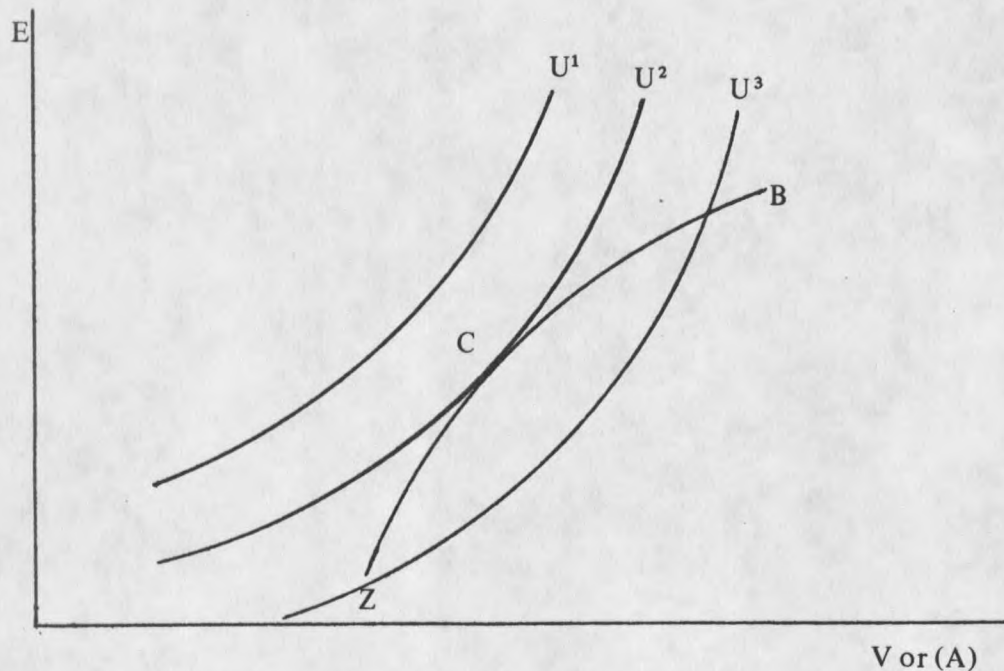


Figure 1. Representation of E - V or (E - A) analysis (Anderson, Dillon, and Hardaker 1980, Figure 7.1).

*An efficient set is a set of portfolios that minimize V or (A) for given E levels or conversely, a set of portfolios that maximize E for given V or (A) levels.

Anderson, Dillon, and Hardaker (1980) point out some desirable and undesirable aspects of quadratic programming. QP is desirable because it is associated with a simple utility function specification. It also implies a risk averse decision maker.

QP is undesirable because the implicit quadratic utility function indicates increasing risk aversion. Additionally, polynomial utility functions in general have been criticized on two other theoretical grounds. First, polynomial functions are not everywhere monotonically increasing. Second, a polynomial utility specification of degree n implies that only the first n moments of the distribution function (returns) are used in specifying the utility function.

The lack of or prohibitive cost of adequate computer codes to handle E-V analysis have encouraged researchers to develop linear decision models.

The MOTAD Model

Hazell (1971) proposed to use the expected income-mean absolute deviation (MOTAD) criterion when analyzing risky alternatives. This criterion is consistent with many characteristics of E-V analysis. The expected income (E) mean absolute deviation (A) approach has an important difference. The E-A criterion has the advantage of allowing the use of common parametric linear programming algorithms to trace out E-A efficient form plans.

Hazell's (1971) minimization of total absolute deviations model can be constructed similar to Watts, Held, and Helmers (1984) formulation. This general form is

$$\begin{array}{ll}
 \text{Min} & v y^+ + v y^- \\
 \text{S.T.} & \\
 (1) & A x \begin{matrix} > \\ \leq \end{matrix} b \\
 (2) & \bar{r} x = \bar{y} \\
 (3) & (R - \bar{R}) x - I y^+ + I y^- = 0 \\
 (4) & x, y^+, y^- \geq 0
 \end{array}$$

where

$v = 1 \times ss$ vector in which each element is 1,

$y^+ = ss \times 1$ vector of annual positive return deviations from $\bar{y}$,

$y^- = ss \times 1$ vector of annual negative return deviations from $\bar{y}$,

$A = s \times n$ matrix of technological constraints,

$x = n \times 1$ vector of decision variables,

$b = s \times 1$ vector of resource levels or constraints,

$\bar{r} = 1 \times n$ vector of expected return levels for each activity,

$\bar{y} =$ mean return level,

$R = ss \times n$ matrix of annual returns for each real activity,

$\bar{R} = ss \times n$ matrix consisting of $ss, \bar{r}$ vectors,

$I = ss \times ss$ identity matrix,

$s =$ number of technological constraints,

$ss =$ number of years (observations or states of nature) considered,

$n =$ number of real activities.

The original MOTAD specification (Hazell 1971) can be re-formulated as a maximization model. Anderson, Dillon, and Hardaker (1980) provided the following maximization model.

$$\begin{array}{ll}
 \text{Max} & \bar{r}x \\
 \text{S.T.} & \\
 (1) & Ax \leq b \\
 (2) & vy^- \leq k \\
 (3) & Rx + Iy^- \geq q \\
 (4) & x, y^- \geq 0
 \end{array}$$

where constraint (3) in the original MOTAD model was re-written as $Rx + Iv^- \geq q$ where $q = \bar{R}x$ or an $ss \times 1$ vector in which each element equals $\bar{y}$.

The E-A efficient frontier is traced out by parametrically running the linear model with respect to k , the maximum total negative deviation level. Figure 1 can diagrammatically represent E-A analysis if the horizontal axis is redefined as mean absolute deviations from the mean (A) and line ZB is an E-A efficient set.

The MOTAD approach assumes a utility function of the general form (Markowitz 1959)

$$U(x) = a_0 + a_1 x + a_2 |x - E(x)|$$

If the correct utility function is quadratic, Hazell (1971) suggested that the E-A criterion will approximate the E-V criterion. He presented some statistical arguments for the sample mean absolute deviation (MAD) as a substitute for the sample variance in estimating population variance and E-V efficient farm plans.

Sample variance and sample MAD are unbiased estimates of population variance. However, there are differences in the relative efficiencies of the two population variance estimators. Hazell (1971) states that for large samples MAD is approximately eighty-eight percent as efficient in estimating population variance as traditionally estimated sample variance.

Thomson and Hazell (1972) further examine the efficiency of the MAD criterion as a risk measure, given a quadratic utility function. They used a different measure of efficiency to analyze the MAD estimator. They stated that alternative risk measures should be compared by their ability to rank basic feasible farm plans. They used the ability to correctly select between three combinations of basic activities to define ranking efficiency. This ranking efficiency is different than the relative efficiency (MAD versus variance) statistics that Hazell (1971) used to compare the estimators.

Thomson and Hazell (1972) state that evaluating this ability to rank farm plans is more complicated than measuring their relative efficiencies. Ranking ability is complicated by differences in (1) population variances of the farm plans, (2) the functional forms of

the income distributions, (3) correlations of the income distributions, and (4) sample size. They attempted to account for all of these complicating factors by using a Monte Carlo approach. It was only in cases of high correlation and/or large samples that the MAD estimator suffered large ranking efficiency losses. The efficiency loss suffered by the MAD estimator was found to be greater when a normally distributed income or gross margin stream was used rather than a income stream that was distributed mixed-normally or as a chi-square. The experiment results indicated that the MAD criterion was more efficient than the authors expected.

An Alternate Model

Risk programmers are questioning the theoretical basis of QP and MOTAD. Articles by Tauer (1983) and Watts, Held, and Helmers (1984) call attention to Markowitz's (1959) contention that semivariance (S) is preferred to variance when selecting portfolios.

The semivariance (measured from a fixed reference point) utility function that Markowitz (1959) finds desirable is of the general form

$$\begin{aligned} U(x) &= a_0 + a_1 x + a_2 [(x - d)^2] & \text{for } x \leq d \\ \text{and } &= a_0 + a_1 x & \text{for } x \geq d \end{aligned}$$

where d is a fixed risk reference point.

Tauer (1983) has included the semivariance concept and a fixed reference point in a linear model called Target MOTAD. In Target MOTAD risk is defined as the expected sum of the negative deviations measured from some arbitrary target reference level. Tauer (1983) shows that Target MOTAD, unlike MOTAD, is second degree stochastic dominant.

The Target MOTAD model as formulated by Watts, Held, and Helmers (1984) is

$$\begin{array}{ll} \text{Max} & \bar{r}x \\ \text{S.T.} & \\ (1) & Ax \leq b \\ (2) & Rx + Iy^- \geq d \\ (3) & vy^- \leq k \\ (4) & x, y^- \geq 0 \end{array}$$

where d is a $ss \times 1$ vector in which all elements equal a fixed risk reference point, k is the maximum acceptable total negative deviations from the target, and y^- in this case is an $ss \times 1$ vector of annual negative return deviations from the risk reference point.

The Target MOTAD approach assumes a utility function (Watts, Held, and Helmers 1984) in which

$$U(x) = a_0 + a_1x + a_2|x - d| \quad \text{for } x \leq d$$

$$\text{and } = a_0 + a_1x \quad \text{for } x \geq d.$$

Watts, Held, and Helmers (1984) used an empirical farm problem to compare MOTAD and Target MOTAD. They emphasized that minimizing only negative deviations from a target has been shown to be consistent with (1) decision makers' actions and (2) Bernoulian utility theory. They emphasized that MOTAD can be re-specified with an objective function that minimizes total positive return deviations measured from a mean return level. They also stated that E-V and E-A analyses both have a moving target level, mean income. This moving income level creates a portfolio ranking problem when attempting to estimate efficient sets of portfolios.

The following chapter summarizes the development of a model farm that is a primary part of this research project. Also in Chapter 2, nineteen years of returns over variable costs observations are developed from historical data. The parameters of the historical returns' distributions are estimated. The estimated parameters are assumed to be population parameters in this study. Based on these population parameters random samples of varying sizes are generated. MOTAD and Target MOTAD solutions from the generated samples are presented in Chapter 3. In Chapter 4, general conclusions are discussed.

CHAPTER 2

MODEL FARM AND SAMPLE GENERATION

Model Farm Development

A hypothetical twenty-five hundred acre small-grain farm was developed to illustrate and compare MOTAD and Target MOTAD solutions. The farm's technological coefficients and resource constraints were derived to represent a typical north-central Montana farming situation.

The farm can produce four types of small-grain crops; winter wheat, spring wheat, durum wheat, and barley. All four grain crops can be raised on land that was fallowed* the previous growing season and all the crops except durum wheat can be grown on land that was cropped the previous season. The abbreviations used in this paper for the seven cropping activities are:

- (1) Winter wheat after fallow (WWF)
- (2) Winter wheat after crop (WWC)
- (3) Durum wheat after fallow (DWF)
- (4) Spring wheat after fallow (SWF)
- (5) Spring wheat after crop (SWC)
- (6) Barley after fallow (BF)
- (7) Barley after crop (BC)

*Fallowing in this study refers to the activity of mechanically maintaining unsown cropland through a growing season to destroy weeds and conserve soil moisture.

A typical crop rotation constraint is imposed on the modelled farm. The rotation constraint allows no more than one-half of the total acres planted in any year to be planted on land that was cropped the previous season. Note that due to the fallowing activity two acres of land are required to grow one acre of the crops WWF, DWF, SWF, and BF while only one acre of land is required to raise an acre of the crops WWC, SWC, and BC.

Field labor is the only other production resource that is explicitly constrained for use in the two linear risk programming frameworks. The amount of the farm operator's labor that is available for field work is limited during the normal crop growing season (April-September). The seven possible labor constraining periods are abbreviated as follows:

- (1) April (L1)
- (2) May (L2)
- (3) June (L3)
- (4) July (L4)
- (5) First-half August (L5)
- (6) Second-half August (L6)
- (7) September (L7)

The majority of the field labor used in this farm planning model is provided by the operator. It was assumed that the farmer will provide up to ten hours of field labor per day during the spring planting (April) and harvesting (August) seasons. Eight hours per day was assumed to be the operator's field labor limit during the remainder of the growing season. When necessary, it was assumed that additional field laborers can be hired for the gross wage rate of six dollars per hour.

The days suitable for fieldwork were derived from Montana Agricultural Experiment Station Report 67 (Yager and Greer 1974) on estimating suitable days for fieldwork. Their report used weather data for north-central Montana to approximate the days that are favorable for fieldwork in that region. The labor availability constraint levels for the seven

periods (L1-L7) are total days suitable* for fieldwork in a given period multiplied by the average number of hours that the operator will spend on fieldwork during a day in that particular period.

Monthly labor requirement coefficients (per acre) were developed for the seven competing cropping activities. The labor coefficients are based on information contained in bulletins published by the Montana State University Cooperative Extension Service (Fogle and Luft 1980).

The field operations performed on the farm and the hours of field labor required per acre for each operation are presented below.

- (1) Fallowing operation (.09 hours)
- (2) Harvesting operation (.63 hours)
- (3) Planting operation (.12 hours)
- (4) Spraying operation (.06 hours)

In Table 1 the number and timing of the field operations for each cropping activity are featured; and in Tables 6 and 7 the total operator field labor constraint levels and crop field labor coefficients are presented.

Historical Data Series

Samples of ROVCs were generated from a distribution. The parameters of that distribution were estimated from historical data series of ROVCs. The historical data series was developed for the nineteen years between 1964 and 1982 inclusive.

Variable costs of production for the seven cropping activities were derived from MSU CES (Fogle and Luft 1980) dryland crop production budgets. The specific crop production budgets that were used in this study are found in Appendix A.

*Eighty percent of the time at least the number of field days (hours) in Tables 6 and 7 will be available for fieldwork.

Table 1. Number and Timing of Field Operations by Crops.

Crop(s)	Operations	Labor Period
WWF	Fallowing	L2, L3, L3, L4
WWF	Harvesting	L5
WWF	Seeding	L7
WWF	Spraying	L3
DWF, SWF, BF	Fallowing	L1, L2, L3, L3, L4
DWF, SWF, BF	Harvesting	L6
DWF, SWF, BF	Seeding	L1
DWF, SWF, BF	Spraying	L3
WWC	Fallowing	L6, L7
WWC	Harvesting	L5
WWC	Seeding	L7
WWC	Spraying	L3
SWC, BC	Fallowing	L1, L1
SWC, BC	Harvesting	L6
SWC, BC	Seeding	L1
SWC, BC	Spraying	L3

For each of the seven alternative cropping activities nominal gross returns were computed from a time series of annual average county yields (Pondera county) and a comparable annual time series of state average prices. The yields were obtained by telephone interview with Randy Van Winkle (1983). The yields were from the Montana Crop and Livestock Reporting Service's long time series on yields and are contained in Table 2. The average annual commodity prices are from the *Montana Agricultural Statistics* (1965-1983) series "Prices Received by Montana Farmers: for selected commodities."

To remove inflation, variable costs of production and prices received for commodities are converted to a real fourth quarter 1982 dollar basis. The Implicit Price Deflator for GNP was used as the adjuster.

The time series data of county yields were regressed against a time variable to check for trend in the data. The ordinary least squares option in White's (1980) statistical package was used to check for an indication of significant trend in the annual yield observa-

Table 2. Crop Yields After Reduction for Seed.*

Year	Crop Enterprise						
	WWF	WWC	DWF	SWF	SWC	BF	BC
1982	48.0	33.1	39.7	45.4	34.0	54.8	51.8
1981	41.1	27.1	33.0	37.0	21.0	47.8	45.8
1980	35.2	27.1	36.2	38.3	33.0	50.5	43.8
1979	30.1	21.1	25.0	27.0	19.0	36.8	32.8
1978	34.0	27.1	30.0	31.2	24.0	42.0	31.8
1977	32.0	20.1	19.6	21.2	16.0	36.6	19.8
1976	38.1	35.1	33.5	35.9	22.0	32.8	29.8
1975	41.1	40.2	30.7	33.3	27.0	49.7	37.8
1974	20.4	18.1	12.8	12.5	5.0	21.2	11.8
1973	23.5	16.1	14.6	13.0	13.0	23.4	16.8
1972	28.3	17.1	29.0	27.1	25.0	42.5	26.8
1971	31.4	29.1	22.0	24.4	20.0	34.3	30.8
1970	31.1	24.1	35.5	33.0	25.0	47.3	45.4
1969	29.6	18.1	31.7	30.0	21.0	48.6	38.9
1968	36.1	26.1	30.0	29.5	22.0	43.1	28.8
1967	31.1	25.1	21.2	21.2	10.5	30.0	19.9
1966	36.2	17.1	27.0	26.4	14.0	47.1	38.8
1965	37.9	37.1	36.0	30.1	17.7	48.4	32.3
1964	36.9	17.1	27.3	25.7	22.0	39.6	32.8

*WWF, WWC yields reduced by .9 bushels per acre; DWF, SWF, SWC yields reduced by 1 bushel per acre; BF, BC yields reduced by 1.2 bushels per acre.

tions. The regression results indicated no statistically observable trend in the yield data over the nineteen year period, therefore, the yields were not adjusted for trend.

Seed requirements for growing a crop were subtracted from the county yields before using the yields to construct a ROVC data set. County yields were multiplied by the inflation adjusted commodity prices to obtain real gross return information. Real budgetted costs were then subtracted from the adjusted gross margins to obtain real ROVC time series data for each of the seven cropping activities. This ROVC data set is presented in Table 3.

Adjusted mean ROVCs, standard deviations, and coefficients of variation were estimated for the seven cropping alternatives and are presented in Table 4. Correlation coefficients of the historical crop ROVCs are illustrated in Table 5. The determinant of the cor-

Table 3. Original Return Over Variable Costs Data (\$).

Year	Crop Enterprise						
	WWF	WWC	DWF	SWF	SWC	BF	BC
1982	111.67	68.260	70.950	98.840	67.890	40.200	43.590
1981	102.53	57.290	65.670	86.830	32.260	57.840	61.800
1980	102.57	74.900	181.39	124.16	107.62	104.46	91.420
1979	80.730	48.630	71.440	63.060	35.530	39.280	37.300
1978	71.310	54.310	58.440	58.810	40.330	37.100	22.170
1977	52.270	20.750	17.950	16.470	6.6500	29.590	-3.1400
1976	81.770	79.820	68.920	86.050	38.430	43.120	42.520
1975	169.52	173.51	166.51	159.72	127.09	110.78	78.550
1974	89.530	82.010	75.470	42.820	-9.9600	38.460	3.2200
1973	135.94	84.270	108.72	45.890	54.840	38.270	19.160
1972	52.990	18.590	51.590	46.710	47.390	46.350	15.560
1971	22.600	25.740	22.660	7.7700	4.4900	3.9900	6.2800
1970	29.620	19.170	44.670	44.550	28.140	22.540	28.120
1969	25.460	2.5500	34.720	37.440	17.140	21.440	13.890
1968	42.020	23.660	46.140	37.000	21.270	23.300	2.2100
1967	43.610	33.230	29.400	18.800	-12.050	6.3200	-7.4600
1966	85.010	19.270	60.090	50.820	7.6900	49.510	38.940
1965	68.160	74.470	71.340	51.610	14.560	55.950	25.930
1964	72.620	12.260	37.950	36.570	31.610	26.730	20.580

Table 4. Summary Statistics of Original ROVC Data.

Crop	Summary Statistic		
	Mean	Standard Deviation	Coefficient of Variation
	(\$)	(\$)	
WWF	75.775	38.205	.504
WWC	51.194	40.082	.783
DWF	67.580	43.344	.641
SWF	58.627	37.943	.647
SWC	34.785	35.847	1.031
BF	41.854	27.357	.654
BC	28.455	26.749	.940

Table 5. Simple Correlation Coefficient Matrix.

	WWF	WWC	DWF	SWF	SWC	BF	BC
WWF	1.000	.846	.792	.781	.704	.753	.664
WWC	.846	1.000	.790	.780	.657	.730	.586
DWF	.792	.790	1.000	.851	.842	.905	.813
SWF	.781	.780	.851	1.000	.880	.891	.915
SWC	.704	.657	.842	.880	1.000	.815	.816
BF	.753	.730	.905	.891	.815	1.000	.869
BC	.664	.586	.813	.915	.816	.869	1.000

relation matrix was very close to zero indicating high multi-collinearity. This is not to imply that all activities are jointly determined.

As previously mentioned, the parameters associated with the historical ROVC data set are assumed to be parameters of the population from which samples of ROVCs are generated.

Generating of Returns Over Variable Costs

The procedure used to generate the returns over variable costs are examined in this section.

Since the original returns distributions were significantly skewed and a multi-variate normal random variate generator was used to generate the samples it was necessary to find a transformation that converted the original data into a multi-variate normal distribution. Then the generated samples were re-transformed and used as inputs in the Target MOTAD and MOTAD models.

A transformation of the general form used by Box and Cox (1964) was appealing because of its flexible form. The *SHAZAM* package (White 1980) was used to estimate the transformation. A search procedure using the maximum likelihood estimation criterion is used to estimate λ , in the Box and Cox (1964) transformation function as shown below (see Appendix B for the λ values that were estimated)

$$\frac{r_t^\lambda - 1}{\lambda} = x_t' \beta + e_t$$

with the e_t i.i.d. $N(0, \sigma^2)$. Where in the non-linear model above $t = 1, 2, \dots, T$ where r_t is the t^{th} observation on a dependent variable (return), x_t is a $(P \times 1)$ vector containing the t^{th} observation on an explanatory variable and β is a $(P \times 1)$ vector of parameters. In this application x_t is treated as constant since a transformation of r_t to a normal distribution was the objective. If x_t is a constant and e_t is normally distributed then the transformed variable is also normally distributed.

A constant was added to each of the historical observations to reduce the possibility that the random deviate generator would generate a non-positive observation that could not be transformed.* The constants that were added increased the mean values of the seven historical data series such that the means were four standard deviations from zero. This modification of the original observations greatly reduced the possibility of generating a non-positive number. If, however, a non-positive number was generated, then the number was treated as a small positive number (.001) and re-transformed.

The random generator was used to generate samples of varying size (10, 20, 30, 40, 50, and 70 return observations per crop). Ten different data sets were generated for each of the sample sizes and incorporated into both the MOTAD and Target MOTAD models. An example of each of the two models as they appeared when the generated sample size (ss) equals ten observations per activity are presented in Tables 6 and 7. The use of standardized target income and total deviations levels allowed comparison between the MOTAD and Target MOTAD results.

*If the generated observation r_t is non-positive then it is impossible to raise it to a non-integral power λ .

Table 6. MOTAD Matrix for 2500-Acre Farm, North-Central Montana (ss = 10).

Constraint	Crop Activities (Acres)								Labor Transfer Activities								Negative Deviations from (\$)										Neg Dev. Trans.	Constraint	
	WWF	WWC	DWF	SWF	SWC	BF	BC	L1	L2	L3	L4	L5	L6	L7	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10	Type	Level			
1. Obj. Function (Mean ROVC)	66.32	26.06	51.18	54.18	29.72	34.82	25.65	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0												N			
2. Mean ROVC	66.32	26.02	51.18	54.18	29.72	34.82	25.65	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0												-1.0	E	0.0	
3. Max. Negative Deviations															1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		LE	k		
4. Land	2.0	1.0	2.0	2.0	1.0	2.0	1.0																			LE	2500		
5. Crop Rota- tion	-1.0	1.0	-1.0	-1.0	1.0	-1.0	1.0																			LE	0.0		
Labor (hrs)																													
6. L1				.21	.21	.30	.21	.30	-1.0																	LE	224.0		
7. L2	.09		.09	.09		.09			-1.0																	LE	171.2		
8. L3	.24	.06	.24	.24	.06	.24	.06			-1.0																LE	136.8		
9. L4	.09		.09	.09		.09					-1.0															LE	195.2		
10. L5	.63	.63										-1.0														LE	108.0		
11. L6		.09	.63	.63	.63	.63	.63						-1.0													LE	136.0		
12. L7	.21	.21												-1.0												LE	199.2		
Gross ROVCs (\$)																													
13. Year 1	2.79	-13.84	4.49	11.69	-9.65	1.46	-8.91	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	1.0											-1.0	GE	0.0	
14. Year 2	106.83	19.04	67.68	37.48	29.39	39.31	30.00	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0		1.0										-1.0	GE	0.0	
15. Year 3	3.92	7.22	12.75	5.59	-19.38	-8.02	-12.08	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0			1.0									-1.0	GE	0.0	
16. Year 4	38.34	31.62	56.40	78.36	55.37	39.44	48.34	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0				1.0								-1.0	GE	0.0	
17. Year 5	102.46	95.90	105.22	72.40	67.61	49.14	39.92	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0					1.0							-1.0	GE	0.0	
18. Year 6	39.74	12.57	43.13	77.15	18.13	63.38	30.58	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0						1.0						-1.0	GE	0.0	
19. Year 7	68.23	29.41	50.21	53.92	38.01	31.29	25.69	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0							1.0					-1.0	GE	0.0	
20. Year 8	147.04	68.12	101.88	120.95	74.29	74.09	79.01	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0								1.0				-1.0	GE	0.0	
21. Year 9	65.75	14.52	33.79	25.61	.56	23.16	12.19	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0									1.0			-1.0	GE	0.0	
22. Year 10	48.08	-3.93	36.19	38.50	42.79	32.99	13.93	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0										1.0	-1.0	GE	0.0		

Table 7. Target MOTAD Matrix for 2500-Acre Farm, North-Central Montana (ss = 10).

Constraint	Crop Activities (Acres)							Labor Transfer Activities							Negative Deviations from (\$)										Neg	Constraint																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
	WWF	WWC	DWF	SWF	SWC	BF	BC	L1	L2	L3	L4	L5	L6	L7	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr	Yr

CHAPTER 3

RESULTS

MOTAD and Target MOTAD solutions for each sample are presented and discussed in this chapter. The stability of the models with regard to sample size is analyzed. The two linear risk models are examined separately then some comparisons are drawn between the models. Total negative deviation levels, target income levels, and sample sizes were consistently specified among and between models to allow comparisons.

MOTAD Model Results

MOTAD solutions for each sample and sample size are presented in Tables 8-13. Each of the Tables 8-13 contains solutions for ten samples of equal size evaluated at three total deviation levels.

The total negative deviation levels are as follows:

- (1) \$10,000 of deviations per sample observation
- (2) \$20,000 of deviations per sample observation
- (3) \$30,000 of deviations per sample observation

where the deviations are measured from the mean ROVC level and generated samples varied from ten to seventy observations in length.

Comparisons can be made between MOTAD models with different observation numbers. The number of deviations per observation is held constant to allow comparison between MOTAD solutions from different sample sizes. A table of statistics is used to make this comparison. The summary statistics in Table 14 were derived in the following manner:

Table 8. MOTAD Model Results (ss = 10).

Sample	Mean Returns (\$)	Enterprise Mix (Acres)						
		WWF	WWC	DWF	SWF	SWC	BF	BC
----- \$10,000 Neg. Deviations Per Observation: From Mean -----								
1	59,678	987.7	0	215.9	0	0	0	0
2	35,518	170.6	0	0	174.3	0	166.0	0
3	41,586	594.8	0	365.1	0	0	0	0
4	35,820	638.4	0	0	215.9	0	0	0
5	38,794	248.8	0	279.6	110.6	0	0	0
6	37,199	383.4	0	283.0	0	0	0	0
7	41,375	0	0	549.8	0	140.8	0	0
8	48,962	968.9	0	0	0	0	0	0
9	66,617	620.9	402.3	230.4	0	0	197.6	0
10	50,544	363.6	0	276.3	74.4	0	535.7	0
----- \$20,000 Neg. Deviations Per Observation: From Mean -----								
1	67,713	833.3	833.3	0	0	0	0	0
2	68,926	341.3	0	0	348.9	0	0	0
3	64,174	833.3	833.3	0	0	0	0	0
4	62,332	303.6	645.0	623.9	0	0	0	0
5	75,165	430.7	133.7	526.6	225.9	0	0	0
6	71,654	888.3	0	361.7	0	0	0	0
7	80,695	0	0	1,231.5	0	36.9	0	0
8	64,900	833.3	833.3	0	0	0	0	0
9	77,425	833.3	39.8	0	0	793.5	0	0
10	66,977	799.7	656.5	122.1	0	0	0	0
----- \$30,000 Neg. Deviations Per Observation: From Mean -----								
1	67,713	833.3	833.3	0	0	0	0	0
2	100,018	694.6	0	0	443.8	0	0	223.1
3	64,174	833.3	833.3	0	0	0	0	0
4	64,930	0	833.3	833.3	0	0	0	0
5	87,031	736.5	833.3	96.8	0	0	0	0
6	85,464	833.3	833.3	0	0	0	0	0
7	86,482	736.5	833.3	96.8	0	0	0	0
8	64,900	833.3	833.3	0	0	0	0	0
9	77,545	833.3	0	0	0	833.3	0	0
10	67,619	736.5	833.3	96.8	0	0	0	0

Table 9. MOTAD Model Results (ss = 20).

Sample	Mean Returns (\$)	Enterprise Mix (Acres)						
		WWF	WWC	DWF	SWF	SWC	BF	BC
----- \$10,000 Neg. Deviations Per Observation: From Mean -----								
1	38,558	406.5	0	0	41.1	0	0	0
2	57,786	767.2	0	0	0	0	215.9	0
3	52,303	383.1	0	300.4	0	449.4	0	0
4	52,914	551.5	0	0	0	0	284.4	0
5	58,017	603.1	0	39.0	339.8	0	0	0
6	41,062	528.9	0	0	0	0	194.5	0
7	41,809	246.4	117.7	0	174.6	0	19.0	5.5
8	54,554	564.5	0	215.9	0	0	0	0
9	44,314	187.7	88.5	358.5	0	0	0	0
10	43,695	640.1	0	20.1	0	0	0	0
----- \$20,000 Neg. Deviations Per Observation: From Mean -----								
1	76,000	891.5	0	0	0	0	0	0
2	87,708	833.3	833.3	0	0	0	0	0
3	89,386	1,013.3	11.2	231.1	0	0	0	0
4	97,051	888.9	175.1	0	0	547.0	0	0
5	87,243	833.3	833.3	0	0	0	0	0
6	79,687	1,148.6	6.1	0	0	196.7	0	0
7	81,653	503.4	228.6	0	360.1	0	0	15.3
8	91,446	833.3	833.3	0	0	0	0	0
9	86,349	126.2	527.5	746.8	0	0	0	0
10	83,395	1,043.1	413.8	0	0	0	0	0
----- \$30,000 Neg. Deviations Per Observation: From Mean -----								
1	109,993	1,197.0	106.1	0	0	0	0	0
2	87,708	833.3	833.3	0	0	0	0	0
3	113,011	817.1	812.1	26.3	0	0	0	0
4	116,749	737.1	778.6	0	96.2	54.8	0	0
5	87,243	833.3	833.3	0	0	0	0	0
6	94,556	833.3	833.3	0	0	0	0	0
7	112,691	833.3	374.9	0	0	458.4	0	0
8	91,446	833.3	833.3	0	0	0	0	0
9	98,671	736.5	833.3	96.8	0	0	0	0
10	85,676	833.3	833.3	0	0	0	0	0

Table 10. MOTAD Model Results (ss = 30).

Sample	Mean Returns (\$)	Enterprise Mix (Acres)						
		WWF	WWC	DWF	SWF	SWC	BF	BC
----- \$10,000 Neg. Deviations Per Observation: From Mean -----								
1	52,037	613.1	144.2	0	0	0	0	0
2	44,128	171.4	0	0	324.5	0	419.7	0
3	57,720	512.8	0	132.8	234.3	0	0	0
4	44,184	301.1	0	89.1	0	11.8	432.3	0
5	46,295	440.1	157.3	72.8	0	0	0	0
6	41,780	409.3	0	215.9	0	0	0	0
7	62,650	510.8	392.2	12.1	0	0	0	0
8	45,961	461.2	0	0	0	0	243.7	0
9	52,532	613.5	0	0	0	0	0	0
10	55,622	41.1	0	1,066.7	0	0	0	0
----- \$20,000 Neg. Deviations Per Observation: From Mean -----								
1	98,533	971.1	544.8	0	0	13.0	0	0
2	82,097	884.6	0	0	365.4	0	0	0
3	97,355	857.1	665.0	0	0	120.9	0	0
4	85,223	773.4	0	319.6	0	0	157.0	0
5	90,862	880.2	314.5	145.5	0	0	0	0
6	81,557	907.8	0	329.4	0	0	0	0
7	103,414	934.6	630.9	0	0	0	0	0
8	88,182	1,034.1	0	86.1	0	0	129.8	0
9	103,252	1,158.9	0	0	0	112.3	0	0
10	89,649	890.3	402.7	158.3	0	0	0	0
----- \$30,000 Neg. Deviations Per Observation: From Mean -----								
1	104,765	115.2	833.3	718.1	0	0	0	0
2	94,798	833.3	833.3	0	0	0	0	0
3	99,727	833.3	833.3	0	0	0	0	0
4	110,009	950.8	598.5	0	0	0	0	0
5	103,362	833.3	833.3	0	0	0	0	0
6	98,689	833.3	833.3	0	0	0	0	0
7	106,518	833.3	833.3	0	0	0	0	0
8	103,421	833.3	833.3	0	0	0	0	0
9	116,456	833.3	833.3	0	0	0	0	0
10	99,216	833.3	833.3	0	0	0	0	0

Table 11. MOTAD Model Results (ss = 40).

Sample	Mean Returns (\$)	Enterprise Mix (Acres)						
		WWF	WWC	DWF	SWF	SWC	BF	BC
----- \$10,000 Neg. Deviations Per Observation: From Mean -----								
1	42,048	685.0	0	0	0	0	8.1	0
2	52,535	240.3	0	208.9	0	0	526.8	0
3	57,349	574.1	0	0	281.7	0	0	0
4	49,652	176.9	0	589.1	0	0	0	0
5	59,339	639.5	0	84.1	0	0	121.4	0
6	36,842	465.0	0	0	0	0	0	0
7	47,408	540.1	0	252.2	0	0	0	0
8	43,486	710.5	0	0	0	0	0	0
9	45,018	376.8	0	348.0	0	0	0	0
10	43,125	171.4	0	492.2	0	0	85.1	0
----- \$20,000 Neg. Deviations Per Observation: From Mean -----								
1	74,572	1,142.1	0	0	0	215.9	0	0
2	90,681	762.6	186.0	316.6	0	155.6	0	0
3	95,046	833.3	833.3	0	0	0	0	0
4	93,148	585.4	723.3	302.9	0	0	0	0
5	101,472	971.9	556.2	0	0	0	0	0
6	72,518	929.9	0	0	0	0	0	0
7	79,116	875.2	621.5	0	0	0	0	0
8	75,435	854.2	503.7	143.9	0	0	0	0
9	82,564	1,031.8	188.8	0	0	247.7	0	0
10	80,232	540.3	215.8	601.8	0	0	0	0
----- \$30,000 Neg. Deviations Per Observation: From Mean -----								
1	74,572	1,142.1	0	0	0	215.9	0	0
2	99,807	833.3	833.3	0	0	0	0	0
3	95,046	833.3	833.3	0	0	0	0	0
4	96,652	833.3	833.3	0	0	0	0	0
5	104,143	833.3	833.3	0	0	0	0	0
6	101,586	1,139.1	221.9	0	0	0	0	0
7	79,748	833.3	833.3	0	0	0	0	0
8	75,482	736.5	833.3	96.8	0	0	0	0
9	88,997	833.3	833.3	0	0	0	0	0
10	97,171	833.3	833.3	0	0	0	0	0

Table 12. MOTAD Model Results (ss = 50).

Sample	Mean Returns (\$)	Enterprise Mix (Acres)						
		WWF	WWC	DWF	SWF	SWC	BF	BC
----- \$10,000 Neg. Deviations Per Observation: From Mean -----								
1	48,878	588.3	0	0	0	211.6	0	0
2	63,971	728.1	0	0	0	0	0	0
3	52,156	362.2	0	71.6	363.1	0	0	0
4	45,546	449.7	0	215.9	0	0	0	0
5	44,358	277.4	0	448.4	0	0	0	0
6	44,416	590.4	0	0	23.3	0	0	0
7	46,250	601.2	0	97.1	0	0	0	0
8	48,952	159.6	0	335.5	444.1	0	0	0
9	56,395	741.6	0	0	0	0	0	0
10	46,719	449.3	0	0	0	0	477.3	0
----- \$20,000 Neg. Deviations Per Observation: From Mean -----								
1	88,462	888.3	352.5	0	0	370.9	0	0
2	115,494	1,051.9	396.3	0	0	0	0	0
3	93,852	1,177.9	144.1	0	0	0	0	0
4	87,941	1,114.5	0	55.2	0	160.7	0	0
5	81,799	968.8	404.3	0	0	158.1	0	0
6	87,072	1,180.7	0	0	46.7	0	0	0
7	84,704	1,118.8	262.3	0	0	0	0	0
8	82,127	790.6	681.9	118.5	0	0	0	0
9	100,639	1,063.5	373.0	0	0	0	0	0
10	85,805	1,191.3	117.3	0	0	0	0	0
----- \$30,000 Neg. Deviations Per Observation: From Mean -----								
1	91,134	736.5	833.3	96.8	0	0	0	0
2	123,329	833.3	833.3	0	0	0	0	0
3	101,468	833.3	833.3	0	0	0	0	0
4	94,502	833.3	833.3	0	0	0	0	0
5	82,069	833.3	720.4	0	0	113.0	0	0
6	97,157	833.3	833.3	0	0	0	0	0
7	89,975	833.3	833.3	0	0	0	0	0
8	83,843	833.3	833.3	0	0	0	0	0
9	109,242	833.3	833.3	0	0	0	0	0
10	92,661	833.3	833.3	0	0	0	0	0

Table 13. MOTAD Model Results (ss = 70).

Sample	Mean Returns (\$)	Enterprise Mix (Acres)						
		WWF	WWC	DWF	SWF	SWC	BF	BC
----- \$10,000 Neg. Deviations Per Observation: From Mean -----								
1	47,420	529.7	0	0	123.1	47.1	0	0
2	49,630	474.8	0	272.7	5.3	0	0	0
3	46,985	513.8	0	0	0	0	215.9	0
4	46,272	525.2	0	199.2	16.7	0	0	0
5	48,712	585.3	103.0	0	54.9	0	0	0
6	45,155	376.0	0	120.7	131.3	0	124.1	0
7	46,410	283.6	0	107.9	342.9	0	0	0
8	52,381	606.6	0	215.9	0	0	0	0
9	52,157	527.4	0	0	215.9	0	0	0
10	52,597	600.8	0	0	0	0	215.9	0
----- \$20,000 Neg. Deviations Per Observation: From Mean -----								
1	89,963	1,093.6	113.1	0	0	199.7	0	0
2	87,522	1,031.1	259.0	0	0	178.9	0	0
3	90,839	1,140.3	0	0	3.6	212.3	0	0
4	81,562	838.2	732.3	0	0	91.3	0	0
5	92,829	840.3	819.3	0	0	0	0	0
6	85,564	1,028.1	0	77.4	60.8	167.5	0	0
7	87,911	990.5	16.5	251.2	0	0	0	0
8	88,292	833.3	833.3	0	0	0	0	0
9	95,809	973.4	399.8	0	0	153.4	0	0
10	92,366	950.7	356.1	0	0	242.6	0	0
----- \$30,000 Neg. Deviations Per Observation: From Mean -----								
1	103,133	833.3	833.3	0	0	0	0	0
2	91,980	833.3	833.3	0	0	0	0	0
3	100,904	833.3	833.3	0	0	0	0	0
4	81,634	833.3	833.3	0	0	0	0	0
5	92,941	833.3	833.3	0	0	0	0	0
6	98,078	833.3	833.3	0	0	0	0	0
7	104,441	833.3	833.3	0	0	0	0	0
8	88,292	833.3	833.3	0	0	0	0	0
9	99,778	833.3	833.3	0	0	0	0	0
10	96,510	736.5	833.3	96.8	0	0	0	0

$$\bar{\hat{\mu}} = \frac{10}{\sum_{i=1}^{10}} \frac{\hat{\mu}_i}{10}$$

where: $\hat{\mu}_i$ equals the cropping policy vector that was developed by the MOTAD algorithm, for the i^{th} randomly generated data set, multiplied by the mean ROVC vector of the original data and

$$s_{\hat{\mu}} = \sqrt{\frac{10}{\sum_{i=1}^{10}} \frac{(\hat{\mu}_i - \bar{\hat{\mu}})^2}{9}}$$

where: $s_{\hat{\mu}}$ is the standard deviation of the $\hat{\mu}_i$'s. The statistic $s_{\hat{\mu}}$ is used as an indicator of model stability and the statistic $\bar{\hat{\mu}}$ is used to indicate bias.

Table 14. Summary Statistics for MOTAD Model Results.

Statistic	Sample Sizes					
	10	20	30	40	50	70
----- \$10,000 of Neg. Deviations Per Observation -----						
$\bar{\hat{\mu}}$	59,618	46,289	50,930	50,869	51,036	50,788
$s_{\hat{\mu}}$	19,220	17,793	9,031	6,700	3,665	3,687
----- \$20,000 of Neg. Deviations Per Observation -----						
$\bar{\hat{\mu}}$	81,751	87,209	89,502	87,534	91,967	92,931
$s_{\hat{\mu}}$	28,363	12,264	5,356	10,761	2,664	4,049
----- \$30,000 of Neg. Deviations Per Observation -----						
$\bar{\hat{\mu}}$	94,612	96,868	98,108	96,925	98,063	98,539
$s_{\hat{\mu}}$	6,288	2,995	1,460	3,440	1,497	97

From visual observation of Tables 8-13 it is apparent that larger sample data sets result in a more stable MOTAD solution. This observation is summarized by the use of the standard deviation statistics in Table 14. For $k = \$10,000$ $s_{\hat{\mu}}$ ranges from \$19,220 for $ss = 10$ to \$3,687 for $ss = 70$; for $k = \$20,000$ $s_{\hat{\mu}}$ ranges from \$28,363 for $ss = 10$ to \$4,049 for $ss = 70$; and for $k = \$30,000$ $s_{\hat{\mu}}$ ranges from \$6,288 for $ss = 10$ to \$97 for $ss = 70$.

Possible bias resulting from the use of MOTAD criterion is less apparent. If the $\bar{\mu}$ statistics are compared across sample sizes while holding deviation levels constant, little consistent bias can be detected.

Target MOTAD Results

Optimal policies as described by the Target MOTAD models are presented in Tables 15-20. Each of the tables is constructed to be consistent with Tables 8-13. Each generated data set was input into the Target MOTAD framework after the MOTAD model solved it. Therefore, sample 1 in Table 8 is identical to sample 1 in Table 15.

The total deviations levels used in the Target MOTAD models are the same as the levels used in the MOTAD models. In the Target MOTAD models only total negative deviations are measured and the deviations are measured from an arbitrary target income level.

To further increase the comparability between the models, the three targets are the means of the ten MOTAD objective function values for each of the three deviation levels when the sample size equals seventy.

No summary statistics are computed for the Target MOTAD solutions. Many of the models were infeasible because of the particular target income level that was specified concurrently with a constraining total negative deviation level. The Target MOTAD solutions stabilized when the sample size exceeded twenty observations.

Comparison of MOTAD and Target MOTAD

Comparison between the models is complicated and difficult since several Target MOTAD models were infeasible.

Some comparison of the models that came to solution is possible. From observation, when ss is constant, the Target MOTAD models yielded a much higher objective function

Table 15. Target MOTAD Model Results (ss = 10).

Sample	Mean* Returns (\$)	Enterprise Mix (Acres)						
		WWF	WWC	DWF	SWF	SWC	BF	BC
----- \$10,000 Neg. Deviations Per Observation: From \$48,772 -----								
1	67,713	833.3	833.3	0	0	0	0	0
2	114,256	833.3	720.4	0	0	113.0	0	0
3	NFS	0	0	0	0	0	0	0
4	NFS	0	0	0	0	0	0	0
5	86,133	194.7	833.3	638.7	0	0	0	0
6	79,717	1,189.5	130.0	0	0	0	0	0
7	86,482	736.5	833.3	96.8	0	0	0	0
8	64,900	833.3	833.3	0	0	0	0	0
9	77,545	833.3	0	0	0	833.3	0	0
10	66,199	876.2	442.2	152.7	0	0	0	0
----- \$20,000 Neg. Deviations Per Observation: From \$89,266 -----								
1	NFS	0	0	0	0	0	0	0
2	NFS	0	0	0	0	0	0	0
3	NFS	0	0	0	0	0	0	0
4	NFS	0	0	0	0	0	0	0
5	NFS	0	0	0	0	0	0	0
6	NFS	0	0	0	0	0	0	0
7	NFS	0	0	0	0	0	0	0
8	NFS	0	0	0	0	0	0	0
9	NFS	0	0	0	0	0	0	0
10	NFS	0	0	0	0	0	0	0
----- \$30,000 Neg. Deviations Per Observation: From \$95,769 -----								
1	NFS	0	0	0	0	0	0	0
2	114,256	833.3	720.4	0	0	113.0	0	0
3	NFS	0	0	0	0	0	0	0
4	NFS	0	0	0	0	0	0	0
5	87,031	763.5	833.3	96.8	0	0	0	0
6	NFS	0	0	0	0	0	0	0
7	86,341	146.4	833.3	687.0	0	0	0	0
8	NFS	0	0	0	0	0	0	0
9	75,725	1,000.2	0	0	0	499.6	0	0
10	NFS	0	0	0	0	0	0	0

*No feasible solution is abbreviated as NFS.

Table 16. Target MOTAD Model Results (ss = 20).

Sample	Mean* Returns (\$)	Enterprise Mix (Acres)						
		WWF	WWC	DWF	SWF	SWC	BF	BC
----- \$10,000 Neg. Deviations Per Observation: From \$48,772 -----								
1	142,470	0	833.3	833.3	0	0	0	0
2	87,708	833.3	833.3	0	0	0	0	0
3	113,997	833.3	833.3	0	0	0	0	0
4	125,224	0	833.3	833.3	0	0	0	0
5	87,243	833.3	833.3	0	0	0	0	0
6	92,757	833.3	731.0	0	0	102.3	0	0
7	112,695	833.3	115.2	0	0	718.1	0	0
8	91,446	833.3	833.3	0	0	0	0	0
9	98,305	553.4	833.3	279.9	0	0	0	0
10	85,676	833.3	833.3	0	0	0	0	0
----- \$20,000 Neg. Deviations Per Observation: From \$89,266 -----								
1	NFS	0	0	0	0	0	0	0
2	85,506	953.5	593.1	0	0	0	0	0
3	113,997	833.3	833.3	0	0	0	0	0
4	125,224	0	833.3	833.3	0	0	0	0
5	85,029	1,041.8	416.3	0	0	0	0	0
6	NFS	0	0	0	0	0	0	0
7	112,695	833.3	115.2	0	0	718.1	0	0
8	91,446	833.3	833.3	0	0	0	0	0
9	93,471	110.5	473.9	902.5	0	0	0	0
10	NFS	0	0	0	0	0	0	0
----- \$30,000 Neg. Deviations Per Observation: From \$95,769 -----								
1	142,469	0	833.3	833.3	0	0	0	0
2	87,708	833.3	833.3	0	0	0	0	0
3	113,997	833.3	833.3	0	0	0	0	0
4	125,224	0	833.3	833.3	0	0	0	0
5	87,243	833.3	833.3	0	0	0	0	0
6	94,556	833.3	833.3	0	0	0	0	0
7	112,695	833.3	115.2	0	0	718.1	0	0
8	91,446	833.3	833.3	0	0	0	0	0
9	98,671	736.5	833.3	96.8	0	0	0	0
10	85,676	833.3	833.3	0	0	0	0	0

*No feasible solution is abbreviated as NFS.

Table 17. Target MOTAD Model Results (ss = 30).

Sample	Mean* Returns (\$)	Enterprise Mix (Acres)						
		WWF	WWC	DWF	SWF	SWC	BF	BC
----- \$10,000 Neg. Deviations Per Observation: From \$48,772 -----								
1	104,765	115.2	833.3	718.1	0	0	0	0
2	94,798	833.3	833.3	0	0	0	0	0
3	99,727	833.3	833.3	0	0	0	0	0
4	115,532	833.3	833.3	0	0	0	0	0
5	103,362	833.3	833.3	0	0	0	0	0
6	98,689	833.3	833.3	0	0	0	0	0
7	106,518	833.3	833.3	0	0	0	0	0
8	103,421	833.3	833.3	0	0	0	0	0
9	116,456	833.3	833.3	0	0	0	0	0
10	99,217	833.3	833.3	0	0	0	0	0
----- \$20,000 Neg. Deviations Per Observation: From \$89,266 -----								
1	104,765	115.2	833.3	718.1	0	0	0	0
2	NFS	0	0	0	0	0	0	0
3	99,727	833.3	833.3	0	0	0	0	0
4	115,532	833.3	833.3	0	0	0	0	0
5	103,362	833.3	833.3	0	0	0	0	0
6	NFS	0	0	0	0	0	0	0
7	106,518	833.3	833.3	0	0	0	0	0
8	99,911	962.3	575.4	0	0	0	0	0
9	116,456	833.3	833.3	0	0	0	0	0
10	99,217	833.3	833.3	0	0	0	0	0
----- \$30,000 Neg. Deviations Per Observation: From \$95,769 -----								
1	104,765	115.2	833.3	718.1	0	0	0	0
2	94,798	833.3	833.3	0	0	0	0	0
3	99,727	833.3	833.3	0	0	0	0	0
4	115,532	833.3	833.3	0	0	0	0	0
5	103,362	833.3	833.3	0	0	0	0	0
6	98,689	833.3	833.3	0	0	0	0	0
7	106,518	833.3	833.3	0	0	0	0	0
8	103,421	833.3	833.3	0	0	0	0	0
9	116,456	833.3	833.3	0	0	0	0	0
10	99,217	833.3	833.3	0	0	0	0	0

*No feasible solution is abbreviated as NFS.

Table 18. Target MOTAD Model Results (ss = 40).

Sample	Mean* Returns (\$)	Enterprise Mix (Acres)						
		WWF	WWC	DWF	SWF	SWC	BF	BC
----- \$10,000 Neg. Deviations Per Observation: From \$48,772 -----								
1	74,572	1,142.1	0	0	0	215.9	0	0
2	99,807	833.3	833.3	0	0	0	0	0
3	95,046	833.3	833.3	0	0	0	0	0
4	103,991	833.3	833.3	0	0	0	0	0
5	104,143	833.3	833.3	0	0	0	0	0
6	115,337	833.3	833.3	0	0	0	0	0
7	79,748	833.3	833.3	0	0	0	0	0
8	75,482	736.5	833.3	96.8	0	0	0	0
9	88,997	833.3	833.3	0	0	0	0	0
10	97,171	833.3	833.3	0	0	0	0	0
----- \$20,000 Neg. Deviations Per Observation: From \$89,266 -----								
1	NFS	0	0	0	0	0	0	0
2	99,807	833.3	833.3	0	0	0	0	0
3	95,046	833.3	833.3	0	0	0	0	0
4	103,991	833.3	833.3	0	0	0	0	0
5	104,143	833.3	833.3	0	0	0	0	0
6	NFS	0	0	0	0	0	0	0
7	NFS	0	0	0	0	0	0	0
8	NFS	0	0	0	0	0	0	0
9	NFS	0	0	0	0	0	0	0
10	NFS	0	0	0	0	0	0	0
----- \$30,000 Neg. Deviations Per Observation: From \$95,769 -----								
1	NFS	0	0	0	0	0	0	0
2	99,807	833.3	833.3	0	0	0	0	0
3	95,046	833.3	833.3	0	0	0	0	0
4	103,991	833.3	833.3	0	0	0	0	0
5	104,143	833.3	833.3	0	0	0	0	0
6	115,337	833.3	833.3	0	0	0	0	0
7	78,176	964.4	414.6	0	0	156.6	0	0
8	NFS	0	0	0	0	0	0	0
9	88,997	833.3	833.3	0	0	0	0	0
10	97,171	833.3	833.3	0	0	0	0	0

*No feasible solution is abbreviated as NFS.

Table 19. Target MOTAD Model Results (ss = 50).

Sample	Mean* Returns (\$)	Enterprise Mix (Acres)						
		WWF	WWC	DWF	SWF	SWC	BF	BC
----- \$10,000 Neg. Deviations Per Observation: From \$48,772 -----								
1	91,134	736.5	833.3	96.8	0	0	0	0
2	123,329	833.3	833.3	0	0	0	0	0
3	101,468	833.3	833.3	0	0	0	0	0
4	94,502	833.3	833.3	0	0	0	0	0
5	82,069	833.3	720.4	0	0	113.0	0	0
6	97,157	833.3	833.3	0	0	0	0	0
7	89,975	833.3	833.3	0	0	0	0	0
8	83,843	833.3	833.3	0	0	0	0	0
9	109,242	833.3	833.3	0	0	0	0	0
10	92,661	833.3	833.3	0	0	0	0	0
----- \$20,000 Neg. Deviations Per Observation: From \$89,266 -----								
1	87,041	1,008.6	151.5	0	0	331.3	0	0
2	123,329	833.3	833.3	0	0	0	0	0
3	101,468	833.3	833.3	0	0	0	0	0
4	NFS	0	0	0	0	0	0	0
5	NFS	0	0	0	0	0	0	0
6	NFS	0	0	0	0	0	0	0
7	NFS	0	0	0	0	0	0	0
8	NFS	0	0	0	0	0	0	0
9	109,242	833.3	833.3	0	0	0	0	0
10	NFS	0	0	0	0	0	0	0
----- \$30,000 Neg. Deviations Per Observation: From \$95,769 -----								
1	91,134	736.5	833.3	96.8	0	0	0	0
2	123,329	833.3	833.3	0	0	0	0	0
3	101,468	833.3	833.3	0	0	0	0	0
4	94,502	833.3	833.3	0	0	0	0	0
5	82,069	833.3	720.4	0	0	113.0	0	0
6	97,157	833.3	833.3	0	0	0	0	0
7	89,975	833.3	833.3	0	0	0	0	0
8	83,843	833.3	833.3	0	0	0	0	0
9	109,242	833.3	833.3	0	0	0	0	0
10	92,661	833.3	833.3	0	0	0	0	0

*No feasible solution is abbreviated as NFS.

Table 20. Target MOTAD Model Results (ss = 70).

Sample	Mean* Returns (\$)	Enterprise Mix (Acres)						
		WWF	WWC	DWF	SWF	SWC	BF	BC
----- \$10,000 Neg. Deviations Per Observation: From \$48,772 -----								
1	103,133	833.3	833.3	0	0	0	0	0
2	91,980	833.3	833.3	0	0	0	0	0
3	100,904	833.3	833.3	0	0	0	0	0
4	81,634	833.3	833.3	0	0	0	0	0
5	92,941	833.3	833.3	0	0	0	0	0
6	104,441	833.3	833.3	0	0	0	0	0
7	88,292	833.3	833.3	0	0	0	0	0
8	99,778	833.3	833.3	0	0	0	0	0
9	96,510	736.5	833.3	96.8	0	0	0	0
10	98,078	833.3	833.3	0	0	0	0	0
----- \$20,000 Neg. Deviations Per Observation: From \$89,266 -----								
1	102,114	833.3	779.0	0	0	54.4	0	0
2	NFS	0	0	0	0	0	0	0
3	100,410	782.4	779.8	50.9	0	53.6	0	0
4	NFS	0	0	0	0	0	0	0
5	92,941	833.3	833.3	0	0	0	0	0
6	NFS	0	0	0	0	0	0	0
7	88,292	833.3	833.3	0	0	0	0	0
8	99,778	833.3	833.3	0	0	0	0	0
9	96,510	736.5	833.3	96.8	0	0	0	0
10	NFS	0	0	0	0	0	0	0
----- \$30,000 Neg. Deviations Per Observation: From \$95,769 -----								
1	103,133	833.3	833.3	0	0	0	0	0
2	91,980	833.3	833.3	0	0	0	0	0
3	100,904	833.3	833.3	0	0	0	0	0
4	81,634	833.3	833.3	0	0	0	0	0
5	92,941	833.3	833.3	0	0	0	0	0
6	104,441	833.3	833.3	0	0	0	0	0
7	88,292	833.3	833.3	0	0	0	0	0
8	99,778	833.3	833.3	0	0	0	0	0
9	96,510	736.5	833.3	96.8	0	0	0	0
10	98,078	833.3	833.3	0	0	0	0	0

*No feasible solution is abbreviated as NFS.

value than the MOTAD models. This increase in the objective functions came with no average increase in negative deviations and is most prominent at the lowest deviation levels.

The enterprise mix determined by the Target MOTAD specification at lower deviation levels became very stable (when a feasible solution exists) for samples larger than twenty observations. The MOTAD models yielded unstable crop mixes at the lower deviation levels for all sample sizes.

Although the MOTAD specification always arrived at a feasible solution this may not be desirable. The fact that the MOTAD model uses a moving target income level (the mean) allows it to always find a feasible solution. However, as Watts, Held, and Helmers (1984) indicate this moving mean target level decreases the theoretical desirability of the traditional MOTAD models.

CHAPTER 4

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this research project was to compare two linear risk models with respect to their performances when data sample sizes are varied. A Monte Carlo experiment was utilized to make this comparison. A typical dryland Montana grain farm provided the data for this study.

Ten samples for each sample size of 10, 20, 30, 40, 50, and 70 were generated. The data sets were installed into the MOTAD and Target MOTAD frameworks. Different ROVC samples produced a wide variety of solutions and objective function values.

Conclusions

Larger sample sizes increased the consistency of the traditional MOTAD model results. The small sample sizes produced highly variable objective function values and basis activities. Solutions were less stable at the lower constraining deviation levels. At the lowest deviation levels the results were unstable for even the largest sample sizes (70 observations).

The Target MOTAD solutions lead to less obvious conclusions. For models with feasible solutions, results were quite stable for samples of thirty observations or more.

The inability of the Target MOTAD model to arrive at feasible solutions should not encourage the use of MOTAD. In fact, Target MOTAD is justifiable and is the preferred approach based upon its utility specification. This particular example indicates that at least thirty observations should be used with the Target MOTAD model.

Recommendations for Further Research

These recommendations chart two distinct routes for further research. The first recommendations are those that urge greater activity in the comparisons of alternative risk specifications. The conclusions of this study are based on a specific example; therefore, additional research using less highly correlated activities is recommended. Comparisons between traditional quadratic models, semivariance models, and these linear models would be useful.

Data collection is the second area where additional research is urged. In this study historical average county yields were used. Yield variability would be more accurately demonstrated by individual farm data. More representative data should improve policy recommendations.

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LITERATURE CITED

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APPENDICES

APPENDIX A
PRODUCTION BUDGETS

Table 21. Variable Production Costs: Fallow (previous land use state = crop).

Item	Unit	Price	Quantity	Cost/Acre
Fertilizer (nitrogen)	lb.	.23		\$
Fertilizer (phosphorus)	lb.	.22		
Crop Chemicals	acre	4.00		
Crop Insurance	acre	3.50		
Machinery: Fuel, Oil, Repairs	acre	5.43	1.19	6.48
Pickup Variable Costs	acre	2.00	1	2.00
Miscellaneous Expense	acre	3.46	.30	1.05
Clean and Treat Seed	bushel	1.00		
Interest on Operating Capital	dollar	.14	1.29	.18
Total Variable Costs 1980				\$ 9.71
*Total Variable Costs 4/1982				\$11.26

*Adjusted with GNP implicit price deflator series to fourth quarter 1982 dollars.

Table 22. Variable Production Costs: Winter Wheat (previous land use state = fallow).

Item	Unit	Price	Quantity	Cost/Acre
Fertilizer (nitrogen)	lb.	.23	45	\$10.35
Fertilizer (phosphorus)	lb.	.22	28	6.16
Crop Chemicals	acre	4.00	1	4.00
Crop Insurance	acre	3.50	1	3.50
Machinery: Fuel, Oil, Repairs	acre	5.43	1	5.43
Pickup Variable Costs	acre	2.00	1	2.00
Miscellaneous Expense	acre	3.46	1	3.46
Clean and Treat Seed	bushel	1.00	.9	.90
Interest on Operating Capital	dollar	.14	23.14	3.24
Total Variable Costs 1980				\$39.04
*Total Variable Costs 4/1982				\$45.27

*Adjusted with GNP implicit price deflator series to fourth quarter 1982 dollars.

Table 23. Variable Production Costs: Duram Wheat (previous land use state = fallow).

Item	Unit	Price	Quantity	Cost/Acre
Fertilizer (nitrogen)	lb.	.23	35	\$10.35
Fertilizer (phosphorus)	lb.	.22	28	6.16
Crop Chemicals	acre	4.00	2.29	9.15
Crop Insurance	acre	3.50	1	3.50
Machinery: Fuel, Oil, Repairs	acre	5.43	1.40	7.59
Pickup Variable Costs	acre	2.00	1	2.00
Miscellaneous Expense	acre	3.46	.98	3.39
Clean and Treat Seed	bushel	1.00	1	1.00
Interest on Operating Capital	dollar	.14	8.88	1.24
Total Variable Costs 1980				\$42.08
*Total Variable Costs 4/1982				\$48.80

*Adjusted with GNP implicit price deflator series to fourth quarter 1982 dollars.

Table 24. Variable Production Costs: Spring Wheat (previous land use state = fallow).

Item	Unit	Price	Quantity	Cost/Acre
Fertilizer (nitrogen)	lb.	.23	35	\$ 8.05
Fertilizer (phosphorus)	lb.	.22	28	6.16
Crop Chemicals	acre	4.00	2.29	9.15
Crop Insurance	acre	3.50	1	3.50
Machinery: Fuel, Oil, Repairs	acre	5.43	1.40	7.59
Pickup Variable Costs	acre	2.00	1	2.00
Miscellaneous Expense	acre	3.46	.98	3.39
Clean and Treat Seed	bushel	1.00	1	1.00
Interest on Operating Capital	dollar	.14	8.88	1.24
Total Variable Costs 1980				\$42.08
*Total Variable Costs 4/1982				\$48.80

*Adjusted with GNP implicit price deflator series to fourth quarter 1982 dollars.

Table 25. Variable Production Costs: Barley (previous land use state = fallow).

Item	Unit	Price	Quantity	Cost/Acre
Fertilizer (nitrogen)	lb.	.23	35	\$ 8.05
Fertilizer (phosphorus)	lb.	.22	28	6.16
Crop Chemicals	acre	4.00	2.29	9.15
Crop Insurance	acre	3.50	1	3.50
Machinery: Fuel, Oil, Repairs	acre	5.43	1.51	8.18
Pickup Variable Costs	acre	2.00	1	2.00
Miscellaneous Expense	acre	3.46	1.02	3.53
Clean and Treat Seed	bushel	1.00	1.20	1.20
Interest on Operating Capital	dollar	.14	8.86	1.28
Total Variable Costs 1980				\$43.05
*Total Variable Costs 4/1982				\$49.92

*Adjusted with GNP implicit price deflator series to fourth quarter 1982 dollars.

Table 26. Variable Production Costs: Winter Wheat (previous land use state = crop).

Item	Unit	Price	Quantity	Cost/Acre
Fertilizer (nitrogen)	lb.	.23	45	\$10.35
Fertilizer (phosphorus)	lb.	.22	28	6.16
Crop Chemicals	acre	4.00	1.5	6.00
Crop Insurance	acre	3.50	1	3.50
Machinery: Fuel, Oil, Repairs	acre	5.43	1	5.43
Pickup Variable Costs	acre	2.00	1	2.00
Miscellaneous Expense	acre	3.46	1	3.46
Clean and Treat Seed	bushel	1.00	.9	.90
Interest on Operating Capital	dollar	.14	23.14	3.24
Total Variable Costs 1980				\$41.04
*Total Variable Costs 4/1982				\$47.59

*Adjusted with GNP implicit price deflator series to fourth quarter 1982 dollars.

Table 27. Variable Production Costs: Spring Wheat (previous land use state = crop).

Item	Unit	Price	Quantity	Cost/Acre
Fertilizer (nitrogen)	lb.	.23	35	\$ 8.05
Fertilizer (phosphorus)	lb.	.22	28	6.16
Crop Chemicals	acre	4.00	2.79	11.15
Crop Insurance	acre	3.50	1	3.50
Machinery: Fuel, Oil, Repairs	acre	5.43	1.40	7.59
Pickup Variable Costs	acre	2.00	1	2.00
Miscellaneous Expense	acre	3.46	.98	3.39
Clean and Treat Seed	bushel	1.00	1	1.00
Interest on Operating Capital	dollar	.14	8.88	1.24
Total Variable Costs 1980				\$44.08
*Total Variable Costs 4/1982				\$51.11

*Adjusted with GNP implicit price deflator series to fourth quarter 1982 dollars.

Table 28. Variable Production Costs: Barley (previous land use state = crop).

Item	Unit	Price	Quantity	Cost/Acre
Fertilizer (nitrogen)	lb.	.23	35	\$ 8.05
Fertilizer (phosphorus)	lb.	.22	28	6.16
Crop Chemicals	acre	4.00	2.79	11.15
Crop Insurance	acre	3.50	1	3.50
Machinery: Fuel, Oil, Repairs	acre	5.43	1.51	8.15
Pickup Variable Costs	acre	2.00	1	2.00
Miscellaneous Expense	acre	3.46	1.02	3.53
Clean and Treat Seed	bushel	1.00	1.20	1.20
Interest on Operating Capital	dollar	.14	8.86	1.28
Total Variable Costs 1980				\$45.05
*Total Variable Costs 4/1982				\$52.24

*Adjusted with GNP implicit price deflator series to fourth quarter 1982 dollars.

APPENDIX B

BOX-COX ESTIMATES OF λ

Table 29. Estimates of Box-Cox Transformation Parameter for Each Activity.

	Cropping Activity						
	WWF	WWC	DWF	SWF	SWC	BF	BC
Box-Cox Parameters (λ)	-.224	-1.343	-1.769	-1.043	-.950	-.801	-.770
Goodness of Fit (χ^2) (5 d.f.)	2.38	2.67	1.70	1.70	1.45	3.37	1.79



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Jones, Clark Thomas

Effects of sample size
on motad and target motad
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