**TITLE: EVALUATION OF OPTIMUM REGRET DECISIONS IN CROP SELLING**[1]

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**ABSTRACT:** Minimum regret solutions from alternative monthly sales for corn, wheat, and soybeans were determined. The data set involved eleven years of monthly prices for corn and soybeans and twelve years for wheat. The regret, risk (MOTAD), and expected value of the optimum regret solutions were compared to solutions using other optimizing techniques.

**KEY WORDS:** Regret, Marketing Strategies, Marketing Risk

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# EVALUATION OF OPTIMUM REGRET DECISIONS IN CROP SELLING

## Background

Regret behavior has long been hypothesized as a useful perspective for decision making under uncertainty. Its relevance has been suggested for personal, investment, and management decisions. In broad terms this approach attempts to minimize the largest regret or opportunity loss resulting from alternative decisions under alternative nature states or, if probabilities of states are known, the weighted regret level. The decision maker attempts to minimize the losses incurred under various states compared to the most profitable decision for that state. Looking backward the decision maker's objective is to avoid a large regret even if the strategy yielding minimum regret has a lower expected return than other alternative decisions.

More formally this approach is (Anderson, et al., pp. 696)

minimize 1) $R(d_1, S_j) = V^*(S_j - V\, d_i\, S_j)$

where

$R(d_iS_j)$ = regret associated with decision alternative $d_i$ and state of nature $S_j$ and

$V^*(S_j)$ = best payoff value under state of nature $S_j$.

For each state the regret matrix is formed by subtracting from the maximum return the return for each $d_i$ thereby yielding a zero for the maximum return and various regret levels for other $d_i$. There may or may not be probabilities attached to each state. If probabilities are attached the optimum choice may be different from where no probabilities are incorporated. It can be argued that under some situations, where state probabilities are unknown the regret solution can be seemingly irrational caused by one outcome in one state. Still, for non-contrived situations it is generally argued that a regret framework is a useful approach among a number of alternative management techniques

for decisions under uncertainty.

Among the management decisions for agricultural firms for which this behavior is potentially either practiced or potentially useful is commodity selling. In fact casual comments by producers indicate major disutility for selling decisions which looking backward results in large opportunity losses regardless of how well that decision performs on an expected value or target return basis. Considerable research in commodity marketing has been directed to optimum return strategies both in terms of absolute profitability as well as securing target returns. In some cases risk behavior has been attached to the analysis. However, far less attention has been directed to regret avoidance which involves a different behavioral objective. The relation between regret behavior and risk defined as volatility is unclear. Whether regret is a separate objective or a subset of general volatility has not received great attention in quantitative research.

In this paper minimum regret choices are determined for sales times (monthly) for wheat, corn, and soybeans and the performance of these regret solutions are evaluated relative to other selling alternatives determined from other decision criteria. Only pure selling decisions are analyzed here and not included are hedging and other techniques which may prove to also be useful in achieving reduced regret.

**Objective**

The objective of this analysis was to determine optimum regret selling time strategies for wheat, corn, and soybeans and to compare these with maximum expected value strategies and various risk minimization strategies. Comparisons involve level of regret, average price, and risk measures (total deviations).

**Methods**

Various programming analyses were used in the examination of minimum regret behavior and its relation to other decision criteria. Analyses were completed for corn, soybeans, and wheat. The basic programming model was a MOTAD model including 12 selling activities for each month of the year. Additional rows were included to enable regret to be minimized or a target-MOTAD analysis to be completed.

Monthly net prices for each crop were assembled for consecutive time periods (11 years for corn and soybeans and 12 years for wheat). These were used directly in the programming matrices related to net returns and risk (deviations). Regret entries for each year were determined by subtracting each monthly price from the maximum price for that marketing year. In addition, an alternative regret was included (termed "major regret") where only regrets above a target regret level were counted. The target regrets were $1.00, $1.00, and $.75 per bu. for corn, soybeans, and wheat respectively. A 100-bushel sale was assumed where sales in any months of the marketing year could be made.

Four analyses were completed. The first developed a return-regret frontier minimizing regret as returns were varied. A second sub analysis examined the same relationship except major regret was used rather than total regret.

A second analysis involved a conventional MOTAD analysis of returns vs. deviations (from mean returns). In addition, total regret and total major regret was tabulated for each frontier point.

The third analysis was a regret-risk (deviation) analysis where minimum regret solutions for various deviation levels were determined. A second sub analysis involved total major regret as opposed to total regret.

Last a Target-MOTAD analysis was completed for each crop. For an arbitrary return,

solutions were developed minimizing target deviations for alternative target levels. The levels of total regret and total major regret were tabulated for each solution.

**Data**

For the marketing year November 1989-October 1990 and each year thereafter until 1999-2000 (11 years) monthly prices for corn and soybeans were assembled and averaged. For wheat the initial date was July 1988-June 1989 (12 years). The locations were Elm Creek, Nebraska for corn, Greenwood, Nebraska for soybeans, and Superior, Nebraska for wheat (Lutgen). It was assumed that the setting was where storage had already been constructed. A one cent per bu. per month charge for operating cost for storage was used in calculating net prices.

In Table 1 the monthly price averages for each crop are presented. The highest (lowest) average net price for corn was May (October), for soybeans May (October), and wheat January (June). For each year each month's differential from the highest price was determined and then totaled for all years. These are presented as total regret. Similarly the totals for maximum regret are presented for each month.

In terms of minimum (maximum) regret for corn the months are May (October). For soybeans it is also May (October). The minimum (maximum) regret for wheat is January (August). When the major regret criteria is used the months are May, June, or July (October) for corn, April (October) for soybeans, and March (July) for wheat. For corn there is no difference in months which minimize regret and major regret (May), however this is not the case for soybeans and wheat.

## Results

The results of the analysis are presented respectively for each of the four analyses.

**Return-Regret**

In Table 2 six solutions are presented for each crop. These include the minimum regret solution, the minimum return solution, and four other solutions at various return levels. It is not unexpected that a selling strategy which involves minimum regret is one which has the highest average monthly net selling price. This is the case for all three crops and no tradeoff between the two objectives are observed. Deviations from mean returns are "carried" in the solutions and are also presented in Table 2. For higher return-lower regret solutions, return deviations increase for the entire range for corn and nearly over the entire range for soybeans and wheat. While the risk criteria of deviations is examined more directly in subsequent analysis, it is clear that a regret-deviation tradeoff is occurs.

The same analysis was also completed where the major regret criterion was used. These results are presented in Table 3 for the same return points as Table 2. For corn the results parallel Table 2 with respect to returns-major regret. For soybeans and wheat, however, a U-shaped phenomenon exists for regret as returns increase. Hence, for these two crops, higher returns result in greater regret for a portion of the return range. This appears to be more important in wheat than for soybeans.

For the major regret analysis as returns increase there is no consistent pattern for deviations among corn, soybeans, and wheat. For corn, deviations increase and then decrease, the opposite occurs for soybeans, and no pattern is observed for wheat.

**Return-Deviation**

The normally expected tradeoff between returns and risk is observed for the MOTAD analysis. In Table 4 solutions are presented for the minimum risk and maximum return solutions as well as three other solutions. Increasingly diversified selling occurs for lower risk solutions. For

wheat the return intervals are close demonstrating that opportunity to reduce risk only occurs for a small return range. Over the entire range for each dollar reduction in returns the reduced risk is greatest in wheat, followed by soybeans and corn.

As returns increase regret levels decline. This is also the case for major regret for corn and soybeans. For wheat this occurs for most of the return range.

**Regret-Deviation**

The tradeoff between regret and risk is demonstrated in Table 5 for each crop. The minimum deviation solution and the minimum regret solution are presented as well as three other solutions. As risk is reduced, regret increases. While this phenomenon was observed indirectly before, it is clearly evident in this frontier. Stronger tradeoffs are observed for corn and soybeans relative to wheat. Lower regret solutions are seen to consistently involve higher returns.

Table 6 demonstrates the regret-risk relationship except major regret is the variable under examination. The results again demonstrate the same tradeoff as previously described. The impact on reduced major regret as deviations increase are similar in magnitude for all three crops. Net returns are observed to decline in corn and soybeans as deviations decline (and major regret increases). In wheat however returns are very stable over the solution range.

**Target-MOTAD**

Target-MOTAD solutions for arbitrary returns for each of the three crops are presented in Table 7. As the target is reduced, deviations below the target are seen to decline in the usual fashion. Regret and major regret levels were tabulated in the solution procedure. Under reduced targets, regret was largely stable for corn and wheat but increased in soybeans. Reducing risk from this perspective involved a regret sacrifice for soybeans. When major regret is considered rather than

regret, increased regret for corn and soybeans is observed as the target (and risk) is reduced. The same relationship was not observed for wheat where the lowest risk solution also had the lowest major regret.

## Conclusions

Incorporating the behavioral concept of regret avoidance to the analysis of risk-return relationships in sales of crops adds some dimensions to the choice decision. The results demonstrated that for corn, soybeans, and wheat no tradeoff occurred between net returns and regret. Thus, high return sales months also yielded low regret. This was also observed when only large or major regret was used to define regret. In the latter case some tradeoff area between return and major regret was observed for soybeans but not corn and wheat.

The usual expected tradeoff between returns and risk (defined as deviations below the mean) was observed in this analysis. As risk increased, however, regret decreases resulted in a significant tradeoff between these two behavioral aspects.

When risk is defined in a target sense (deviations only below a target return) risk decreases as the target level declines. However, in this case decreased risk is not accompanied uniformly by increased regret. For soybeans and corn this was observed but not for wheat. For wheat when reduced risk defined as reduced target deviations is accompanied by a reduced major regret.

## References

1. Anderson, D.R., D.J. Sweeney, and T.W. Williams. Statistics for Business and Economics. West., St. Paul, Minn. 1987.

2. Lutgen, L. Unpublished data.

**Table 1. Monthly Average Net Prices for Corn (1989-99), Soybeans (1989-99) and Wheat (1988-99).**

| | Corn $/bu. | | | Soybeans $/bu. | | | Wheat $/bu. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ave. Net Price | Total Regret | Total Major Regret | Ave. Net Price | Total Regret | Total Major Regret | Ave. Net Price | Total Regret | Total Major Regret |
| November | 2.28* | 5.11 | 1.14 | 5.61* | 8.25 | 1.84 | 3.32 | 5.25 | .64 |
| December | 2.31 | 4.75 | 1.13 | 5.67 | 7.55 | 1.26 | 3.39 | 4.32 | .32 |
| January | 2.34 | 4.41 | .85 | 5.64 | 7.93 | .91 | 3.41 | 4.16 | .37 |
| February | 2.34 | 4.45 | 1.08 | 5.65 | 7.79 | .62 | 3.40 | 4.19 | .17 |
| March | 2.45 | 3.27 | .52 | 5.70 | 7.34 | .32 | 3.36 | 4.82 | .02 |
| April | 2.48 | 2.95 | .21 | 5.78 | 6.36 | .01 | 3.33 | 5.06 | .06 |
| May | 2.57 | 1.95 | 0 | 5.98 | 4.18 | .05 | 3.31 | 5.37 | .12 |
| June | 2.49 | 2.77 | 0 | 5.82 | 5.93 | .15 | 3.18 | 6.91 | .98 |
| July | 2.45 | 3.24 | 0 | 5.69 | 7.32 | .81 | 3.22* | 6.39 | 1.88 |
| August | 2.56 | 5.38 | .01 | 5.50 | 9.41 | 2.38 | 3.20 | 6.60 | 1.63 |
| September | 2.12 | 6.57 | 1.07 | 5.58 | 8.59 | 4.19 | 3.24 | 6.14 | 1.27 |
| October | 2.07 | 7.43 | 1.51 | 5.25 | 12.16 | 3.63 | 3.27 | 5.77 | 1.35 |

* Beginning of marketing year.

**Table 2. Return-Regret Frontier for Monthly Sales of Corn, Soybeans, and Wheat.**

| | Corn | Soybeans | Wheat |
|---|---|---|---|
| Regret - $ | 195.0 | 418.0* | 416.0* |
| Return - $ | 256.7 | 597.6 | 340.7 |
| Organization - bu. | 100 May | 100 May | 100 Jan. |
| Motad Deviations $ | 236 | 467 | 345 |
| Regret - $ | 264.5 | 447.0 | 483.4 |
| Return - $ | 250.0 | 595.0 | 335.0 |
| Organization - bu. | 85 May, 15 Sep. | 90.8 May, 9.2 Jul. | 69.8 Jan., 30.2 Jul. |
| Motad Deviations $ | 216 | 458 | 323 |
| Regret - $ | 367.8 | 667.0 | 542.9 |
| Return - $ | 240.0 | 575.0 | 330.0 |
| Organization - bu. | 62.6 May, 37.4 Sep. | 20.7 May, 79.3 Jul. | 43.1 Jan., 56.9 Jul. |
| Motad Deviations $ | 199 | 396 | 329 |
| Regret - $ | 471.1 | 887.0 | 602.4 |
| Return - $ | 230.0 | 555.0 | 325.0 |
| Organization - bu. | 40.2 May, 59.8 Sep. | 64.1 Jul., 6.8 Aug., 29.1 Oct. | 16.4 Jan., 83.6 Jul. |
| Motad Deviations $ | 189 | 356 | 344 |
| Regret - $ | 574.4 | 1107.0 | 662.9 |
| Return - $ | 220.0 | 535.0 | 320.0 |
| Organization - bu. | 17.9 May, 82.1 Sep. | 22.5 Jul., 77.5 Oct. | 54 Jul., 46 Jun. |
| Motad Deviations $ | 187 | 341 | 325 |
| Regret - $ | 743.0 | 1216.0 | 691.0 |
| Return - $ | 206.9 | 525.1 | 317.8 |
| Organization - bu. | 100 Oct. | 100 Oct. | 100 Jun. |
| Motad Deviations $ | 183 | 345 | 366 |

* Minimum Regret Solution

**Table 3. Return-Major Regret Frontier for Monthly Sales of Corn, Soybeans, and Wheat.**

| | Corn | Soybeans | Wheat |
|---|---|---|---|
| Major Regret - $ | 0* | 5 | 37 |
| Return - $ | 256.7 | 597.6 | 340.7 |
| Organization - bu. | 100 May | 100 May | 100 Jan. |
| Motad Deviations $ | 236 | 468 | 345 |
| Major Regret - $ | 0 | 4.5 | 2.4* |
| Return - $ | 250.0 | 595.0 | 336.0 |
| Organization - bu. | 42.6 May, 57.4 Jul. | 13.3 Apr., 86.7 May | 89.6 Mar., 10.4 Apr. |
| Motad Deviations $ | 276 | 461 | 356 |
| Major Regret - $ | .26 | 1.0* | 15.9 |
| Return - $ | 240.0 | 578.0 | 330.0 |
| Organization - bu. | 74.3 Jul., 25.7 Aug. | 99.1 Apr., .9 May | 95.5 May, 4.5 Jun. |
| Motad Deviations $ | 308 | 420 | 392 |
| Major Regret - $ | .77 | 136.4 | 49.4 |
| Return - $ | 230.0 | 555.0 | 325.0 |
| Organization - bu. | 22.9 Jul., 77.1 Aug. | 75.3 Feb., 24.7 Oct. | 56.5 May, 43.5 Jun. |
| Motad Deviations $ | 267 | 348 | 361 |
| Major Regret - $ | 44.4 | 287.9 | 82.9 |
| Return - $ | 220.0 | 535.0 | 320.0 |
| Organization - bu. | 59 Aug., 41 Sep. | 24.9 Feb., 75.1 Oct. | 17.5 May, 82.5 Jun. |
| Motad Deviations $ | 227 | 281 | 364 |
| Major Regret - $ | 151 | 363 | 98 |
| Return - $ | 206.9 | 525.1 | 317.8 |
| Organization - bu. | 100 Oct. | 100 Oct. | 100 Jun. |
| Motad Deviations $ | 184 | 345 | 366 |

* Minimum Major-Regret Solution.

**Table 4. Return-Deviation Frontier for Monthly Sales of Corn, Soybeans, and Wheat.**

| | **Corn** | **Soybeans** | **Wheat** |
|---|---|---|---|
| Deviations - $ | 235.8 | 467.5 | 345.4 |
| Return - $ | 256.7 | 597.6 | 340.7 |
| Organization - bu. | 100 May | 100 May | 100 Jan. |
| Regret $ | 195 | 418 | 416 |
| Major Regret $ | 0 | 5 | 37 |
| Deviations - $ | 200.9 | 449.6 | 328.5 |
| Return - $ | 250.0 | 595.0 | 340.0 |
| Organization - bu. | 74.8 Apr., 25.2 May | 93.4 May, 6.6 Sep. | 50 Dec., 50 Jan. |
| Regret $ | 270 | 447 | 424 |
| Major Regret $ | 16 | 32 | 35 |
| Deviations - $ | 169.3 | 335.2 | 313.2 |
| Return - $ | 240.0 | 575.0 | 339.0 |
| Organization - bu. | 56.3 Feb., 43.7 Apr. | 25.4 Dec., 37.5 May, 37.1 Sep. | 2.6 Jul., 88.2 Dec., 9.2 Jan. |
| Regret $ | 380 | 667 | 436 |
| Major Regret $ | 70 | 189 | 37 |
| Deviations - $ | 139.7 | 251.9 | 309.2 |
| Return - $ | 230.0 | 555.0 | 338.0 |
| Organization - bu. | 51.1 Feb., 12.6 Apr., 16.9 Oct. | 48.4 Dec., 5 Aug., 25.7 Sep., 20.8 Oct. | 8.2 Jul., 84.9 Dec., 6.9 Jan. |
| Regret $ | 489 | 887 | 448 |
| Major Regret $ | 105 | 256 | 45 |
| Deviations - $ | 118.7* | 240.7* | 303.3* |
| Return - $ | 221.0 | 543.0 | 336.0 |
| Organization - bu. | 66.8 Nov., 33.2 Oct. | 42.2 Dec., .9 Aug., 56.9 Oct. | 18.5 Jul., 1.0 Aug., 73.2 Dec., 7.4 Feb. |
| Regret $ | 588 | 1019 | 472 |
| Major Regret $ | 126 | 262 | 61 |

* Minimum Deviation Solution.

**Table 5. Regret-Deviation Frontier for Monthly Sales of Corn, Soybeans, and Wheat.**

| | **Corn** | **Soybeans** | **Wheat** |
|---|---|---|---|
| Regret - $ | 584.9 | 1004 | 471.1 |
| Deviations - $ | 118.7 | 240.7 | 303.3 |
| Organization - bu. | 68.2 Nov., 31.8 Oct. | 42.3 Dec., 6.2 Aug., 51.5 Oct. | 18 Jul., .8 Aug., 74.5 Dec., 6.4 Feb., .4 Jun. |
| Net Returns $ | 221 | 544 | 336 |
| | | | |
| Regret - $ | 547.0 | 898.0 | 445.6 |
| Deviations - $ | 125.0 | 250.0 | 310.0 |
| Organization - bu. | 62.8 Nov., 11.2 Apr., 26.0 Oct. | 48.4 Dec., 6.0 Aug., 21.9 Sep., 23.6 Oct. | 7.1 Jul., 85.5 Dec., 7.4 Jan. |
| Net Returns $ | 225 | 554 | 338 |
| | | | |
| Regret - $ | 359.0 | 637.1 | 425.7 |
| Deviations - $ | 125.0 | 350.0 | 325.0 |
| Organization - bu. | 42.6 Feb., 57.4 Apr. | 21.0 Dec., 45.37 May, 33.6 Sep. | 60.4 Dec., 39.6 Jan. |
| Net Returns $ | 242 | 578 | 340 |
| | | | |
| Regret - $ | 212.4 | 446.4 | 418.5 |
| Deviations - $ | 225.0 | 450.0 | 340.0 |
| Organization - bu. | 13.2 Mar., 86.8 May | 93.6 May, 6.4 Sep. | 15.9 Dec., 84.1 Jan. |
| Net Returns $ | 255 | 595 | 341 |
| | | | |
| Regret - $ | 195.0* | 418.0* | 416.0* |
| Deviations - $ | 235.8 | 467.5 | 345.4 |
| Organization - bu. | 100 May | 100 May | 100 Jan. |
| Net Returns $ | 257 | 598 | 341 |

* Minimum Regret Solution

**Table 6. Deviation-Major Regret Frontier for Monthly Sales of Corn, Soybeans, and Wheat.**

| | Corn | Soybeans | Wheat |
|---|---|---|---|
| Major Regret - $ | 125.9 | 260.5 | 60.9 |
| Deviations - $ | 118.7 | 240.7 | 303.3 |
| Organization - bu. | 67 Nov., 32 Oct. | 42 Dec., 2.2 Aug., 55.7 Oct. | 18.4 Jul., 1.0 Aug., 73.4 Dec., 7.2 Feb. |
| Net Returns $ | 221 | 543 | 336 |
| Major Regret - $ | 109.7 | 216.7 | 39.5 |
| Deviations - $ | 125.0 | 250.0 | 310.0 |
| Organization - bu. | 66.3 Nov., 1.8 Aug., 31.9 Sep. | 37 Dec., 3.1 Apr., 9.3 Jun., 12.1 Aug. | 6.2 Jul., .6 Aug., 82.3 Dec., 10.9 Apr. |
| Net Returns $ | 223 | 551 | 338 |
| Major Regret - $ | 38.8 | 80.2 | 19.0 |
| Deviations - $ | 175.0 | 350.0 | 325.0 |
| Organization - bu. | 25.6 Nov., 44.4 Apr., 30.0 Aug. | 63.4 Apr., 8.1 Jun., 20.1 Aug., 8.4 Oct. | 50 Dec., 50 Apr. |
| Net Returns $ | 236 | 568 | 336 |
| Major Regret - $ | .1 | 1 | 9.5 |
| Deviations - $ | 225.0 | 450.0 | 340.0 |
| Organization - bu. | 57.4 May, 29.2 Jun., 13.4 Aug. | 100 Apr. | 25.1 Dec., 74.9 Mar. |
| Net Returns $ | 250 | 578 | 337 |
| Major Regret - $ | 0* | 1* | 7* |
| Deviations - $ | 235.8 | 467.5 | 345.4 |
| Organization - bu. | 100 May | 100 Apr. | 16.9 Dec., 83.1 Mar. |
| Net Returns $ | 257 | 578 | 337 |

* Minimum Major Regret Solution.

**Table 7. Target-MOTAD Solutions for Monthly Sales of Corn, Soybeans, and Wheat.**

| | Corn | Soybeans | Wheat |
|---|---|---|---|
| Return - $ | 250.0 | 585.0 | 340.0 |
| Target - $ | 250.0 | 585.0 | 340.0 |
| Deviations - $ | 200.9 | 379.0 | 328.5 |
| Organization - bu. | 74.8 Apr., 25.2 May | 100 May | 50 Dec., 50 Jan. |
| Regret - $ | 270 | 418 | 424 |
| Major Report | 16 | 5 | 35 |
| | | | |
| Return - $ | 250.0 | 585.0 | 340.0 |
| Target - $ | 230.0 | 555.0 | 300.0 |
| Deviations - $ | 86.2 | 199.0 | 173.1 |
| Organization - bu. | 74.8 Apr., 25.2 May | 11.2 Dec., 83.0 May, 5.8 Sep. | 3.6 Jul., 96.4 Jan. |
| Regret - $ | 270 | 481 | 424 |
| Major Report | 16 | 20 | 42 |
| | | | |
| Return - $ | 250.0 | 585.0 | 340.0 |
| Target - $ | 210.0 | 515.0 | 260.0 |
| Deviations - $ | 28.2 | 83.0 | 67.8 |
| Organization - bu. | 26.7 Feb., 7.3 Apr., 66.0 May | 41.3 Dec., 58.7 May | 84.6 Jan., 15.4 Mar. |
| Regret - $ | 269 | 557 | 426 |
| Major Report | 30 | 55 | 32 |
| | | | |
| Return - $ | 250.0 | 585.0 | 340.0 |
| Target - $ | 190.0 | 475.0 | 221.0 |
| Deviations - $ | 1.7 | 8.7 | 0 |
| Organization - bu. | 29.6 Feb., 70.4 May | 41.3 Dec., 58.7 May | 89.7 Feb., 10.3 Mar. |
| Regret - $ | 269 | 557 | 426 |
| Major Report | 32 | 55 | 16 |