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Effects of the 1986 Tax Reform Act on Grain Marketing Decisions:

A Case Study of Winter Wheat Producers

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Abstract

Dynamic programming is utilized to derive an optimal monthly cash grain marketing decision rule for years before and after the 1986 Tax Reform Act. State variables of grain price, storage, and before-tax income were considered in this analysis. Results indicate changes in optimal marketing decisions for different tax years.

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Grain producers throughout the U.S. have historically used grain storage as a primary tool for reducing and/or deferring tax liabilities. Passage of the 1986 Tax Reform Act (TRA) has brought about a dramatic change in the progressivity of Federal income tax rates for individuals which have a taxable income of over $30,000.00. Consequently, optimal grain marketing or storage decisions may be substantially altered for grain producers under the new tax rate schedule. Furthermore, the 1986 TRA implemented different progressivity of income tax rates for 1987 and 1988 tax years. Thus, optimal grain marketing-storage decisions may also be substantially different for 1988 than for 1987.

The primary objective of this paper is to derive an optimal cash grain-storage decision rule, and determine how optimal monthly grain marketing-storage decisions may have been altered for grain producers from implementation of the 1986 TRA. A representative Montana (MT) grain producer which utilizes cash grain sales is chosen to address the issue of how implementation of the 1986 TRA may have altered optimal grain marketing-storage decisions. That is, MT dryland grain producers essentially have only winter wheat as an economically viable crop alternative so that a much simpler model formulation results for a MT grain producer than for a grain producer from a multiple crop region. Furthermore, changes in optimal grain marketing-storage decisions from the 1986 TRA for a single crop producer should be similar to those for a multiple crop producer since the issue is primarily timing of grain sales rather than crop selection.

Optimal grain marketing-storage decisions will be generated under the assumption of a multiperiod horizon where the producer is presumed to maximize expected wealth (i.e. risk neutrality). Dynamic Programming (DP) was chosen as a multiperiod optimization method over optimal control theory since an explicit solution is often not achieved for many problems when using optimal control theory (Burt 1982) and stochastic variants further complicate this problem (Whittle).

The next section of this paper presents the DP recursive equation for the MT winter wheat grain marketing-storage model. Calculation of MT winter wheat price transition probabilities are discussed in the third section, and the fourth section describes the effects of the 1986 Tax Reform Act on marginal tax rates. The fifth section discusses other critical input figures and features which are important for this illustrative model and is followed by a section examining the major differences in optimal grain marketing-storage decisions for 1986, 1987, and 1988 tax years. Lastly, a section of concluding comments concerning the limitations of this study and implications for grain producers making marketing-storage decisions is presented.

Dynamic Programming Model

The objective function for this winter wheat storage model is to maximize the expected present value of after-tax profit over a monthly T-period planning horizon subject to winter wheat price, winter wheat in storage, and current income level. The DP model optimized is given algebraically in the following recursive equation:

$$(1)\quad V_t(P_t, SS_t, INC_t) = \max_{X_t} E[T\{R(P_t, SS_t, INC_t)\} + b\, V_{t+1}(P_{t+1}, SS_{t+1}, INC_{t+1})]$$

Subject to:

$$(2)\quad SS_t = SS_{t-1} + Q_t - X_t$$

(3) $0 \leq SS_t \leq SC$

(4) $0 \leq X_t \leq SS_t + Q_t$

(5) $INC_t = 0$ at the beginning of the tax year (i.e. January).

(6) $INC_t = INC_{t-1} + P_tX_t + DEF_t - C_t$ (i.e. for remainder of the tax year).

where t = monthly time period; $V_t(\cdot)$ is the maximum expected return from the current time period t through the terminal period T; P_t = price of MT winter wheat in period t; SS_t = storage state (i.e. amount of grain in storage) for grain at the beginning of month t; INC_t = the before-tax income state of the producer at the beginning of month t; E = expectation operator; $R(\cdot)$ is before tax income; $T\{R(\cdot)\}$ is after-tax income as a function of before-tax income; b is the discount factor; Q_t = total production for period t (positive only for the month of August); SC = total storage capacity; DEF_t = deficiency payments from month t (Calculated from the "first five" marketing months of June to October); C_t = costs of production incurred for period t; and X_t is the decision variable of optimal winter wheat sales for period t from which the optimal marketing-storage level can be obtained.

P_t is a stochastic state variable while SS_t and INC_t are deterministic state variables. P_t enters the before-tax function $(R(\cdot))$ linearly, but the after tax function $(T\{\cdot\})$ is nonlinear so that the certainty equivalence requirements are not satisfied for P_t (Simon; Theil), requiring the treatment of P_t as a stochastic state variable in the DP model.

Montana Winter Wheat Price Transition Probabilities

The monthly Markovian winter wheat price transition relationship was estimated from mid-month (i.e. 15th of each month) MT prices (source, U.S.D.A., Agricultural Prices). Mid-month MT prices are not available prior to January 1977 so that the monthly data series runs from January 1977 to September 1987.

All prices are adjusted by the consumer price index for all urban consumer goods (source: Survey of Current Business) to equal real September 1987 dollars.

To determine mid-month MT winter wheat price Markovian transition probabilities, wheat price was estimated as a function of own lagged price, a harvest dummy variable (i.e. 1 for the months of June, July, and August; and 0 otherwise), and a time trend with consideration given to an autoregressive error structure. Lagged MT wheat prices are hypothesized to capture current grain market conditions. A harvest dummy variable for the months of June, July, and August is included to capture any dampening effect the harvest of wheat may have on MT winter wheat prices. A time trend variable is included to test for any significant trend in MT wheat prices over time.

Maximum Likelihood (ML) was utilized for estimating models with an autoregressive error structure and Ordinary Least Squares (OLS) was utilized otherwise. Under the assumption that lagged MT wheat price and the autoregressive error structure is no greater than three periods, the order for these lag lengths was determined by Schwarz's Bayesian Information Criteria (BIC) (Granger and Newbold). The variable which had the lowest student's t-ratio for the full model (i.e. full lag lengths and inclusion of all previously mentioned variables) was first omitted and then the variable which had the lowest student's t-ratio for this model (i.e. the full model minus the first omitted variable) was omitted. This backwards step-wise model truncation was done until there was only one remaining independent variable and a constant term. The model which obtained the lowest BIC value was chosen as the appropriate model specification. Thus, the BIC was utilized to determine the appropriate lag length and variables for model specification.

BIC resulted in the following recursive price relationship for mid-month MT winter wheat prices[1];

$$(7)\quad P_t = \underset{(2.500)}{.39592} + \underset{(30.582)}{.93057P_{t-1}} - \underset{(-3.194)}{.11916HD_t} - \underset{(-2.217)}{.001487TR_t} + e_t$$

where P_t is mid-month MT winter wheat price, HD_t is a harvest dummy variable (i.e. 1 for months of June, July, and August; 0 otherwise), TR_t is a monthly time trend variable (equals 129 for September 1987) and e_t is a normally distributed error term with constant variance. The autoregressive error term was determined to be insignificant by the BIC for all lag lengths. The adjusted coefficient of determination and Durbin's h statistic for equation (7) are .950 and -.225, respectively.

Monthly seasonality was found to be influential only for the months of June, July, and August. Therefore, when the estimated coefficients for the three months (i.e. using three dummy variables) were found to be insignificantly different, a single dummy variable (i.e. harvest dummy variable) was constructed to capture monthly harvest impacts. Significance of the monthly time trend variable means that a different price transition probability matrix is required for each period in the DP model. Taylor's (1984) approximation to a normal distribution was used in conjunction with equation (7) to calculate MT winter wheat price transition probability matrices utilized for each period.

Marginal Tax Rate Schedules

Schedule-Y (Primarily for married taxpayers filing joint returns) of the 1986 Federal Income Tax Tables was used for calculation of the "old" tax function, $T_o(R)$. $T_o(R)$ has 15 marginal tax rates, ranging from 0% for individuals with taxable income less than \$3,670 to 50% for individual with taxable income exceeding \$175,250. Two personal exemptions (i.e. \$2,160) are claimed in $T_o\{R\}$. In Figures 1 and 2 the year 1986 is used to denote tax years prior to the 1986 TRA or $T_o\{R\}$.

The "new" tax function, $T_n\{R\}$, has 5 marginal tax rates for 1987 and just 2 marginal tax rates for 1988. For 1987, the marginal tax rates range from 11% at the bottom to 38.5% for individuals on the upper end with taxable income over \$90,000 and the marginal tax rate after 1987 is 15% (28%) for individuals with taxable income less (greater) than \$29,750. Standard deductions for a married couple (i.e. \$5,660 for 1987 and \$6,965 for 1988) and two personal exemptions (i.e. \$1900 for 1987 and \$1950 for 1988) are claimed in $T_n\{R\}$. Social Security payments were not considered in $T_o\{R\}$ or $T_n\{R\}$ since they are viewed as a direct transfer of income.

To compare the effects of the tax change on optimal grain storage, $T_o\{R\}$ was used for all periods in one DP formulation while $T_n\{R\}$ was used in another formulation. Due to the different tax rates between 1987 and 1988, optimal grain marketing-storage decisions are given for both of these years. Differences in optimal grain marketing-storage decisions from using $T_n\{R\}$ instead of $T_o\{R\}$ should be more for 1988 than 1987 since the marginal tax rate is decreased more in 1988 at higher income levels.

Other Critical Input Features and Values

It is assumed that this representative MT producers complies with all Acreage Reduction Program (ARP) requirements since compliance rates are so high. This allows the producer to receive deficiency payments and receive a price at least as high as the loan rate (i.e. \$2.28 bu. for wheat). Producers receive 40% of their expected deficiency payment when they sign up for compliance with the ARP, approximately 30% of their expected deficiency payment in July, and any remainder of their realized deficiency payment (calculated from grain prices for the months of June to October, farm payment acreage, and farm program yield) not paid for in December. If wheat price is less than the target price (currently \$4.38 bu.) for any of the months of June to October, a deficiency payment is calculated for each of these months as follows; (Target Price - Wheat Price)(Farm Payment Acreage)(Farm Program Yield)(20%). This formula is utilized since these five months are used by the government to determine the national wheat price and total realized deficiency payment for a tax year.

Critical parameters for the production side of this illustrative model are: Farm payment acreage or crop production acreage of 1,035 for 1986 and 1,000 for 1987 and beyond; farm program yield and expected winter wheat yield of 30 bu. per acre; variable per-acre production costs of \$6 and \$42.32 incurred in August and September, respectively; fixed costs of \$17,700; a monthly discount factor of 1/1.005; and a given storage capacity (SC) of 50,000 bushels. Production cost figures are primarily based on Economic Research Service production costs for hard red winter wheat in the Northern Plains. Farm size, winter wheat yield, and storage capacity are specified at levels felt to be most reflective for a typical "full-time" Montana winter wheat producer.

Discretization of the state space was as follows; 13 price (P_t) states (from \$2.25 bu. to \$5.25 bu. in \$0.25 increments); 16 income (INC_t) states (from \$-60,000. to \$200,000. in \$20,000. increments); and 21 storage states (SS_t) (from 0 bu. to 50,000 bu. in 2,500 bu. increments). The state space for the decision variable (X_t) is equal to the state space for SS_t for all months except the harvesting month of August which has 34 sell states (from 0 bu. to

82,500 bu. in 2,500 bu. increments). The given state space is felt to adequately represent the current state space of Montana winter wheat producers with a small probability of values occurring outside the indicated state space.

Major Changes in the Optimal Decision Rule for Marketing Winter Wheat

Graphical or numerical presentation of the complete decision rule for all 12 months and states would result in an unduly large set of output for this paper. Therefore, a storage state of 10,000 bushels for the months of August and December, and a zero before-tax income state for the month of January is used to give insight to the optimal decision rule for marketing MT winter wheat (refer to Figures 1 and 2). The months of January, December, and August are chosen over other months since January and December are key months for income tax management strategies, and August is the harvest month.

Figure 1 shows the decision rule for marketing MT winter wheat for the month of January (which has zero before-tax income) depending on price, and grain storage states. For price states of \$3.0 bu. to \$3.5 bu. Figure 1 shows that it is more profitable to sell grain at lower prices for 1988 than 1987, and for 1987 than 1986. This result is attributed to the implementation of lower marginal tax rates for more recent years. Thus, the decision to store grain in January at lower prices (i.e. less than \$3.5 bu. for wheat) is somewhat less lucrative than it has been in years past due to the 1986 TRA.

Given a storage state of 10,000 bu., Figure 2 shows the decision rule for marketing MT winter wheat for the months of August and December depending on price and income states. For the month of August (panels a to c), changes in the optimal decision rule occur for prices between \$2.75 and \$4.25 per bushel. Results suggest quite strongly that it became better to store less grain in 1987 than 1986, and store less grain in 1987 than 1988. Similar to the month of January, this result is attributed to a lowering of the marginal tax rate with the 1986 TRA.

December is the month most crucial for income tax management strategies due to the time value of money. This is probably why changes in the optimal decision rule from the 1986 TRA for the month of December (panels d to f) are somewhat more mixed than for other months. That is changes between 1986 and 1987 tax years indicate that it is somewhat better to store more grain during December 1987 than December 1986, while it is better to store less grain during December 1988 than December 1986. This is especially true for before-tax income levels above $80,000.

The result of being better to store more grain for December 1987 than December 1986 is attributed mainly to the fact that lower marginal tax rates are anticipated in $T_n\{R\}$ for the 1988 tax year. That is, the expected gain from selling at a lower marginal tax rate in the future tended to outweigh expected losses associated with the time value money and the probability of wheat prices decreasing. This is because a producer needs to store his/her grain only one more month to take advantage of lower marginal tax rates. Similar to the months of January and August, the result of being better to store less grain in 1988 than 1986 is attributed to a lowering of the marginal tax rate from the 1986 TRA.

Panel f in Figure 2 reveals that at before-tax income states above $80,000 and price states between $3.0 and $3.5 per bu. that it becomes more profitable to store grain until before-tax income reaches $160,000. When before-tax income exceeds $160,000 it becomes better to increase wheat sales for price states between $3.0 and $3.5 per bushel. This phenomenon of optimal wheat sales increasing from an increase in the before-tax income state is due to the unlikelihood of the producer being able to lower his/her marginal tax rate at high income level by storing grain and the likelihood of price decreasing.

Concluding Comments

One of the main limitations of this study is that the price transition probability matrix generated from past prices does not account for events that could bring about a structural change. However, this would primarily apply to conditional price probabilities that are in the more distant future. Other limitations of this study are that crop production, machinery and/or land purchases, and storage capacity are given and not allowed to be chosen optimally with the decision variable of optimal grain sales (X_t).

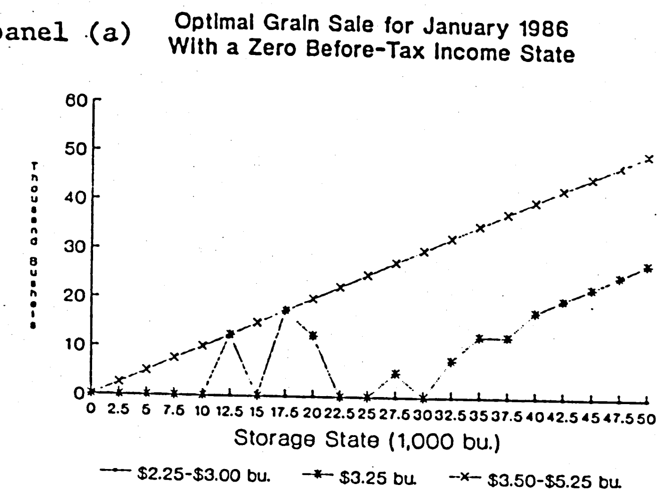
In general, results of this study indicate that changes in optimal grain storage decisions from the 1986 TRA are to store less grain. This is especially true for winter wheat prices between $2.75 and $3.75 per bushel. Therefore, the expected returns to a grain producer from increasing his/her current storage capacity have been reduced from the 1986 TRA. Even though the complexity of the income tax schedule has been reduced by having fewer tax brackets, sensitivity of the optimal grain storage decision rule to the state variables of price, storage, and before-tax income still exists. This sensitivity may be somewhat magnified at potential income tax levels near tax bracket changes (i.e. $29,750, $71,901, and $171,090) since the 1986 TRA brought about larger jumps in marginal tax rates. Thus the results of this analysis suggest that producers should still carefully evaluate their potential tax liability given current price, storage, and before-tax income levels.

Footnote

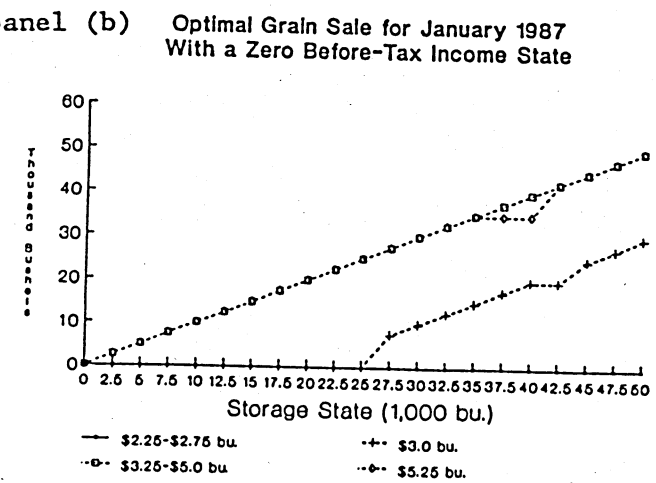
1 t-values are given in parentheses.

Figure 1. shows optimal grain sales for the month of January (panels a, b, and c) depending on various grain price states, storage states, and year of tax liability. Note that 1986 refers to years prior to implementation of the 1986 Tax Reform Act.

panel (a)



panel (b)



panel (c)

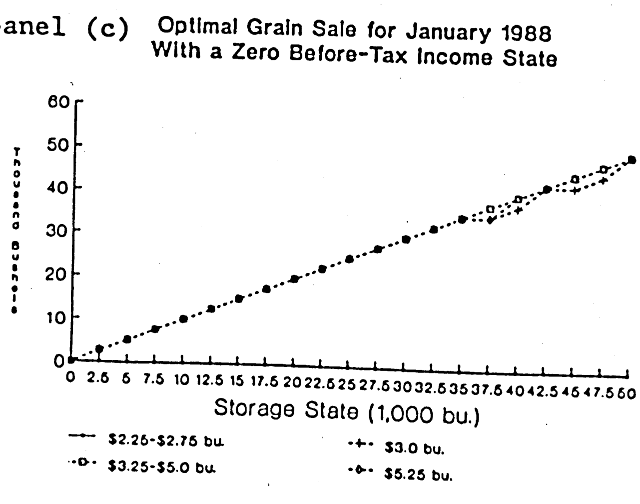
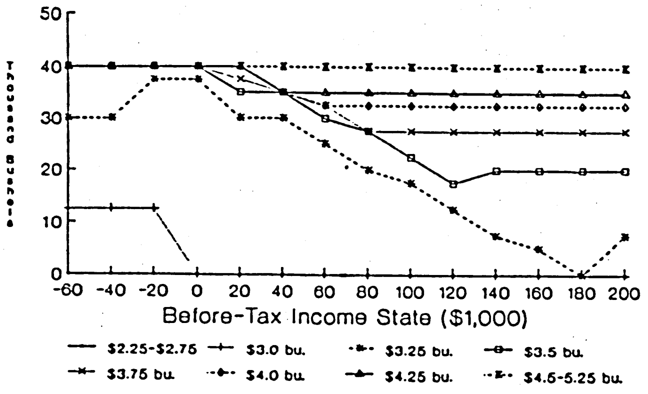
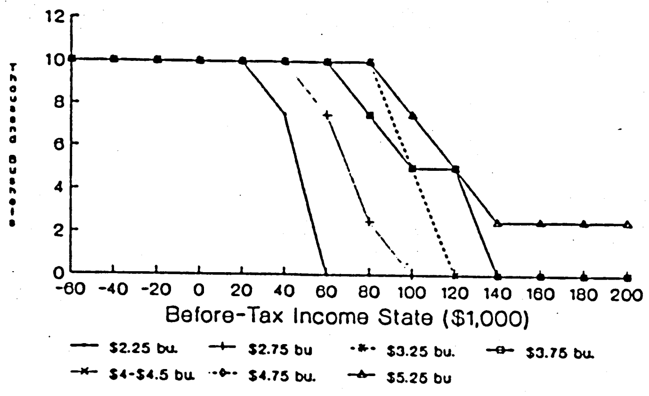


Figure 2. shows optimal grain sales for the months of August (panels a through c), and December (panels d through f) depending on a storage state of 10,000 bushels, grain price states, before-tax income states, and year of tax liability. Note that 1986 refers to years prior to implementation of the 1986 Tax Reform Act.

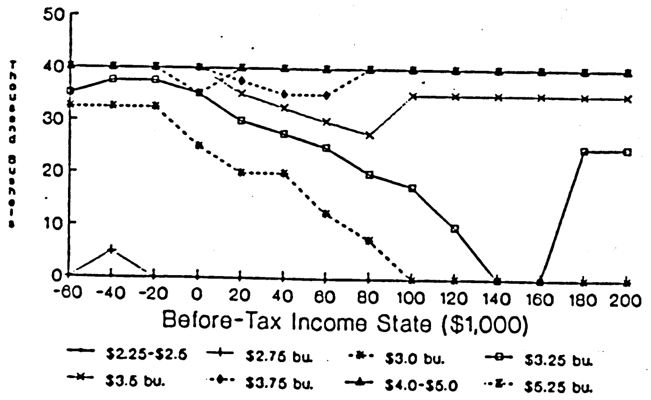
panel (a) Optimal Grain Sale for August 1986 Given a Storage State of 10,000 bu.



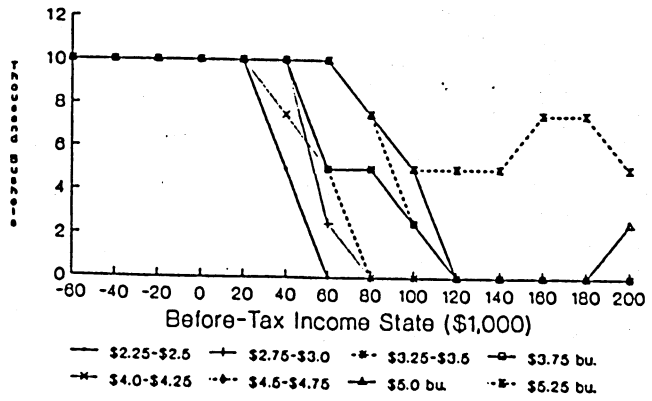
panel (d) Optimal Grain Sale for December 1986 Given Storage State of 10,000 bu.



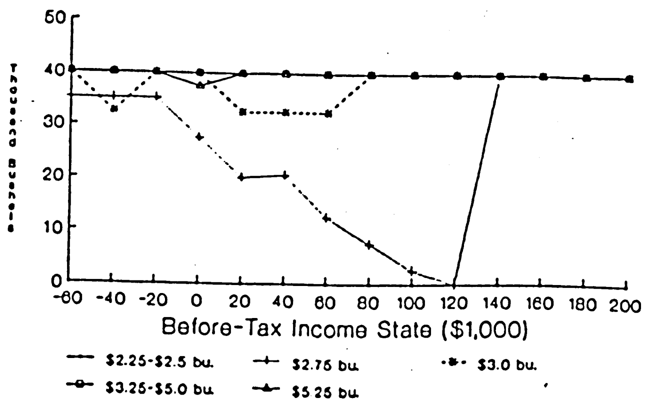
panel (b) Optimal Grain Sale for August 1987 Given a Storage State of 10,000 bu.



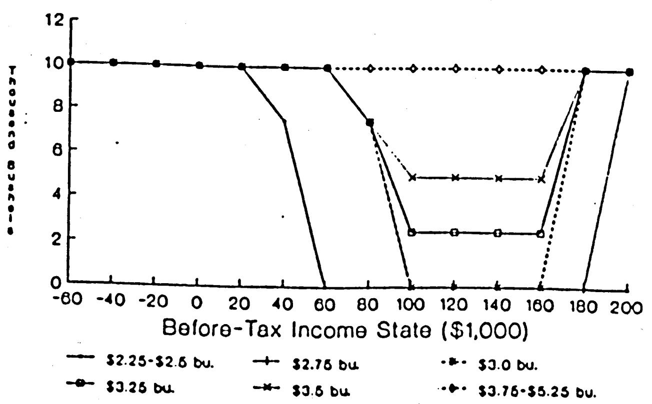
panel (e) Optimal Grain Sale for December 1987 Given a Storage State of 10,000 bu.



panel (c) Optimal Grain Sale for August 1988 Given a Storage State of 10,000 bu.



panel (f) Optimal Grain Sale for December 1988 Given a Storage State of 10,000 bu.



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