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Lower stumpage costs by using probabilistic and skewed bidding methods| A case study of timber sales on the Lolo National Forest

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Lower Stumpage Costs by Using Probabilistic and Skewed Bidding Methods: A Case Study of Timber Sales on the Lolo National Forest

by

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Probabilistic and skewed bidding techniques can significantly lower a wood products firm's stumpage costs and increase its profits. Results from the study of 114 sales on the Lolo National Forest show that 16 percent of the volume sold, having average sale characteristics, could have been purchased at 57 percent of the average bid price per thousand board feet (MBF) by using probabilistic bidding methods. If the optimal skewed bid was submitted on each of 60 closed sales, savings from the amount bid to the amount paid of up to $72.51 per MBF (1980 $) could have been realized.

Selling value and cost equations, based on sale characteristics, for a hypothetical firm are developed to determine the timber value remaining to be distributed between the stumpage bid and profit. Probabilities of obtaining a specified volume of timber at various profit margins are calculated and the optimal profit margin determined. The optimal bid for each species, using linear programming, is determined to maximize the difference between the bid and the expected payment. The constraints of base rates, advertised rates, base indices and projected indices are used to factor in the effects of escalation clauses.

The results provide a methodology for more profitable timber procurement and identify when the methodology may be used most effectively.

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CHAPTER ONE

INTRODUCTION

Wood product manufacturing firms recently have had low profit margins, and some have had substantial losses. Low profits and losses result from low market prices and/or high costs. A firm has little control over market prices; therefore, it must reduce costs to be competitive. Stumpage costs are a significant portion of total wood product production costs. This is especially true in the case of higher valued species such as white and ponderosa pine. The lower the average price paid for similar timber the greater the profit for the firm. As long as the lumber selling price is greater than the variable costs of production, relatively constant production and timber supplies should be maintained to cover fixed costs. For many firms there are few alternatives to the National Forests for their supply of timber. The purchase of National Forest timber is primarily by sealed bid or oral auction. The high bid is seldom rejected as long as it is greater than or equal to the advertised rate, which is based on a Forest Service appraisal. Historically, the total bid price has been distributed among the species sold in each sale. That is, each species is bid on separately, but the total bid is the basis for contract award. Large sales are sold predominantly with payment for each species based on scaled volume at the mill.

The competitive nature of bidding suggests that the company with the best bidding strategy will have lower stumpage costs and higher profits than its competitors. Bidding strategy for National Forest timber is based primarily on two objectives:

1) Minimize the average bid price per thousand board feet for timber of similar product selling price and stump-to-market costs while obtaining the required volume of timber.

2) Maximize the difference between the amount bid and the amount paid (or minimize if payment is greater than bid).

The first objective suggests the need for a model to assist the purchaser in arriving at a bid price that has the optimal combination of probability of being the high bid and probability of profit if the bid is the high one. The second objective consists of skewing the bid by placing an abnormally high proportion of the total bid on a particular species, anticipating the scale (payment) volume will be less than the cruise (bid) volume.

Objective

The objective of the following analysis is to determine the effectiveness of using probabilistic bidding, regression analysis and linear programming to meet the above bidding objectives. The three techniques are applied to 54 open and 60 closed sales on the Lolo National Forest.

Summary

In this study of timber sales on the Lolo National Forest, the potential effectiveness of probabilistic and skewed bidding techniques for timber procurement are examined. Selling value and cost equations are developed which include the factors of lumber price, tree diameter, slope, logging method, haul distance, volume per acre and total sale volume.

The selling value and cost equations are used to determine a net value before profit and stumpage costs. The probability of sale award at various profit levels, after actual bid prices are subtracted, is calculated and the maximum profit level for obtaining sufficient volume for a hypothetical firm is determined. This is done on both a bid basis and an expected payment basis and is compared to regression analysis.

The optimal bid for each species, using linear programming, is determined to maximize the difference between the bid and the expected payment. The optimal bid distribution assumes the firm has done an extensive cruise, accurately determining the scale volume of each species. The constraints of base rates, advertised rates, base indices and projected indices are used to factor in the effects of escalation clauses. A procedure using seasonal and cyclical indices is defined for estimating the projected indices.

The results provide a methodology for more profitable timber procurement and identify when the methodology may be used most effectively.

CHAPTER TWO

PROBABILISTIC AND REGRESSION BIDDING MODELS

Chapter Two begins with a review of the literature concerning probabilistic and regression models for determining the optimal bid and predicting competitors' bids. The source and type of data used in the analysis is then described. Selling value and production cost formulas are developed to determine the net value remaining for stumpage and profit. Probabilistic and regression models are described and the results of using each are compared to each other and to actual company results.

Literature Review

Probabilistic bidding models are based on optimizing the probability of bid acceptance and profit if the bid is accepted. The optimum bid is the one that maximizes the following equation:

$E(X) = P(X)\ Z(X)$ where:
- X = amount of the bid
- $Z(X)$ = estimated profit if accepted
- $P(X)$ = probability of bid X being accepted
- $E(X)$ = expected profit of a bid of X

P(X) is calculated by first calculating the percentage a competitor's bid exceeds the subject company's estimated direct costs for several prior projects. Second, the number of projects that fall below specified ranges of percent overbid (over cost) is determined. The percentage (probability) of bids below each percent overbid range is then determined. The estimation of the probability is subject to two assumptions: 1) the competitor's estimates of direct costs bear a constant relationship to the bidder's estimates of direct costs, and 2) the competitor will act in the future as he has in the past (Morse, 1975).

If several unknown bidders are encountered, the average bidder approach is often used. This approach makes the above calculations using the "average" bidder, and raises the probability [P(X)] to the n power where n is the number of unknown bidders. The average bidder approach is inherently biased and tends to overestimate the actual chances of winning. The size of the error varies directly with the standard deviation of the averaged opponents' bids and with the number of opponents. To neutralize the bias, $P(X)^n$ is multiplied by the correction factor $[1 - (S.D./P(X))^2]^{n/2}$ where S.D. is the standard deviation (Kottas, 1976).

The bidder's own estimate of costs frequently must be corrected for bias by determining the average difference between cost estimates and actual costs, and the variability of those differences, for past projects awarded to the bidder. Constraints on the amount of contracts accepted due to physical or financial resource limitations, when simultaneously bidding on more than one contract, may be included through nonlinear programming (Friedman, 1956). Other models attempt to incorporate the potential loss to the firm resulting from failure to win a contract (Edelman, 1965). If the cost of developing a bid is high, pay-off tables for two stages of bid development may be used. In the first stage, prior probability of success computations can be utilized to determine whether or not to proceed with pay-off tables and bid formulation (Paranka, 1969).

Literature concerning probabilistic bidding has generally been concerned with situations, such as construction, where the award is to the lowest bidder. In these situations, greater bid-to-cost ratios yield greater profit, but with less probability of bid acceptance. The opposite situation occurs in bidding for timber where the highest bidder is awarded the contract. In this case, greater bid-to-net value ratios yield lower profit, but with greater probability of bid acceptance. Net value is defined as selling price less total non-stumpage expenses. The literature is not very specific as to the difference between using profit margin and contribution margin (price minus variable costs) and the implications of cost-volume-price (CVP) relationships. Another factor that complicates both probabilistic bidding and CVP relationships is that the stumpage unit of measure (MBF) is not a constant unit because it varies, nonlinearly, with tree diameter and height (i.e., taper). Therefore, per unit variable costs, prices, profits and contribution margins vary with timber sale characteristics. The assumptions noted previously are much less applicable to the timber purchase situation. The primary reason is that net value estimates require both an estimate of costs and an estimate of future market value. Such future market value estimates induce a much higher variation in the estimates of net value due to differing expectations.

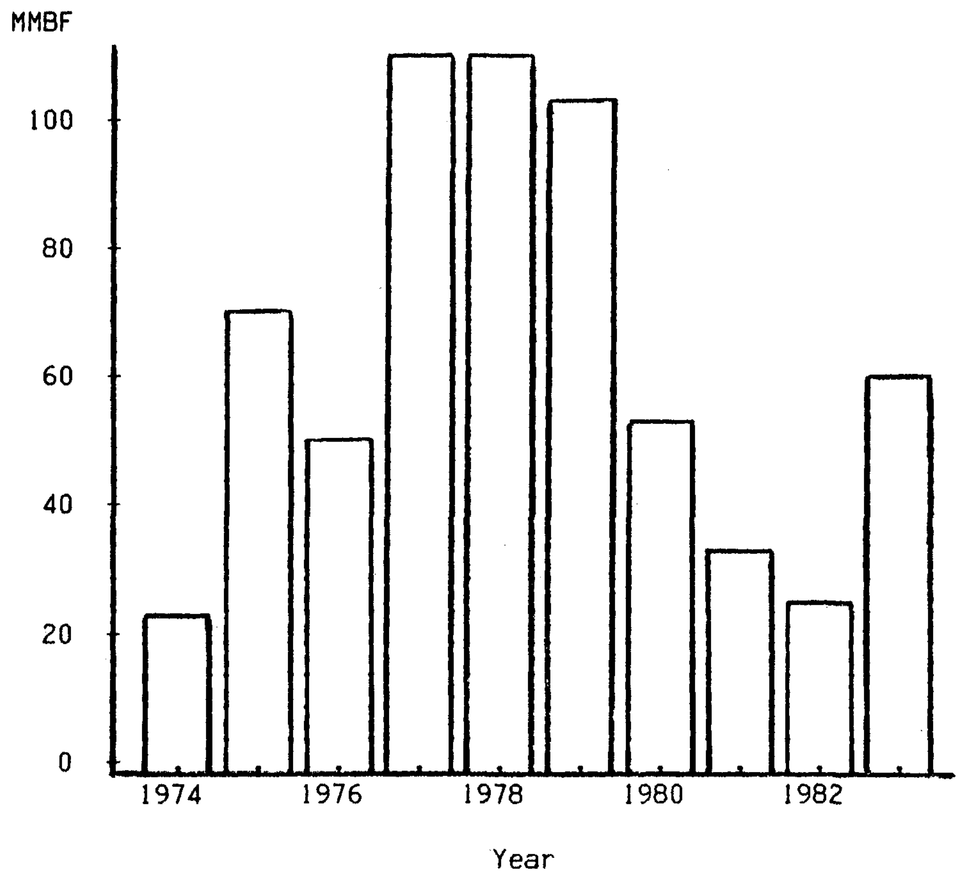
Method Introduction

A large sample of observations is necessary to reliably calculate the probability that an event will occur. Also, because of the cyclical nature of the wood products market, a lengthy time period must be observed to determine true averages. One hundred fourteen sales were selected from the 157 timber sales, greater than 500 MBF in size, sold from 1974 through 1983 on the Lolo National Forest. Selection was based primarily on accessibility of information. Sixty of the 114 selected sales have been completed and closed, most of which were sold prior to 1980. The 54 open sales and the 60 closed sales made up two study subpopulations. Sale data collected included: cruise volume by species, average diameter by species, volume per acre cut, average percent slope, percent of volume to be skyline logged, appraised haul miles and destination, purchaser credits, sale date and contract term by quarter, and whether the sale was a Small Business Administration (SBA) set-aside. Bid data collected included bids by bidder and species and Forest Service values for manufacturing costs, logging costs, appraised rates, base rates and base indices. Data for the closed sales included scale volume and actual money receipts and credits. The Western Wood Products Association's quarterly price index, by species group, is used as a basis for selling price calculations. All dollar figures were adjusted by the GNP implicit price deflator to a constant 1980 dollar.

The supply of timber for sale is not included in the analysis, but is assumed to be relatively constant over the long term. This is assumed because of Forest Service policies of sustained yield and community stability. In practice, the volume of timber sold on the Lolo has declined somewhat but private land harvest has increased (see Graph 1 for Lolo N. F. large-sale volume, 1974 through 1983).

Graph 1

VOLUME SOLD BY LOLO N. F.
(Sales > 500 MBF)



To determine the effectiveness of probabilistic bidding methods a hypothetical firm (Firm X) located at Superior, Montana with a hypothetical, but realistic, cost structure is assumed to be the bidding firm (see Table 1 for assumptions related to the firm). The critical value necessary is an estimate of the net value remaining after estimated nonstumpage costs are subtracted from projected long-term selling value. Both costs and selling values are estimated by firms. Therefore, it is not necessary for the values to be perfectly accurate for the analysis to be valid.

Table 1

ASSUMPTIONS ABOUT FIRM X

1) Firm X's Long-Term Average Cost Structure (Constant 1980 $):

		$/MBF	Percent	Annual
Selling value		$ 320	100 %	
Variable costs:				
Stumpage	$ 80			
Other	112			
		192	60	
Contribution margin		128	40 %	
Fixed costs		96	30	$ 960,000
Profit margin		$ 32	10 %	
Normal capacity (82% from sales > 500 MBF)				10,000-MBF

2) Firm X is eligible for SBA set-aside sales

Expected Sell Value Calculations

Contract terms ranged from 0.5 to 6.75 years with an average term of 3.6 years. Because of the long period between purchase and final harvest, it is assumed bidding should be based on an expected long-term average price. The assumption for this analysis was that 10-year period average prices, after adjustment for inflation and market cycles, would have no apparent trend. Regression lines in Graphs 2, 3, 4, and 5 indicate that price trends over the period were level for white and ponderosa pine but declined from two to three percent per year for other species groups. The cyclical nature of lumber prices causes trend lines to shift according to where in the cycle the data begins but the period defined is believed to be well balanced in the cycle. Therefore, the base long-term selling value for each species group was obtained by averaging the WWPA quarterly price indices for the 10-year period for each species group.

Graph 2

AVERAGE QUARTERLY LUMBER PRICES
(Ponderosa pine, 1980 $)

```
$/MBF

$ 450 +                    o                       ooo Prices
      !                oooo                        *** Trend line
  400 +               o     o
      !                      o
  350 +o          oooo        o  oo
      !********ooo*************oo**o*******oo*
  300 + o     o                       o     o  o
      !     oo                        oo
  250 +    o                            ooo
      !  oo
  200 +
      !
  150 +
      !
  100 +
      !___,___,___,___,___,___,___,___,___,___,___
      1974    1976    1978    1980    1982    1984

                         Year
```

Graph 3

AVERAGE QUARTERLY LUMBER PRICES
(Douglas-fir/western larch, 1980 $)

```
$/MBF

$ 450 +                                                    ooo Prices
      !                                                    *** Trend line
  400 +
      !
  350 +
      !
  300 +
      !             o oooooooo
  250 +o*********ooo o
      !      ooo*************o*oo
  200 + o  ooo                 o**ooo******oo*
      !  oo                          o    o  o
  150 +                               oooo
      !
  100 +
      !____,____,____,____,____,____,____,____,____,____,____
     1974     1976     1978     1980     1982     1984

                          Year
```

Graph 4

AVERAGE QUARTERLY LUMBER PRICES
(Lodgepole pine/spruce, 1980 $)

```
$/MBF

$ 450 +                                                    ooo Prices
      !                                                    *** Trend line
  400 +
      !
  350 +
      !
  300 +
      !
  250 +               oooo o
      !             oo     o oo
  200 +o******oooooo******     o
      ! o  ooo              *****oooooo******oo*
  150 +  oo                              oooo o  o
      !                                      o
  100 +
      !____,____,____,____,____,____,____,____,____,____,____
     1974     1976     1978     1980     1982     1984

                          Year
```

Graph 5

AVERAGE QUARTERLY LUMBER PRICES
(Grand/subalpine fir, 1980 $)

```
$/MBF

$ 450 +                                           ooo Prices
      !                                           *** Trend line
  400 +
      !
  350 +
      !
  300 +
      !                     o
  250 +             o oooooo o
      !o********o*oo o        o
  200 + o     oo o**************oo o       o
      !    ooo                 o**o*o*****o*o*
  150 +  oo                          ooooo   o
      !
  100 +
      !___,___,___,___,___,___,___,___,___,___,___
      1974    1976    1978    1980    1982    1984

                         Year
```

The second major factor in determining selling value is lumber grade, which is primarily a function of tree diameter. White/ponderosa pine and Douglas-fir/western larch are the species groups which have significant premiums added to the value due to increased grade recovery. For white/ponderosa pine, the formula "[1 + (-.4122 + .0217 x dbh)] x average long-term sell value" was used to adjust for grade differences. This formula was determined by regressing average percent select lumber for grade 2 logs (Davis, 1954), adjusted to a tree basis, with diameter class. This was done only through 18 inch dbh; therefore, it may not be applicable to areas with much greater average tree diameters. The formula was then adjusted to the point where a 19 inch dbh was neutral. That is, greater diameters increased selling value, while lesser diameters decreased value. The rationale for this is that the WWPA index is based on the average lumber mix which, in turn, is produced from the average diameter tree. The average white/ponderosa pine tree diameter was 17.7 inches, but an additional 1.3 inches was added to account for the fact that a certain percentage of ponderosa pine is lower-valued bull pine. The actual amount of bull pine is not identifiable from sale data, which is a cause for some error in valuing individual sales.

The formula "[1 + (-.3145 + .0217 x dbh)] x average long-term sell value" was used for Douglas-fir/western larch. The formula determination was made through the same procedure as above with two exceptions. First, the average diameter of the species group was determined to be near 14.5 inches, which is the neutral diameter for the formula. Second, no adjustment for lower-valued subgroups was made. The WWPA average long-term price indices were used without adjustment for the other species groups. Unsound and dead volume was grouped together and valued at the lodgepole pine price index because the majority of the volume was dead lodgepole and the unsound white/ponderosa pine and Douglas-fir/western larch should be valued lower than sound wood.

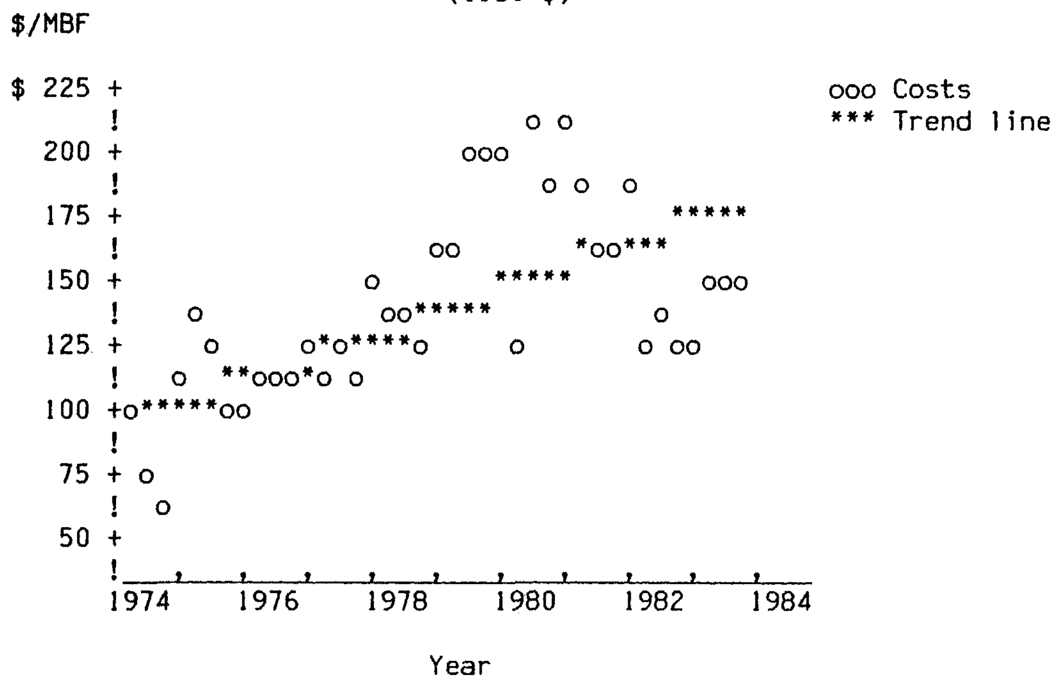
The third factor determining selling value on a log scale basis is the overrun factor. Overrun, on a tree basis, declines logarithmically with an increase in diameter. The overrun formula used was "[2 - .22 x LN(dbh)]" times the selling value obtained previously. Overrun may be increased through technological advances and management improvements. Some adjustment in the overrun factor will be required as advances and improvements are made.

Estimated Cost Calculation

Cost data from industry are generally unavailable to outside users. A second alternative was to assume that the selling value less the actual bid, on a per MBF basis, was a reasonable estimate of costs. Multiple regression using the primary determinants of costs (diameter, slope, % skyline, volume/acre, haul miles, etc.) as independent variables and the residual of sell value minus bid as the dependent variable proved unsatisfactory with R Square values less than 0.5. A third alternative was to use Forest Service appraisal estimates. The regression lines in Graphs 6 and 7 indicate Forest Service cost estimates have increased approximately five percent per year in constant dollars. The difference between Forest Service appraised value and the actual bid was negatively correlated with Forest Service estimated logging and manufacturing costs (-.67 & -.63) and with the sale date (-.38). This indicates that Forest Service cost estimates may have been rising more rapidly than actual costs during the 10-year period; although, bidders' expectations of rapid and continuous lumber price escalation could have been a contributing factor. The graphs and the strong correlations do cast considerable doubt on the accuracy of Forest Service cost estimations because the wood products industry is mature with a moderate growth pattern where excessive cost pressures would not be expected. Note that the following graphs are based on log scale volume and the previous graphs are based on lumber tally volume. Therefore, to compare the two sets of graphs, the previous set must be adjusted by an overrun factor.

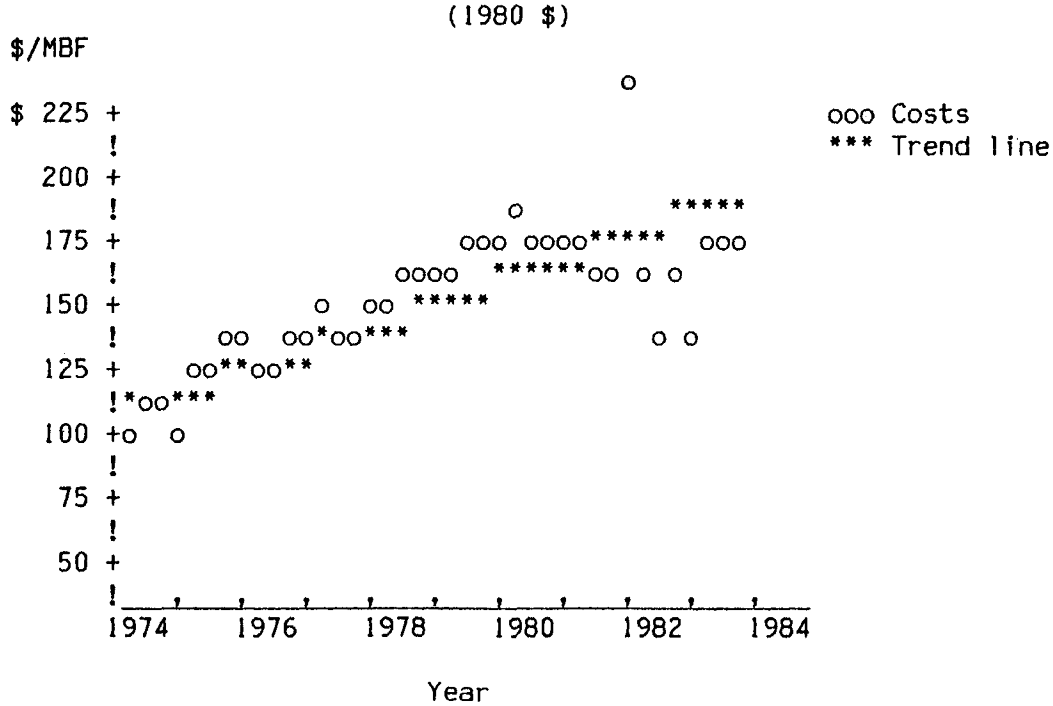
Graph 6

AVERAGE QUARTERLY FOREST SERVICE LOGGING COST ESTIMATES
(1980 $)



Graph 7

AVERAGE QUARTERLY FOREST SERVICE MANUFACTURING COST ESTIMATES
(1980 $)



The alternative selected was to use a published logging cost study (Withycombe, 1982) as a base for logging costs and Forest Service 10-year average manufacturing cost estimates, all adjusted to 1980 dollars. Simple regression formulas were developed for each variable and then combined into one formula. An average 10 percent before-tax profit on sales was included in the formulas for testing purposes. The testing and adjustment of the formulas was done to reduce significant bias toward any cost variable. This bias was minimized by adjusting the formulas to minimize the correlation of the error (net value minus actual bid) with each of the cost variables.

Manufacturing costs per MBF (log scale) are primarily a function of diameter due to higher costs per MBF (lumber tally) of smaller diameter trees, which is only partially offset by higher overruns. Because of various log sizes per tree the cost declines linearly with tree diameter (even though costs may decline logarithmically with log diameter). The initial formula was developed by using regression of average Forest Service cost estimates with average diameter for each species. Because Douglas-fir and western larch are peeler species with a different cost structure and Firm X was assumed to be a sawmill, those species were excluded from the regression data. The final adjusted formula used for manufacturing costs per MBF was "(160 - 2.134 x dbh)".

Withycombe's study was used to determine logging costs according to diameter class, logging method (ground skidding, cable yarding) and haul distance. An average 1000-foot skidding and yarding distance was assumed. The skidding and yarding costs were by log size class;

therefore, they were converted to tree size class by determining the approximate number of logs of each size class that would occur in each tree size class. The study identified costs on a cunit measure which required conversion to the MBF unit of measure. The results indicated that logging costs per MBF are approximately a function of the natural log of tree diameter. However, the study did not account for some other important variables, such as, slope, volume per acre cut, economies of scale (total sale volume) or potential excess purchaser credit granted for road construction. These other variables were included and adjusted to minimize the correlation of the variable coefficient with the net value error (net value minus bid). The final adjusted formula used for logging costs per MBF was "[(150 - 30 x LN(dbh)) x (1 + .003 x Slope%) x (1 + .0092 x %Skyline) - 6.6 x LN(Vol/ Acre) + .16 x Haul Miles + 35 - 6.2 x LN(Total Vol)]". Total cost per MBF was determined to be "Manufacturing Cost + Logging Cost - .21 x Purchaser Credit/MBF". The reduction for purchaser credit was required to minimize the correlation of the net value/bid difference with the amount of purchaser credit. This reduction suggests that Forest Service estimates of road costs may average 21 percent greater than actual costs. This is partially explained by the inclusion of profit in such estimates, which are based on previous road construction bids.

Table 2 shows that the correlation between the error (calculated net value minus actual bid) and each cost or selling value variable is very low. This suggests the cost and selling value formulas are relatively unbiased toward any variable. Positive correlations indicate the calculated net values may be overstated and negative correlations may indicate understatement of net values in relation to the particular variable. The major positive correlations are with the sell value and volume percentage of white/ponderosa pine. This may be due to bull pine being a larger factor than anticipated.

Table 2

CORRELATIONS OF NET VALUE-BID DIFFERENCE WITH SALE VARIABLES

Variable	Correlation	Variable	Correlation
Weighted average dbh	-.0498	% white/ponderosa	.0838
Slope %	-.0652	% D.-fir/larch	-.0660
% Skyline logged	-.0652	% lodgepole	.0276
Volume/acre	-.0455	% grand/subalpine fir	-.1393
Total sale volume	-.0655	Logging cost	-.0746
Haul miles	-.0629	Manufacturing cost	.0498
Date of sale	.0863	Total cost	-.0648
Brush disposal deposits	.0198	Overrun	.0546
Purchaser credit/MBF	-.0322	Selling value	.1027

Haul mileage is the distance from the sale to the appraised destination. After the formulas were developed and the correlations computed, an additional haul cost was added for the distance from the appraised destination to the hypothetical firm's location. This cost was calculated at $.10 per MBF per mile since no additional unloading costs are required and only paved roads are traveled (Table 3).

Table 3

ADDITIONAL HAUL COST
(Appraised location to Firm X)

Appraised Location	Miles	$/MBF
Plains	43	$ 4.30
Missoula	57	5.70
Thompson Falls	69	6.90
Seeley Lake	105	10.50

Probabilistic Approach

Except for "direct" (nonbid) sales, a firm cannot predict accurately the number of bidders that will submit bids. Therefore, neither the single known competitor nor the average bidder approaches are very useful. The average bidder approach has drawbacks for two reasons: 1) several firms often submit "speculative" minimum bids which may inconsistently lower the average bid, and 2) it is difficult to determine ahead of the bid submission deadline how many bidders are competing. Because the average bidder approach requires correction by adding the standard deviation of the bids (Kottas, 1976), the results become similar to those using the high bidder. The high bidder approach was used in the analysis because of greater simplification and the assumption that the number of bidders cannot accurately be determined prior to bidding. The probabilistic approach included four steps: 1) net value estimation for each sale, 2) profit margin calculation if the actual bid were paid, 3) determination of the expected volume at various profit margins (i.e., probability of receiving the award times the total volume sold over the 10-year period), and 4) determination of the profit margin required to obtain the 10-year volume objective of the firm.

Refer to Appendix B.1 as each step is described. The net value per MBF was determined by subtracting the total estimated production cost from the selling value estimates determined in the previous sections. The profit margin was determined by subtracting the actual bid per MBF (stumpage value) from the net value and dividing the remainder (expected profit) by the selling value per MBF. The sales were then arranged, according to profit margin, in ascending order. The expected volume, if Firm X bid at the various calculated profit margins, was determined by adding the volumes of all sales having profit margins greater than, or equal to, each profit margin level. The highest profit margin needed to obtain expected volume greater than the volume objective was determined to be the profit margin Firm X would base its bids on. Since Firm X is assumed to require 82,000 MBF from National Forest Sales (> 500 MBF) over the 10-year period, the objective was determined to be one-half (41,000 MBF) for the 54-sale subpopulation and the remaining amount for the 60-sale subpopulation. The 50-50 split was chosen because total volume of both subpopulations are nearly equal (267,939 MBF and 256,280 MBF). Appendix B.1 shows that a profit margin less than 20.7 percent is required to obtain 41,943 MBF for the 54-sale subpopulation. Appendix B.2 shows that the 20.7 percent profit margin selected by the 54-sale subpopulation and applied to the 60-sale subpopulation would obtain 38,538 MBF.

Regression Bid Prediction Approach

Hanssmann and Rivett (1959) suggest the use of linear regression analysis of past bid prices and independent factors that influence the prices to estimate probable competitor bid prices. Jackson and McQuillan (1979) developed a regression model which predicts stumpage price as a function of tree diameter, harvested volume per acre, logging method, harvest method, and lumber selling price (constant dollars).

A second approach, using regression to predict competitors' bids, was compared to the pure probabilistic approach. The second approach included seven steps: 1) development of a regression formula to predict the bid per MBF in 1980 dollars (Table 4), 2) calculate actual bid-to-predicted bid ratios, removing ratios greater than one because they would not have been awarded to Firm X, 3) calculate predicted bid-to-net value ratios, 4) determine the expected volume as done in the probabilistic approach, 5) calculate the profit margin if the predicted bid were paid, 6) determine the minimum predicted bid-to-net value ratio required to obtain the 10-year volume objective, and 7) calculate the volume weighted average profit margin for sales with ratios less than, or equal to, the minimum ratio required in step 6.

Table 4

REGRESSION EQUATION COEFFICIENTS
(54-Sale Subpopulation)

	Coefficient	Standard Error	t-Value
Constant	-210.627	48.057	-4.383
DBH	3.305	1.942	1.702
SKLN	- .296	.107	-2.757
SBA	54.624	13.481	4.052
ACSV	.087	.076	1.141
PRCR	.637	.225	2.835
LTVL	9.333	4.657	2.004
ADVR	.899	.167	5.391
Adj. R-Square	.779		
Standard Error	27.310		
F Value	26.957		

Where:

DBH = ave. dbh per species, weighted by volume/species

SKLN = percent of volume skyline logged

SBA = dummy variable for small business administration set-aside sales (1 = set-aside, 2 = non-set-aside)

ACSV = actual sell value per MBF (1980 $) at time of sale (used procedure similar to "Expected Selling Value", except cyclical values used rather than long-term ave.)

PRCR = purchaser credit per MBF

LTVL = natural log of the total sale volume

ADVR = advertised rate per MBF

Appendix C.1 shows the bids predicted by the previous formula and the results of the previously itemized steps. The actual bid-to-predicted bid ratios were calculated to identify and remove those sales which would not be awarded to the bidder if the regression formula was used as a basis for bidding. Twenty-one of the 54 sales had ratios greater than one and would not have been awarded to Firm X. The predicted bid-to-net value ratios were calculated as a proxy for profit (i.e., the percentage of net value that would be bid verses the percentage that would be profit). The sales remaining after the previous elimination procedure were then arranged, according to predicted bid-to-net value ratios, in descending order. The lower the ratio the greater the profit. The expected volume was calculated by adding the volumes of all sales with predicted bid-to-net value ratios less than, or equal to, each ratio level. Profit margins of the predicted bids were also calculated. Appendix C.1 shows that a predicted bid-to-net value ratio greater than 0.59 is required to obtain 42,425 MBF for the 54-sale subpopulation. Appendix C.2 shows the calculated values for the 60-sale subpopulation. To compare the probabilistic and regression approaches the profit margins of selected sales of the regression approach (=< 0.59 ratio) were averaged on a volume weighted basis.

CVP Relationships

Cost-volume-profit relationships are important, but were not analyzed thoroughly for this paper. The hypothetical firm's contribution margin, rather than profit margin, would have been a more effective basis for calculating probabilities. For example, a sale that can be logged and milled more rapidly may produce more total profit even though it has a lower profit margin. Such an analysis would have required many more assumptions about the firm. The relationship of prices, variable costs, fixed costs and volume of production vary with species mix, diameter class, operating characteristics of the sale and characteristics of the firm. Variable costs may vary dramatically with species mix and bid prices.

It should be noted that as Firm X operates below its normal capacity, the profit margin declines rapidly because fixed costs are not being spread over as much volume. Excess inventory would produce a similar decline in profit margins if excess long-term volume were purchased and not resold. This indicates that optimum expected volume is nearly equivalent to optimum expected profit and is the primary determinant of the profit margin level that should be selected for the long-term analysis. Therefore, optimum profit margins (probabilistic approach) and optimum predicted bid-to-net value ratios (regression approach) were based on expected volume equal to the long-term volume capacity objective (82,000 MBF from sales >= 500 MBF over the 10-year period for Firm X).

Results

The effectiveness of probabilistic bidding is shown by comparing sales that would have been awarded to Firm X with those actually awarded to various firms over the 10-year period. Table 5 shows average sale characteristics of sales Firm X would have been awarded with the Probabilistic Approach, using the 20.65 percent profit margin required to obtain at least 82,000 MBF, compared to actual sales awarded to specific firms. The sales are those in Appendix B.1 and Appendix B.2 with greater than 20.65 percent profit margin. Use of the approach would have resulted in award to Firm X of sales having an average mix of sale characteristics.

Table 5

AVERAGE AWARDED SALE CHARACTERISTICS

Firm	DBH	% SKLN	VOL/AC	% W/P PINE	% D FIR/L	TOTAL-VOL
X	13.7	40.6	11.7	14.7	49.3	84,948
1	14.1	37.8	11.2	8.6	51.8	50,098
2	13.3	74.1	11.5	16.0	45.1	35,136
3	14.8	52.4	6.9	22.8	58.9	27,757
4	13.5	78.0	20.3	4.8	61.8	9,852
5	13.2	35.0	13.0	14.6	45.0	51,353
6	11.3	26.9	10.6	5.7	35.4	37,382
7	14.9	43.4	6.1	38.2	50.1	29,389
8	16.5	63.0	10.7	22.2	47.6	67,524
9	13.1	22.1	9.3	5.2	54.1	31,378
10	13.5	94.2	15.0	11.8	49.3	53,182
Others	12.9	31.5	9.5	21.7	33.6	121,180

Table 6 shows the average prices paid and profit margins based on Firm X's cost structure.

Table 6

AVERAGE AWARDED SALE STUMPAGE COST & PROFIT MARGIN

Firm	Purchaser Credit	Stumpage Cost/MBF	Profit Margin	Firm X's Profit Margin Objective @ Firm's Volume
X	$ 30.73	$ 47.63	20.7 %	20.7 %
1	40.09	127.40	- 6.1	24.2
2	30.03	71.80	3.7	25.0
3	34.76	109.98	2.7	29.8
4	99.83	17.73	21.8	38.1
5	28.52	69.05	13.7	24.2
6	32.50	74.18	5.1	25.0
7	44.13	111.04	10.1	27.1
8	22.15	93.70	9.4	23.7
9	26.52	37.84	21.1	25.7
10	27.40	70.31	- 1.7	24.2
Others	33.16	83.99	10.9	17.7

The approach is clearly superior in profit margin to all actual firms, except firms 4 and 9, while obtaining a significantly larger volume. Firms 4 and 9 obtained a large portion of their volume through SBA set-aside sales. The set-aside sales benefited Firm X, but to a much smaller degree. It should be noted that 55 percent of SBA sales had one or less bidders and 73 percent had two or less. Non-SBA sales had 21 percent and 40 percent, respectively.

Probabilistic bidding which includes the oral auction bidding method requires that an additional assumption be made. This assumption is that the competitive bidding has pushed the bid of the high bidder to his estimate of the value, given his cost structure. Appendices B.1 and B.2 show that, to obtain the volume objective of 41,000 MBF for each subpopulation, a 20.7 percent profit margin is required for the 54-sale subpopulation while a profit margin of 19.8 percent is required for the 60-sale subpopulation. Because of the inconsistency between subpopulations and because the oral auction assumption is not totally valid, actual probabilistic bidding practice should include a safety margin to be certain enough volume is acquired. Statistical methods for arriving at a safety margin are not applicable because there are insufficient subpopulations to calculate a standard deviation for required profit margins and the number of oral auction bids that may be lost are unknown. The author suggests a reduction of 10 percent of the optimal profit margin may be required (i.e., from 20.7 to 18.6). As a firm uses probabilistic bidding, data will be continually updated and the optimal profit margin adjusted as sales are lost due to these unknowns; thereby improving the accuracy.

Probabilistic and Regression Approach comparisons were based on three criteria: 1) average profit margin, 2) consistency between subpopulations, and 3) flow of timber to the firm. The Regression Approach had a lower average profit margin, with significantly less consistency between subpopulations (Table 7).

Table 7

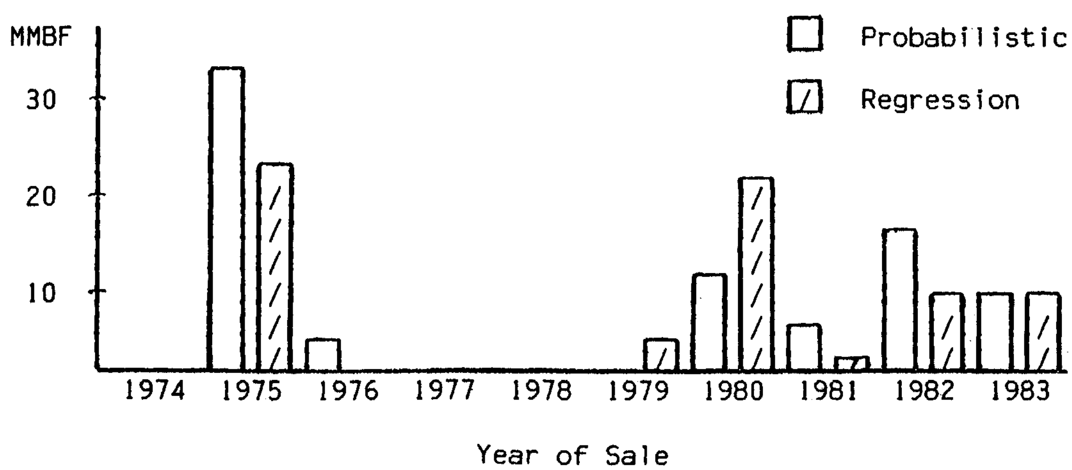
COMPARISON OF PROBABILISTIC & REGRESSION APPROACHES

	Probabilistic	Regression
Average Profit Margin:		
Base subpopulation (54 sales)	20.7 %	18.2 %
Predicted subpopulation (60 sales)	20.7	19.6
Volume Awarded From Predicted Sales:		
Objective	40,057 MBF	39,575 MBF
Awarded	38,538	30,785

The flow of timber was only slightly more even with the Regression Approach (Graph 8).

Graph 8

VOLUME AWARDED TO FIRM X PER YEAR



Two conclusions can be drawn from this chapter: 1) simple probabilistic bidding models based on long-term average profit margins and expected long-term volume objectives can substantially reduce stumpage costs, and 2) probabilistic models are superior to regression models for obtaining lower cost stumpage. Although probabilistic models may appear to result in flow problems, these may be easily corrected. First, because most of the sales that would have been awarded to Firm X in 1975 had terms of five to six years, only minor flow problems would have occurred, and then only in 1979. Second, a narrow range of profit margin objectives could be established, increasing the allowable margin during recession (low stumpage price) years and decreasing the allowable margin at other times to obtain a slightly more even flow. Another alternative would be to make short-term perchases of logs during occasional shortages of contract timber.

CHAPTER THREE

SKEWED BIDDING

Chapter Three introduces the components of skewed bidding models and explains how each component affects the skewness of the bid. A linear programming model is developed to determine the optimal distribution of the total bid among the bid species. The effects of assumptions made by the bidder are discussed. The expected payments of optimal skewed bidding are compared to actual payments made for the 60 closed sales.

Introduction

As discussed in Chapter One, placing a high proportion of the total bid on a particular species is known as skewed bidding. The amount that should be placed on each species is dependent on three factors:

1) Bidding rules

2) Expected difference between cruise and scale volume

3) Escalation clauses

Bidding rules determine whether bids other than the advertised rate for each species are allowed. If no other bid amount is allowed, the bid can not be skewed toward that species. The bidding rules are at the discretion of the Forest Service. The primary reason for allowing a bid only at the advertised rate is to prevent skewed bidding. The primary species so restricted are those with a very small percentage of the total volume or those with high potential for defect or dead material. The true firs, lodgepole pine and spruce are most often restricted and unsound and dead wood is nearly always restricted. Even in unrestricted species the minimum bid allowed is the advertised rate. Another method used to reduce skewed bidding is to group the species into a few bid groups. Recently the majority of Lolo N. F. sales have been grouped into one bid group. However, the following analysis is concerned with 60 closed sales sold between 1974 and 1982, most of which had more than one bid group.

The expected difference between the cruise (bid) volume and the scale (paid) volume is the primary determinant of which species to skew the bid toward. Maximizing the difference between the bid price and payment, considering only the volume-difference factor, occurs by placing the greatest proportion of the total bid on the species with the highest expected percentage decrease in volume from cruise to scale. This can be determined by calculating the percentage of total volume of each species for both the cruise and expected scale volumes and then calculating the percentage change from cruise to scale. The cruise is a sample of the sale population and has a percent standard error of the sample calculated. This expected error range (normally less than ± 10 percent) is for the total volume and depends on the relative size of the sample and the variability of the stand of timber. However, the standard error for each species sampled is much greater than that for the whole sale. The smaller the relative volume of the species, the smaller the sample of that species, the greater the potential error.

The effective use of skewed bidding requires a knowledge superior to the Forest Service cruise as to the actual volumes involved. This suggests that the bidder must both make a superior cruise prior to bidding and monitor the scaling at the time of harvest since the volume difference depends on both cruise and scale accuracy. This also suggests that control of the volumes of each species harvested must be maintained. Such control procedures would include careful bucking practices and not allowing sale adjustments unless the percentage of the species with the skewed bid is reduced.

Escalation clauses, used by intermountain area Regions of the Forest Service, provide a formula for adjusting stumpage bid (payment) rates to reflect lumber market fluctuations. The species allowed to escalate are at the discretion of the Forest Service. Again, the true firs, lodgepole pine and spruce are more likely to be bid at "flat" (nonescalating) rates and unsound and dead wood always at flat rates. The escalation procedure is based on the Western Wood Products Association's (WWPA) quarterly price indices for each species group. When the current calendar quarter index average is lower than the base index (quarterly index at the time of sale appraisal), the bid rate is adjusted downward by the full amount (100 percent) of such difference, but not below the base rate (minimum established payment rate). When the quarterly index is above the base index, the bid rate is adjusted upward by one-half (50 percent) of the difference, but limited to an amount no greater than the amount by which downward escalation could be effective (i.e., <= bid minus base rate) (USDA Forest Service, 1977).

Escalation clauses affect skewed bidding differently depending on whether the market fluctuation from sale appraisal to harvest is expected to be downward or upward. An expected downward escalation suggests that the bid on escalating species be enough higher than base rates to allow the full downward escalation. Because the escalation generally occurs on a much larger proportion of the sale volume (i.e., more species) than does the cruise-to-scale volume change of a particular species, it is normally more profitable to allow for such expected escalation changes. However, this depends on the relative degree of the escalation and volume changes expected. An upward escalation suggests that the bid on certain escalating species be made at base rates (when advertised rates equal base rates) to prevent any escalation from occurring. Escalation is prevented because the maximum escalation cannot be greater than the difference between the bid and the base rate. The species so selected, and the effectiveness, depends on the volume of the species and the difference between advertised rates and base rates. The greater the volume and the smaller the difference between advertised and base rates, the more effective. Again, the relative advantage is dependent on the relative degree of the expected escalation and volume changes.

Because the objective of skewed bidding is to maximize the difference between the amount bid and the amount paid (when payment is less than the bid) and because of the many constraints discussed, linear programming can be an effective tool for solving the optimal bid distribution. However, as a generalization, the skewness of a bid will be more pronounced under the following conditions:

1) The species declining in relative volume makes up a small proportion of total volume

2) The expected decline in relative volume is very large, thereby reducing the risk of sample error

3) Species prone to disease or insect damage, such as lodgepole or white pine, are involved

4) The lumber market (quarterly index) is expected to rise, rather than fall

5) Advertised rates are low, near base rates

6) Bids are high and competition intense

Method

The 60 closed sales described in Chapter Two were selected for analysis. Because escalation effects are partially dependent on inflation, actual dollar values were used rather than constant 1980 dollars. The following data for each bid species group for each sale was run through a linear programming model:

1) Bid (cruise) volume

2) Payment (scale) volume

3) Projected quarterly index

4) Base index

5) Base rate

6) Advertised rate

7) Actual total high bid for the sale

All data, except projected quarterly indices, were obtained from sale records. The projected quarterly indices are required to estimate the escalation that may occur. The projection is for the term of the contract, which may range from 0.5 to 6.75 years. Exponential smoothing, regression and even sophisticated econometric models are not very accurate for forecasts extended that far into the future. The lumber market, however, is seasonal and very cyclical. The market cycle occurs with peaks rather regularly at approximately five-year intervals. The lumber and wood products price index, after adjustment for inflation (using the GNP deflator), shows peaks occurring in 1955, 1959, (1964), 1969, 1973, 1979 and (1983). Parentheses indicate years with very minor peaks (Council of Economic Advisers, 1985). Cycle troughs are somewhat less predictable. Quarterly seasonal indices were calculated for the 1974 to 1983 period (based on WWPA indices in constant 1980 dollars). The deseasonalized WWPA quarterly indices were then used to calculate quarterly cyclical indices based on a five-year cycle (Appendix D). The cyclical index was multiplied by the seasonal index to obtain a combined index for each quarter for each sale. For the analysis it was assumed the bidder knew where in the cycle the sale was made. Professional judgment should allow for relatively accurate prediction of where in the cycle the market is. Even if the timing is missed a quarter or two, the cyclical index sequence can easily be adjusted at the next quarter for the next sales. Inflation is another factor that can not be accurately predicted very far into the future. For this analysis a long-term average inflation rate of five percent was used. For shorter-term contracts professional judgment may be used to increase or decrease the assumption to reflect current expectations.

To summarize, the projected quarterly indices for each species group was determined by:

1) Calculating a seasonal index (quarterly basis)

2) Calculating a five-year cyclical index (quarterly basis) of deseasonalized data

3) Calculating a combined index, by multiplying the two above

4) Averaging the combined indices for the term of the contract

5) Obtaining an index multiplier by dividing the contract-average index by the combined index on the sale date (represents the percentage change from current to the average expected index)

6) Multiplying the multiplier times the current WWPA quarterly index

7) Including a five percent inflation factor by the annuity formula:

   $$(\text{Index}/ct) \times (((1+r)^{ct}-1)/r)$$

   where: ct = contract term (years)
   r = annual inflation rate

   (This assumes that the sale is harvested evenly throughout the contract term)

The linear program model for downward escalation is as follows:

$$
\begin{array}{llllllll}
\text{Maximize:} & S = & Yx_1 & + Zx_2 & - yx_3 & - zx_4 & & \\
\text{Subject to:} & & & & & & & \\
\quad\text{Total bid:} & & Yx_1 & + Zx_2 & & & = & TB \\
\quad\text{Escalation:} & & x_1 & & - x_3 & & \leq & E_1 \\
 & & & x_2 & & - x_4 & \leq & E_2 \\
\quad\text{Base rate:} & & & & x_3 & & \geq & BR_1 \\
 & & & & & x_4 & \geq & BR_2 \\
\quad\text{Advertised rate:} & & x_1 & & & & \geq & AR_1 \\
 & & & x_2 & & & \geq & AR_2
\end{array}
$$

Where: x_1; x_2 = \$ bid/MBF (species 1; species 2)
x_3; x_4 = \$ paid/MBF (species 1; species 2)
Y; Z = Bid volume (species 1; species 2)
y ; z = Scale volume (species 1; species 2)
TB = Total bid price
E_1; E_2 = Base index - projected index (absolute value) (species 1; species 2)
BR_1; BR_2 = Base rate (species 1; species 2)
AR_1; AR_2 = Advertised rate (species 1; species 2)

The general linear program model for upward escalation is:

Maximize: $S = Yx_1 + Zx_2 - yx_3 - zx_4$

Subject to:

Total bid: $Yx_1 + Zx_2 = TB$

Escalation:
$$-2x_1 + 2x_3 >= E_1$$
$$-2x_2 + 2x_4 >= E_2$$

or

Maximum rate:
$$2x_1 - x_3 <= BR_1$$
$$2x_2 - x_4 <= BR_2$$

Advertised rate:
$$x_1 >= AR_1$$
$$x_2 >= AR_2$$

Linear programming is not easily applicable to upward escalations. As noted in the model description, either of two constraints may apply (the escalation limit or the maximum rate limit). Different bids will change which constraint applies to each species. This requires more than one calculation of the model to determine which constraint applies. One method is to maximize using >= escalation and maximum rate constraints and then determining which variable (constraint) is limiting through right-hand-side sensitivity analysis. If the limiting variable of decrease for the maximum rate constraint is the same as the maximum rate constraint, no change in the inequality sign is necessary. If the maximum rate constraint is limited by another variable, the escalation and maximum rate constraint signs are changed to <=, making the maximum rate the limiting constraint. Occasionally, a run of this formulation will miss a constraint that should be changed to be limited by the maximum rate. Therefore, if an additional maximum rate constraint could be limiting (i.e., the difference between the advertised and base rate is less than one-half of the expected escalation), the variable should be constrained by the maximum rate constraint to test for a better solution. Because some species are not allowed bids other than advertised rates, an equality advertised rate constraint must be used for those species.

After the optimal bid combination was determined, two comparisons were made. First, actual payments, expected payments of the successful bidder under the escalation assumptions and expected payments of Firm X's optimal skewed bid under those assumptions were compared. This comparison isolates the difference of expected from actual due to escalation assumptions from the difference due to skewed bidding. The escalation assumptions were: a cyclical index, five percent inflation and an even cutting pattern during the contract term. Actual dollars were used because dates and volumes of actual harvest were unknown; therefore, constant dollar calculations for actual payments could not be made. Second, probabilistic bidding results based on bids as determined in Chapter Two, expected payments of the successful bidder under the previous assumptions and expected payments of Firm X's optimal skewed bid were compared. This comparison shows the potential benefits of probabilistic/skewed bidding combinations. Constant 1980 dollars were used in this comparison.

Assumptions/Skewed Bidding Comparison

The average expected payment was $19,140 ($4.61/MBF) less than actual payments. This was due primarily to two factors: 1) the average inflation rate was much greater during the late 1970s than the assumed five percent, and 2) the majority of cutting occurred during the last year or two of the contract rather than according to the assumed even cutting pattern. Incorrect assumptions would have less adverse affect on skewed bidding in an upward escalating market than a down market because some species would be bid at base rates, resulting in no escalation. An insufficient allowance in a down market would allow payment rates to reach base rates before full utilization of the downward escalation.

The average expected payment for Firm X was $37,096 ($8.93/MBF) less than the expected payment of the successful bidder. This indicates that extensive timber cruises, market projections and skewed bidding can have substantial benefits. Because of the underestimation of inflation, the actual benefits would have been greater than indicated. Since extensive cruises and market analyses are expensive and may produce favorable returns on only a small percentage of the sales, an analysis of the returns for each sale based on the probabilistic bidding method is instructive.

Probabilistic/Skewed Bidding Comparison

Because of contract escalation clauses and differences between cruise and scale volumes, the amount paid for timber will not be the same as the amount bid. Basing probabilistic bidding on the amount of expected payment, rather than the amount bid, will produce different profit margins and sales awarded. That is, the bid would be adjusted to reflect the expected payment and the probabilities of paying, rather than bidding, a specified amount would be determined. Appendix E shows the indicated profit percentage of each sale for probabilistic bidding for three bases: 1) bid basis, 2) expected payment basis by the successful bidder, and 3) expected payment basis by Firm X with optimal skewed bidding. There is a substantial change in profit margins for some sales using an expected payment basis rather than the bid basis used in Chapter Two. In general, this indicates that probabilistic bidding may be more accurate and effective based on expected payments rather than bid amounts. However, the sales selected, based on expected payments (not skewed), resulted in a change of only one sale (#54) from the bid basis and the change in profit margins of the selected sales was minimal (Table 8; Bid Basis and Expected Payment Basis). If many more sales were required to reach capacity, a difference would have been apparent (Appendix E). Using skewed bidding expected payments, two additional sales (#11 and #60) become highly profitable (Table 8; Skewed Bid Expected Payments Basis).

Table 8

BID, EXPECTED PAYMENT, SKEWED BID BASES COMPARISON

Bid Price Basis

Sale No.	Bid Date Yr.Qtr	Profit Percent	Skewed Expected Savings/MBF	Expected Volume
10	75.2	21.7	$ .00	40,108
7	75.1	24.2	15.31	38,635
9	75.2	24.3	17.50	22,728
19	76.2	30.7	.78	15,013
57	80.2	31.6	.00	9,404
8	75.1	41.7	2.11	6,156

Expected Payment Basis

Sale No.	Bid Date Yr.Qtr	Profit Percent	Skewed Expected Savings/MBF	Expected Volume
9	75.2	18.3	$ 17.50	43,398
10	75.2	22.2	.00	35,683
54	79.3	24.5	.00	18,303
7	75.1	24.5	15.31	34,210
57	80.2	31.0	.00	15,013
19	76.2	32.5	.78	11,765
8	75.1	42.5	2.11	6,156

Skewed Bid Expected Payment Basis

Sale No.	Bid Date Yr.Qtr	Profit Percent	Skewed Expected Savings/MBF	Expected Volume
54	79.3	24.5	$ .00	40,139
60	82.4	24.9	72.51	36,849
11	75.2	26.6	69.20	36,306
7	75.1	28.9	15.31	30,920
57	80.2	31.0	.00	15,013
19	76.2	32.7	.78	11,765
8	75.1	43.2	2.11	6,156

Table 8 shows the dates sold, profit margins, expected volumes and skewed bidding savings per MBF. Note that the 24.5 percent profit margin for the skewed bid expected payments basis is a significant increase over the 21.7 percent of the bid basis. The bid date of selected sales is a very important indicator of what sales to expend funds on for extensive cruises. All sales selected, and most near the selection profit margin, were sold during low market periods.

The savings per MBF for skewed bidding (Appendix E) does not reflect the total benefit of skewed bidding. All zero-savings sales were due to three causes: 1) single species bid (or all but one species allowed to be bid at advertised rates only), 2) sale was bid at advertised rates, or 3) the successful bidder skewed the bid the most profitable way. Nearly one-half of the zero-savings sales were bid at, or within a few cents of, advertised rates. The greater the bid premium over advertised rates the more skewed bidding would save.

Tables 9 and 10 show what Firm X would have bid and paid per MBF at the 24.45 percent profit margin required to obtain the capacity volume.

Table 9

OPTIMAL SKEWED BID FOR SELECTED SALES

Sale No.	White P. Ponderosa	D.-Fir Cedar	Larch	Lodgepole Spruce	Firs
54	$ 89.14	$ 28.47	$ 27.65		
60	14.35	14.35		$ 10,567.50	$ 10.10
11	4.25	2.83	2.83	305.32	1.42
7	7.40	5.96	5.96	5.96	586.62
57	14.16	13.15		129.55	12.14
19	24.38	4.23	251.49	4.23	2.89
8	8.04	6.61	267.41	6.61	5.17

Table 10

EXPECTED PAYMENT FOR OPTIMAL SKEWED BID

Sale No.	White P. Ponderosa	D.-Fir Cedar	Larch	Lodgepole Spruce	Firs
54	$ 3.26	$ 2.99	$ 2.17		
60	14.35	14.35		$ 10,567.50	$ 10.10
11	4.25	2.83	2.83	350.68	1.42
7	7.40	5.96	5.96	5.96	595.95
57	14.16	13.15		138.94	12.14
19	43.19	4.23	274.15	4.23	2.89
8	8.04	6.61	281.74	6.61	5.17

Sale 54 benefited from an expected large drop in the market, therefore, skewing the bid would not be beneficial. The remainder of the sales were sold during a relatively low market and had large scale-to-cruise volume deviations. The benefit from skewing the bid came from both the volume change and the ability to prevent an upward escalation on the other species by bidding at base rates. Sale 60 is noteworthy because the extreme skewed bid is due to a change in lodgepole pine volume from 5 MBF to 3 MBF. The small proportion of the sale volume and the large percentage reduction is reflected in the large bid.

Purchaser Credit

Throughout the paper road costs have been assumed to be consistently at 79 percent of purchaser credits, with the other 21 percent an excess allowance for profit on the road construction. Road costs relative to purchaser credit allowances will vary significantly, but no data could be obtained for the actual road construction costs.

The variation between actual road construction costs and purchaser credit should be considered in net value calculations for probabilistic bidding.

It has also been assumed that all purchaser credit could either be utilized on the sale or transferred to, and utilized on, another sale. This will generally be true when purchasing rather large quantities of timber on one Forest. However, since purchaser credit is only transferable within the Forest it is earned on and the Forest Service can limit the amount transferred into any one sale, excess purchaser credits may need to be considered. Excess purchaser credit is defined as road credits which cannot be used by the firm. Purchaser credit cannot be used below base rates, and often not below base rates plus a specified amount of reforestation (K.V.) costs. Successful bidding on some sale combinations with high reforestation costs could result in excess purchaser credits and additional costs to the purchaser. The sales selected by probabilistic bidding appeared not to present an excess purchaser credit problem.

CHAPTER FOUR

CONCLUSIONS

Probabilistic Bidding:

* Probabilistic bidding can significantly lower stumpage costs and increase profit.

* Probabilistic bidding is superior in consistency and profitability to regression prediction of bids.

* Expected payments, rather than bids, may be a more accurate basis for probabilistic bidding if reasonably accurate predictions of market cycles and inflation rates can be made.

* Probabilistic bidding will tend to result in successful bids being concentrated during recession years.

* The flow of timber will produce large inventories of standing stock at the beginning of a market cycle and low inventories at the market peak. If inventory becomes insufficient at the market peaks, short-term log purchases can be made where material costs and product prices can be more closely matched. If an excess timber supply is purchased and the contracts will come due prior to manufacture, the logs can be sold profitably to other mills while the market cycle is relatively high, or the timber can be traded for similar timber for later delivery.

Skewed Bidding:

* Skewed bidding may reduce payments substantially, provided extensive cruise and market analyses are made prior to bidding and control procedures are used during harvest.

* Linear programming can be an effective tool for determining the optimal species' bids, but judgment and trial must be used to select upward escalation constraints.

* Cruise and market analyses and skewed bidding can be most profitably used with probabilistic bidding and concentrated during recession years. The larger expenditures for timber procurement should be made when other firms are reducing expenditures.

Purchaser Credit:

* If excess purchaser credit (after potential transfers) may occur, an additional cost must be added to the sale to compensate for the excess.

* A second method, available to small firms, for preventing excess credit is to have the Forest Service construct the road and forgo the credits. This method is especially effictive when purchasing large amounts of timber during recession years because it lowers the risk by reducing cash investment prior to actual harvest.

APPENDIX A

SALE CHARACTERISTICS

Sale No.	Ave DBH Vol Wtd	Slope %	% Skyline	Volume Per Acre	Haul Miles	Sale Volume (MBF)	Bid Date Yr.Qtr	Contract Term (Yrs)
1	12.5	30	12	9.1	11	6,360	74.2	4.75
2	17.2	30	0	7.5	25	4,070	74.2	3.75
3	15.8	60	69	7.1	17	6,105	74.2	4.75
4	18.5	20	0 *	7.7	13	2,840	74.3	2.50
5	20.2	50	66 *	8.1	26	1,418	74.2	3.25
6	17.5 *	15	0	9.0	15	1,080	74.4	2.25
7	15.3	50	66 *	17.7	37	17,150	75.1	6.00
8	12.5	35	0	8.8	30	5,250	75.1	5.00
9	12.3	35	26	3.3	41	7,913	75.2	5.75
10	8.0	20 *	0 *	5.0 *	35	1,875	75.2	.50
11	11.9	35	0	10.5	40	6,400	75.2	5.25
12	12.1	31	23 *	13.5	43	19,890	75.3	5.75
13	13.0 *	15	0	3.1	4	1,221	75.4	2.00
14	19.5	45	85	7.3	34	4,010	75.4	3.25
15	15.4	50	66 *	10.6	31	7,599	76.2	5.25
16	13.9	50	73	8.3	47	7,520	76.2	4.75
17	19.5	40	43	9.0	32	2,723	76.2	2.75
18	15.7	50	66	6.9	31	12,092	76.2	6.75
19	14.6	35	32 *	2.8	32	3,230	76.2	3.25
20	16.6	50	74	9.5	31	3,600	76.2	3.75
21	17.1	40	44 *	14.2	32	2,473	76.2	3.25
22	13.8	45	32	3.1	30	665	76.4	1.00
23	16.5	50	64	6.5	35	5,757	77.1	3.75
24	12.7	35	49	10.0	46	3,600	77.1	4.00
25	12.0	45	88	12.8	31	14,900	77.1	5.50
26	15.8	25	10 *	5.0	34	3,950	77.2	2.75
27	19.6	65	100 *	12.3	29	4,499	77.3	3.50
28	9.0	20	0	9.1	35	2,270	77.3	1.25
29	14.1	50	66 *	11.4	44	4,550	77.3	3.50
30	9.0	10	0 *	10.2	35	6,730	77.3	2.25
31	15.8	30	21 *	3.2	32	1,993	77.3	1.75
32	14.9	50	75	5.0	34	2,580	77.3	3.50
33	13.2	40	55	5.4	38	6,080	77.3	4.50
34	14.1	35	33	8.7	41	2,442	77.3	3.00
35	15.3	35	0	7.5	19	3,120	77.3	6.50
36	15.3	43	50 *	8.4	24	9,440	77.4	5.25
37	11.6	45	55 *	4.5	34	5,220	78.1	6.50
38	13.4	47	59 *	2.5	22	1,270	78.1	2.50
39	10.0 *	30	0	5.6	22	1,247	78.2	2.50
40	19.2	45	76	10.2	36	3,745	78.2	3.50

SALE CHARACTERISTICS

Sale No.	Ave DBH Vol Wtd	Slope %	% Skyline	Volume Per Acre	Haul Miles	Sale Volume (MBF)	Bid Date Yr.Qtr	Contract Term (Yrs)
41	10.0 *	30	21 *	9.0	24	643	78.2	1.50
42	13.3	30	21 *	8.0	23	2,420	78.3	3.50
43	16.3	50	66 *	4.2	12	2,220	78.3	4.50
44	11.5 *	0	0	5.0	53	1,928	78.3	2.50
45	13.6	40	44 *	6.0	43	2,068	78.3	3.50
46	16.0 *	35	42	6.0	26	1,687	78.3	3.25
47	10.0 *	25	0	6.0	38	1,166	78.3	2.50
48	13.9	50	67	8.0	14	6,290	78.3	5.50
49	13.5 *	40	44 *	6.0	23	954	78.3	1.50
50	13.5 *	45	55 *	5.0	23	779	78.4	3.00
51	15.5 *	25	10 *	6.7	31	2,130	79.1	2.50
52	13.6	40	44 *	5.4	31	3,480	79.2	4.50
53	10.0 *	35	32 *	6.2	35	4,170	79.2	4.75
54	20.5	55	200	3.1	10	3,390	79.3	1.75
55	11.4	37	37 *	7.4	34	3,010	79.3	3.00
56	13.5 *	50	66 *	10.0	12	2,310	79.3	2.50
57	12.3	15	0 *	8.0	5	3,120	80.2	3.75
58	13.5	40	57	10.5	21	2,988	80.4	2.75
59	17.5 *	55	77 *	7.6	15	2,080	81.2	2.50
60	17.0	50	75	10.0	26	570	82.4	1.75
61	12.7	25	24	14.2	26	19,320	78.2	2.84
62	13.4	40	41	3.6	34	5,630	78.3	1.85
63	12.0	49	96	7.5	16	1,988	79.1	4.79
64	19.1	65	200	5.7	5	7,940	79.1	4.82
65	13.9	45	57	11.2	18	9,100	79.2	4.85
66	18.0	40	57	15.0	15	4,520	79.2	1.85
67	12.1	10	0	8.0	5	4,150	79.3	4.84
68	17.2	25	0	13.8	43	5,750	79.3	3.84
69	17.4	55	74	4.5	49	5,270	79.3	4.83
70	18.0	48	78	6.0	24	4,870	79.3	4.84
71	13.0	45	59	18.0	23	8,130	79.3	1.86
72	12.0	35	10	9.3	35	5,610	79.3	1.84
73	12.0	30	6	7.5	37	4,500	79.4	1.84
74	20.8	45	200	3.6	25	4,210	80.3	4.82
75	10.5	30	0	8.0	54	1,664	80.3	1.83
76	13.3	55	88	28.0	32	5,732	80.3	3.84
77	17.8	15	10	7.0	9	2,830	80.4	1.84
78	15.0	30	0	14.5	36	9,600	80.4	1.86
79	15.2	45	50	11.0	24	4,800	80.4	4.84
80	9.7	40	28	8.0	38	4,467	80.4	1.85

SALE CHARACTERISTICS

Sale No.	Ave DBH Vol Wtd	Slope %	% Skyline	Volume Per Acre	Haul Miles	Sale Volume (MBF)	Bid Date Yr.Qtr	Contract Term (Yrs)
81	17.7	60	200	13.6	14	12,355	80.4	1.86
82	12.0	60	88	15.0	41	10,191	81.4	4.85
83	11.4	28	0	13.0	34	6,337	81.4	1.87
84	13.8	55	64	9.6	18	4,120	81.1	3.86
85	13.0	30	52	9.0	18	5,930	81.1	1.87
86	13.0	30	10	6.0	2	600	81.2	4.83
87	12.7	45	45	5.1	12	2,260	81.2	4.84
88	9.9	15	5	13.5	39	14,099	81.3	1.86
89	11.4	20	0	12.0	20	4,418	82.4	4.86
90	13.9	18	28	23.1	25	7,198	82.4	4.86
91	12.0	20	9	12.0	16	4,650	82.4	4.86
92	10.0	53	90	9.0	12	670	82.1	4.83
93	12.4	15	9	13.0	16	4,344	82.2	1.86
94	11.4	25	0	7.0	36	1,180	82.3	4.84
95	11.0	20	0	14.0	44	871	81.4	3.83
96	13.0	39	35	9.4	16	9,110	83.3	4.87
97	10.9	35	0	17.0	29	1,308	83.4	1.23
98	11.7	45	100	18.9	41	1,153	83.4	2.00
99	12.6	55	84	22.0	42	1,940	83.4	1.92
100	8.8	20	0	18.0	28	1,005	83.1	1.70
101	9.2	35	0	20.5	34	756	83.2	1.50
102	13.1	40	53	20.6	43	7,308	83.2	4.48
103	15.0	40	50	5.6	41	4,294	83.2	3.67
104	10.1	15	5	12.8	39	12,944	83.2	3.80
105	14.8	50	73	12.0	31	1,110	83.2	2.27
106	9.8	20	0	11.6	37	3,089	83.2	2.77
107	14.4	50	36	6.7	42	605	83.2	1.34
108	16.9	38	0	2.4	28	1,259	83.2	1.48
109	18.1	20	0	37.3	28	635	83.3	1.17
110	9.1	25	17	11.2	37	11,440	83.2	4.77
111	12.0	45	22	18.1	31	3,858	83.3	2.10
112	9.0	25	0	24.3	47	1,400	83.3	2.10
113	10.2	20	0	3.2	55	604	83.3	1.45
114	12.1	45	69	13.2	39	4,817	83.3	3.00

* Estimated data:

DBH - dbh by species unavailable; estimates from species mix and average dbh for the sale.

SKYLINE - estimates obtained by regression analysis of known sales using slope % as the independent variable (200 percent = helicopter).

APPENDIX B.1

PROBABILISTIC APPROACH (54 SALES)

Sale No.	Sale Volume (MBF)	Bid Date Yr.Qtr	Selling Value ($/MBF)	Firm X Cost ($/MBF)	Net Value ($/MBF)	Actual Bid ($/MBF)	Profit Margin (%)	Expected Volume (MBF)
68	5,750	79.3	312.59	163.75	148.84	221.10	-23.1	267,939
82	10,191	81.4	305.68	254.67	51.01	111.77	-19.9	262,189
71	8,130	79.3	309.19	218.85	90.34	146.35	-18.1	251,998
61	19,320	78.2	290.17	186.18	103.99	153.88	-17.2	243,868
70	4,870	79.3	345.20	214.74	130.46	189.55	-17.1	224,548
92	670	82.1	299.97	292.18	7.79	45.25	-12.5	219,678
69	5,270	79.3	396.12	219.17	176.95	208.61	- 8.0	219,008
77	2,830	80.4	328.31	168.37	159.94	180.27	- 6.2	213,738
66	4,520	79.2	358.79	195.49	163.30	183.54	- 5.6	210,908
67	4,150	79.3	301.56	188.28	113.28	123.86	- 3.5	206,388
98	1,153	83.4	306.29	279.56	26.73	34.62	- 2.6	202,238
83	6,337	81.4	296.34	180.96	115.38	120.03	- 1.6	201,085
62	5,630	78.3	340.22	211.79	128.43	129.75	- .4	194,748
78	9,600	80.4	306.07	167.44	138.63	138.33	.1	189,118
81	12,355	80.4	342.98	304.51	38.47	28.90	2.8	179,518
72	5,610	79.3	303.84	187.40	116.44	100.18	5.4	167,163
65	9,100	79.2	320.21	217.29	102.92	85.13	5.6	161,553
63	1,988	79.1	311.67	281.44	30.23	10.89	6.2	152,453
99	1,940	83.4	318.56	260.30	58.26	37.90	6.4	150,465
106	3,089	83.2	290.15	201.60	88.55	67.05	7.4	148,525
114	4,817	83.3	311.95	240.07	71.88	44.34	8.8	145,436
88	14,099	81.3	286.68	198.13	88.55	60.56	9.8	139,509
105	1,110	83.2	342.53	241.46	101.07	67.39	9.8	140,619
110	11,440	83.2	287.15	214.43	72.72	43.29	10.2	125,410
102	7,308	83.2	298.37	216.08	82.29	50.56	10.6	113,970
73	4,500	79.4	318.64	194.49	124.15	89.07	11.0	106,662
75	1,664	80.3	295.19	210.19	85.00	48.93	12.2	102,162
85	5,930	81.1	294.27	224.85	69.42	32.22	12.6	100,498
86	600	81.2	332.58	198.06	134.52	86.57	14.4	94,568
107	605	83.2	320.88	222.16	98.72	50.71	15.0	93,968
96	9,110	83.3	337.96	204.21	133.75	82.87	15.1	92,759
113	604	83.3	290.24	226.70	63.54	19.65	15.1	93,363
64	7,940	79.1	383.56	296.63	86.93	28.12	15.3	83,649
104	12,944	83.2	290.10	200.10	90.00	43.94	15.9	75,709
91	4,650	82.4	293.58	197.87	95.71	47.29	16.5	62,765
97	1,308	83.4	293.41	203.38	90.03	40.82	16.8	58,115
112	1,400	83.3	287.09	205.82	81.27	29.91	17.9	56,807
87	2,260	81.2	336.34	222.78	113.56	49.59	19.0	55,407
100	1,005	83.1	292.28	214.31	77.97	21.63	19.3	53,147
76	5,732	80.3	305.98	229.05	76.93	17.41	19.5	52,142
80	4,467	80.4	292.04	225.38	66.66	7.14	20.4	46,410

PROBABILISTIC APPROACH (54 SALES)

Sale No.	Sale Volume (MBF)	Bid Date Yr.Qtr	Selling Value ($/MBF)	Firm X Cost ($/MBF)	Net Value ($/MBF)	Actual Bid ($/MBF)	Profit Margin (%)	Expected Volume (MBF)
93	4,344	82.2	299.71	194.62	105.09	43.18	20.7	41,943
111	3,858	83.3	294.57	204.74	89.83	26.45	21.5	37,599
109	635	83.3	344.12	158.35	185.77	110.50	21.9	33,741
94	1,180	82.3	280.56	208.20	72.36	7.89	23.0	33,106
74	4,210	80.3	376.85	284.44	92.41	3.03	23.7	31,926
101	756	83.2	297.11	211.96	85.15	14.21	23.9	27,716
84	4,120	81.1	305.45	210.94	94.51	18.17	25.0	26,960
103	4,294	83.2	353.29	218.52	134.77	44.05	25.7	22,840
95	871	81.4	280.30	201.93	78.37	2.52	27.1	18,546
89	4,418	82.4	294.29	193.10	101.19	13.59	29.8	17,675
90	7,198	82.4	287.60	188.34	99.26	13.59	29.8	13,257
108	1,259	83.2	373.81	184.89	188.92	67.19	32.6	6,059
79	4,800	80.4	334.28	201.79	132.49	5.26	38.1	4,800

APPENDIX B.2

PROBABILISTIC APPROACH (60 SALES)

Sale No.	Sale Volume (MBF)	Bid Date Yr.Qtr	Selling Value ($/MBF)	Firm X Cost ($/MBF)	Net Value ($/MBF)	Actual Bid ($/MBF)	Profit Margin (%)	Expected Volume (MBF)
59	2,080	81.2	319.63	232.41	87.22	143.35	-17.6	256,280
49	954	78.3	286.06	228.66	57.40	94.03	-12.8	254,200
28	2,270	77.3	286.39	214.93	71.46	98.56	- 9.5	253,246
42	2,420	78.3	294.89	206.17	88.72	116.61	- 9.5	250,976
46	1,687	78.3	378.22	194.86	183.36	214.55	- 8.2	248,556
56	2,310	79.3	331.53	235.89	95.64	122.73	- 8.2	246,869
4	2,840	74.3	319.66	170.57	149.09	173.39	- 7.6	244,559
21	2,473	76.2	261.58	200.78	60.80	80.62	- 7.6	241,719
30	6,730	77.3	286.39	197.18	89.21	102.05	- 4.5	239,246
36	9,440	77.4	348.00	204.21	143.79	156.56	- 3.7	232,516
51	2,130	79.1	350.87	181.25	169.62	181.07	- 3.3	223,076
44	1,928	78.3	298.03	203.38	94.65	94.16	.2	220,946
48	6,290	78.3	346.51	226.38	120.13	118.52	.5	219,018
15	7,599	76.2	332.07	212.24	119.83	117.73	.6	212,728
12	19,890	75.3	292.81	196.98	95.83	93.06	.9	205,129
22	665	76.4	312.80	227.28	85.52	81.79	1.2	185,239
58	2,988	80.4	315.28	212.52	102.76	96.69	1.9	184,574
25	14,900	77.1	301.61	247.46	54.15	47.06	2.4	181,586
37	5,220	78.1	298.70	243.94	54.76	47.02	2.6	166,686
40	3,745	78.2	398.30	203.75	194.55	182.43	3.0	161,466
34	2,442	77.3	300.60	209.24	91.36	81.56	3.3	157,721
47	1,166	78.3	301.23	215.10	86.13	75.78	3.4	155,279
52	3,480	79.2	323.35	223.89	99.46	87.12	3.8	154,113
31	1,993	77.3	362.79	200.27	162.52	147.91	4.0	150,633
55	3,010	79.3	300.34	233.07	67.27	53.98	4.4	148,640
24	3,600	77.1	348.22	221.99	126.23	105.63	5.9	145,630
5	1,418	74.2	418.49	198.97	219.52	188.64	7.4	142,030
16	7,520	76.2	379.72	237.53	142.19	113.88	7.5	140,612
50	779	78.4	273.78	247.80	25.98	5.25	7.6	133,092
26	3,950	77.2	322.44	187.05	135.39	109.16	8.1	132,313
27	4,499	77.3	387.98	213.45	174.53	142.63	8.2	128,363
45	2,068	78.3	333.61	226.07	107.54	80.05	8.2	123,864
13	1,221	75.4	304.40	203.21	101.19	74.92	8.6	121,796
2	4,070	74.2	356.13	159.78	196.35	164.15	9.0	120,575
17	2,723	76.2	377.75	185.33	192.42	157.59	9.2	116,505
32	2,580	77.3	343.01	245.85	97.16	64.85	9.4	113,782
41	643	78.2	311.83	232.56	79.27	47.74	10.1	111,202
53	4,170	79.2	301.60	234.10	67.50	35.72	10.5	110,559
6	1,080	74.4	306.58	175.14	131.44	98.43	10.8	106,389
23	5,757	77.1	349.72	213.29	136.43	97.20	11.2	105,309
43	2,220	78.3	371.91	229.90	142.01	100.49	11.2	99,552
29	4,550	77.3	325.26	224.38	100.88	63.71	11.4	97,332
1	6,360	74.2	302.27	186.11	116.16	81.44	11.5	92,782

PROBABILISTIC APPROACH (60 SALES)

Sale No.	Sale Volume (MBF)	Bid Date Yr.Qtr	Selling Value ($/MBF)	Firm X Cost ($/MBF)	Net Value ($/MBF)	Actual Bid ($/MBF)	Profit Margin (%)	Expected Volume (MBF)
3	6,105	74.2	385.08	217.26	167.82	119.96	12.4	86,422
11	6,400	75.2	319.21	191.39	127.82	87.87	12.5	80,317
60	570	82.4	370.37	216.27	154.10	103.92	13.5	73,917
38	1,270	78.1	335.89	243.75	92.14	41.19	15.2	73,347
20	3,600	76.2	400.75	215.91	184.84	122.05	15.7	72,077
35	3,120	77.3	353.32	169.80	183.52	125.35	16.5	68,477
33	6,080	77.3	318.13	224.60	93.53	37.07	17.7	65,357
18	12,092	76.2	370.62	203.88	166.74	100.37	17.9	59,277
54	3,390	79.3	375.74	297.17	78.57	7.03	19.0	47,185
14	4,010	75.4	350.60	215.07	135.53	65.96	19.8	43,795
39	1,247	78.2	329.67	203.64	126.03	59.76	20.1	39,785
10	1,875	75.2	291.30	223.84	67.46	4.21	21.7	38,538
7	17,150	75.1	347.06	210.40	136.66	52.52	24.2	36,663
9	7,913	75.2	315.59	209.49	106.10	29.28	24.3	19,513
19	3,230	76.2	323.88	215.16	108.72	9.26	30.7	11,600
57	3,120	80.2	298.62	191.07	107.55	13.10	31.6	8,370
8	5,250	75.1	328.47	184.68	143.79	6.97	41.7	5,250

APPENDIX C.1

REGRESSION APPROACH (54 SALES)

Sale No.	Sale Volume (MBF)	Bid Date Yr.Qtr	Net Value ($/MBF)	Pre-dicted Bid ($/MBF)	Ac.Bid-Pr.Bid Ratio	Pr.Bid-Nt.Valu Ratio	Expected Volume (MBF)	Profit Margin (%)
98	1,153	83.4	26.73	14.26	2.43	.53	0	.0
82	10,191	81.4	51.01	55.03	2.03	1.08	0	.0
105	1,110	83.2	101.07	37.25	1.81	.37	0	.0
86	600	81.2	134.52	48.26	1.79	.36	0	.0
85	5,930	81.1	69.42	19.15	1.68	.28	0	.0
78	9,600	80.4	138.63	84.58	1.64	.61	0	.0
81	12,355	80.4	38.47	17.67	1.64	.46	0	.0
92	670	82.1	7.79	30.96	1.46	3.97	0	.0
99	1,940	83.4	58.26	25.99	1.46	.45	0	.0
77	2,830	80.4	159.94	128.65	1.40	.80	0	.0
67	4,150	79.3	113.28	92.57	1.34	.82	0	.0
100	1,005	83.1	77.97	17.15	1.26	.22	0	.0
70	4,870	79.3	130.46	153.81	1.23	1.18	0	.0
71	8,130	79.3	90.34	119.56	1.22	1.32	0	.0
68	5,750	79.3	148.84	183.15	1.21	1.23	0	.0
89	4,418	82.4	101.19	11.60	1.17	.11	0	.0
106	3,089	83.2	88.55	57.27	1.17	.65	0	.0
83	6,337	81.4	115.38	105.13	1.14	.91	0	.0
97	1,308	83.4	90.03	37.25	1.10	.41	0	.0
107	605	83.2	98.72	46.82	1.08	.47	0	.0
61	19,320	78.2	103.99	150.90	1.02	1.45	0	.0
62	5,630	78.3	128.43	126.61	1.02	.99	0	.0
69	5,270	79.3	176.95	213.92	.98	1.21	156,948	- 9.3
66	4,520	79.2	163.30	183.97	1.00	1.13	151,678	- 5.8
114	4,817	83.3	71.88	72.81	.61	1.01	147,158	- .3
65	9,100	79.2	102.92	103.06	.83	1.00	142,341	.0
96	9,110	83.3	133.75	132.13	.63	.99	133,241	.5
72	5,610	79.3	116.44	112.32	.89	.96	124,131	1.4
109	635	83.3	185.77	161.95	.68	.87	118,521	6.9
63	1,988	79.1	30.23	25.18	.43	.83	117,886	1.6
102	7,308	83.2	82.29	65.53	.77	.80	115,898	5.6
110	11,440	83.2	72.72	56.50	.77	.78	108,590	5.6
88	14,099	81.3	88.55	67.22	.90	.76	97,150	7.4
73	4,500	79.4	124.15	92.85	.96	.75	83,051	9.8
87	2,260	81.2	113.56	71.86	.69	.63	78,551	12.4
64	7,940	79.1	86.93	54.91	.51	.63	76,291	8.3
84	4,120	81.1	94.51	58.76	.31	.62	68,351	11.7
75	1,664	80.3	85.00	51.01	.96	.60	64,231	11.5
104	12,944	83.2	90.00	53.98	.81	.60	62,567	12.4
90	7,198	82.4	99.26	59.06	.23	.60	49,623	14.0

REGRESSION APPROACH (54 SALES)

Sale No.	Sale Volume (MBF)	Bid Date Yr.Qtr	Net Value ($/MBF)	Pre-dicted Bid ($/MBF)	Ac.Bid-Pr.Bid Ratio	Pr.Bid-Nt.Valu Ratio	Expected Volume (MBF)	Profit Margin (%)
111	3,858	83.3	89.83	52.89	.50	.59	42,425	12.5
91	4,650	82.4	95.71	50.20	.94	.52	38,567	15.5
76	5,732	80.3	76.93	39.22	.44	.51	33,917	12.3
108	1,259	83.2	188.92	94.79	.71	.50	28,185	25.2
103	4,294	83.2	134.77	65.20	.68	.48	26,926	19.7
93	4,344	82.2	105.09	49.25	.88	.47	22,632	18.6
112	1,400	83.3	81.27	37.21	.80	.46	18,288	15.3
113	604	83.3	63.54	23.85	.82	.38	16,888	13.7
94	1,180	82.3	72.36	27.23	.29	.38	16,284	16.1
101	756	83.2	85.15	29.46	.48	.35	15,104	18.7
79	4,800	80.4	132.49	37.27	.14	.28	14,348	28.5
95	871	81.4	78.37	18.80	.13	.24	9,548	21.3
74	4,210	80.3	92.41	20.80	.15	.23	8,677	19.0
80	4,467	80.4	66.66	11.30	.63	.17	4,467	19.0

APPENDIX C.2

REGRESSION APPROACH (60 SALES)

Sale No.	Sale Volume (MBF)	Bid Date Yr.Qtr	Net Value ($/MBF)	Pre-dicted Bid ($/MBF)	Ac.Bid-Pr.Bid Ratio	Pr.Bid-Nt.Valu Ratio	Expected Volume (MBF)	Profit Margin (%)
59	2,080	81.2	87.22	37.00	3.87	.42	0	.0
28	2,270	77.3	71.46	51.70	1.91	.72	0	.0
22	665	76.4	85.52	44.58	1.83	.52	0	.0
30	6,730	77.3	89.21	59.18	1.72	.66	0	.0
49	954	78.3	57.40	56.81	1.66	.99	0	.0
44	1,928	78.3	94.65	62.09	1.52	.66	0	.0
56	2,310	79.3	95.64	83.66	1.47	.87	0	.0
47	1,166	78.3	86.13	52.25	1.45	.61	0	.0
11	6,400	75.2	127.82	63.41	1.39	.50	0	.0
19	3,230	76.2	108.72	6.75	1.37	.06	0	.0
60	570	82.4	154.10	82.77	1.26	.54	0	.0
51	2,130	79.1	169.62	147.14	1.23	.87	0	.0
12	19,890	75.3	95.83	76.10	1.22	.79	0	.0
13	1,221	75.4	101.19	64.05	1.17	.63	0	.0
16	7,520	76.2	142.19	99.62	1.14	.70	0	.0
42	2,420	78.3	88.72	109.86	1.06	1.24	0	.0
55	3,010	79.3	67.27	50.89	1.06	.76	0	.0
3	6,105	74.2	167.82	114.07	1.05	.68	0	.0
52	3,480	79.2	99.46	82.66	1.05	.83	0	.0
4	2,840	74.3	149.09	169.29	1.02	1.14	0	.0
1	6,360	74.2	116.16	80.53	1.01	.69	0	.0
21	2,473	76.2	60.80	110.93	.73	1.82	173,001	-19.2
25	14,900	77.1	54.15	89.01	.53	1.64	170,528	-11.6
37	5,220	78.1	54.76	70.07	.67	1.28	155,628	- 5.1
34	2,442	77.3	91.36	115.84	.70	1.27	150,408	- 8.1
48	6,290	78.3	120.13	149.17	.79	1.24	147,966	- 8.4
29	4,550	77.3	100.88	123.97	.51	1.23	141,676	- 7.1
33	6,080	77.3	93.53	111.94	.33	1.20	137,126	- 5.8
36	9,440	77.4	143.79	171.70	.91	1.19	131,046	- 8.0
27	4,499	77.3	174.53	207.32	.69	1.19	121,606	- 8.5
46	1,687	78.3	183.36	213.69	1.00	1.17	117,107	- 8.0
5	1,418	74.2	219.52	240.91	.78	1.10	115,420	- 5.1
23	5,757	77.1	136.43	147.84	.66	1.08	114,002	- 3.3
15	7,599	76.2	119.83	123.97	.95	1.03	108,245	- 1.2
35	3,120	77.3	183.52	187.91	.67	1.02	100,646	- 1.2
40	3,745	78.2	194.55	192.46	.95	.99	97,526	.5
24	3,600	77.1	126.23	125.42	.84	.99	93,781	.2
26	3,950	77.2	135.39	132.88	.82	.98	90,181	.8
2	4,070	74.2	196.35	190.66	.86	.97	86,231	1.6
18	12,092	76.2	166.74	159.81	.63	.96	82,161	1.9
58	2,988	80.4	102.76	97.75	.99	.95	70,069	1.6
17	2,723	76.2	192.42	179.02	.88	.93	67,081	3.5

REGRESSION APPROACH (60 SALES)

Sale No.	Sale Volume (MBF)	Bid Date Yr.Qtr	Net Value ($/MBF)	Predicted Bid ($/MBF)	Ac.Bid-Pr.Bid Ratio	Pr.Bid-Nt.Valu Ratio	Expected Volume (MBF)	Profit Margin (%)
31	1,993	77.3	162.52	149.05	.99	.92	64,358	3.7
50	779	78.4	25.98	23.79	.22	.92	62,365	.8
20	3,600	76.2	184.84	168.15	.73	.91	61,586	4.2
39	1,247	78.2	126.03	107.95	.55	.86	57,986	5.5
41	643	78.2	79.27	66.06	.72	.83	56,739	4.2
32	2,580	77.3	97.16	77.87	.83	.80	56,096	5.6
6	1,080	74.4	131.44	101.31	.97	.77	53,516	9.8
45	2,068	78.3	107.54	80.04	1.00	.74	52,436	8.2
43	2,220	78.3	142.01	100.49	1.00	.71	50,368	11.2
53	4,170	79.2	67.50	47.84	.75	.71	48,148	6.5
9	7,913	75.2	106.10	73.77	.40	.70	43,978	10.2
14	4,010	75.4	135.53	89.16	.74	.66	36,065	13.2
38	1,270	78.1	92.14	57.20	.72	.62	32,055	10.4
57	3,120	80.2	107.55	59.68	.22	.55	30,785	16.0
8	5,250	75.1	143.79	69.59	.10	.48	27,665	22.6
7	17,150	75.1	136.66	62.23	.84	.46	22,415	21.4
10	1,875	75.2	67.46	28.16	.15	.42	5,265	13.5
54	3,390	79.3	78.57	30.05	.23	.38	3,390	12.9

APPENDIX D

SEASONAL/CYCLICAL INDICES

Year.Qtr	Seasonal Index	Cyclical Index	Combined Index
1974.1	.998	1.077	1.075
1974.2	1.016	1.088	1.105
1974.3	1.019	1.088	1.109
1974.4	.967	1.076	1.04
1975.1	.998	.956	.954
1975.2	1.016	.812	.825
1975.3	1.019	.905	.922
1975.4	.967	.976	.944
1976.1	.998	.931	.929
1976.2	1.016	.923	.938
1976.3	1.019	.921	.938
1976.4	.967	.978	.946
1977.1	.998	.99	.988
1977.2	1.016	.954	.969
1977.3	1.019	1.003	1.022
1977.4	.967	1.033	.999
1978.1	.998	1.063	1.061
1978.2	1.016	1.066	1.083
1978.3	1.019	1.048	1.068
1978.4	.967	1.113	1.076
1979.1	.998	1.077	1.075
1979.2	1.016	1.088	1.105
1979.3	1.019	1.088	1.109
1979.4	.967	1.076	1.04
1980.1	.998	.956	.954
1980.2	1.016	.812	.825
1980.3	1.019	.905	.922
1980.4	.967	.976	.944
1981.1	.998	.931	.929
1981.2	1.016	.923	.938
1981.3	1.019	.921	.938
1981.4	.967	.978	.946
1982.1	.998	.99	.988
1982.2	1.016	.954	.969
1982.3	1.019	1.003	1.022
1982.4	.967	1.033	.999
1983.1	.998	1.063	1.061
1983.2	1.016	1.066	1.083
1983.3	1.019	1.048	1.068
1983.4	.967	1.113	1.076

APPENDIX E

PROBABILISTIC/SKEWED BIDDING COMPARISON

Sale No.	Bid Basis (Profit %)	Expected Payment Basis (Profit %)	Skewed Bid Exp. Payment Basis (Profit %)	Skewed Bid Expected Savings ($/MBF)
1	11.5	12.9	14.1	$ 3.69
2	9.0	11.9	12.1	.85
3	12.4	13.6	14.0	1.46
4	- 7.6	9.6	14.1	14.78
5	7.4	12.3	18.0	23.69
6	10.8	17.9	17.9	.00
7	24.2	24.5	28.9	15.31
8	41.7	42.5	43.2	2.11
9	24.3	18.3	23.8	17.50
10	21.7	22.2	22.2	.00
11	12.5	5.9	26.6	69.20
12	.9	9.4	21.9	35.94
13	8.6	9.5	11.8	7.08
14	19.8	14.1	16.4	7.97
15	.6	- 1.8	3.0	15.85
16	7.5	3.6	4.0	1.36
17	9.2	6.1	11.1	19.23
18	17.9	12.6	12.6	.00
19	30.7	32.5	32.7	.78
20	15.7	11.9	13.2	5.43
21	- 7.6	-11.2	-11.0	.57
22	1.2	- 3.1	- 3.1	.07
23	11.2	8.7	9.9	4.27
24	5.9	2.4	5.1	9.26
25	2.4	- 1.2	- 1.1	.48
26	8.1	4.1	7.0	9.20
27	8.2	7.9	8.4	1.72
28	- 9.5	-18.1	-18.1	.00
29	11.4	13.3	13.5	.09
30	- 4.5	-14.7	-14.7	.00
31	4.0	1.9	4.6	10.35
32	9.4	7.0	10.8	13.85
33	17.7	15.7	15.7	.00
34	3.3	2.8	4.0	3.68
35	16.5	15.6	16.2	2.03
36	- 3.7	- 4.2	- 3.1	3.64
37	2.6	.9	5.2	13.47
38	15.2	16.7	17.8	3.79
39	20.1	17.4	17.4	.00
40	3.0	3.5	4.0	2.22

PROBABILISTIC/SKEWED BIDDING COMPARISON

Sale No.	Bid Basis (Profit %)	Expected Payment Basis (Profit %)	Skewed Bid Exp. Payment Basis (Profit %)	Skewed Bid Expected Savings ($/MBF)
41	10.1	7.6	9.1	4.69
42	- 9.5	- 6.4	- 1.9	13.10
43	11.2	12.9	12.9	.00
44	.2	3.3	6.6	9.83
45	8.2	12.0	12.0	.01
46	- 8.2	- .7	2.7	13.07
47	3.4	6.0	7.4	4.19
48	.5	2.5	3.1	2.28
49	-12.8	-14.7	-11.2	9.8
50	7.6	7.5	7.5	.00
51	- 3.3	1.9	7.4	20.34
52	3.8	3.4	9.5	19.11
53	10.5	14.7	17.3	7.92
54	19.0	24.5	24.5	.00
55	4.4	9.1	12.3	9.79
56	- 8.2	- 8.5	6.6	52.46
57	31.6	31.0	31.0	.00
58	1.9	- 5.4	10.6	50.60
59	-17.6	17.2	17.2	.00
60	13.5	5.7	24.9	72.51

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