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# An Economic Analysis of Machinery Complement Selection

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# AN ECONOMIC ANALYSIS OF MACHINERY COMPLEMENT SELECTION

By

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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T.A. LONE

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# INTRODUCTION

In the early 1800s the American farmer's machine complement consisted of the ax, the hoe, the sickle, and the scythe, all of which were hand tools(12). A farmer was able to work a few acres of land with these hand tools and rarely produced more than sustenance levels. Choices of type and size of implement were very limited during this time period and did not improve until the mid and late 1800s. Then in 1837 John Deere produced a steel plow, far superior to the wooden and cast-iron plows developed earlier, that could turn the heavy prairie soils of the west(32). Harrows, disks, cultivators, planting and harvesting equipment came into widespread use at about the same time(12).

The rapid mechanization of agriculture started in the 1880s and 1890s with the development of the tractor(12). The tractor 1) increased improvement of existing implements to take advantage of the greater power of tractors, 2) made farming more acres possible, and 3) made it possible to produce commodities far beyond sustenance levels. But perhaps the greatest contribution of the tractor was the elimination of almost all hard human physical labor on farms(12).

Today these are just reminders of how agriculture has progressed. Sophisticated four wheel drive tractors, some with on board computers, and the massive size of today's machinery are examples of continued technological advances made in American agriculture. Today's farmers have a choice of whom to buy implements from and what types and sizes of implements to buy. But just as machinery has changed, so too have the financing options for its attainment. Since today's farmer has many machinery and financing alternatives available, more than at any other time, the investment decision can have a great impact on the profitability of the farm operation.

## The Problem

The importance of machinery to the farm operation can be viewed from two perspectives. Farm machinery is important for performing the physical tasks of producing a crop and machinery is important from a financial standpoint. Machinery as a proportion of non-real estate assets and total production expenses of the farm operation can be just as important as the physical contribution of machinery. The condition of today's agricultural economy, with 1) input prices rising while commodity prices fall, 2) tighter credit restrictions, and 3) many farmers in trouble financially, stresses the increasing importance of machinery in the financial structure of the farm.

Machinery accounts for a substantial proportion of non-real estate assets and total production expenses of the farm operation. For each of the past eight years machinery has represented around 40 percent of non-real estate assets and over 50 percent of total production expenses in the United States(Chapter III contains further information and tables). These facts become readily apparent when machinery values throughout the country are considered. In recent years farmers have bought four wheel drive tractors with 150-300 horsepower that are priced $60,000 and up(3). When tractors and the implements required for crop production are added together, an investment in machinery of $100,000-200,000 for a single farm is not an unrealistic amount. Continued increases in machinery prices, above price increases in other production items, could make machinery an even greater part of farm assets. The price of used machinery should stabilize or increase slightly as those who cannot afford new machinery keep demand for used equipment constant. Farm managers are aware of the fact that an input accounting for a significant amount of non-real estate assets and production expenses is something they cannot afford to consider lightly, and therefore must carefully examine this investment decision.

The method of financing machinery, be it lease or purchase, affects the cash flow expectations of a farm operation. Downpayment amounts, interest rates, repayment periods, and salvage value will all have an affect on the financial condition of the farm operation during the period of the agreement. One financing alternative may provide considerable savings over others. When the accelerated cost recovery system(ACRS) of depreciation, investment tax credit, and expensing option are considered along with the financing of machinery, the possibility of lowering the net present value(cost) of machinery and the taxable income of the farm can become reality. Since the farm is like any other business, with the goal of profit maximization, selection of a financing alternative and the use of tax changes will have an impact on the amount of profit made each year. Therefore every option must be carefully considered before investing in machinery. The investment decision can be a contributing factor to the ultimate success or failure of the farm operation.

The wrong size of machinery can affect farm profits too. Machinery too small for a farm operation can result in increased fuel, labor, and timeliness costs of production. Larger than needed machinery does not make good economic sense either, although as a status symbol it may be quite nice. The argument that large equipment will reduce the amount of time required to complete field operations and that when worked easily will have less repair costs can be offset by the tremendous increase in purchase price and annual loan payments associated with larger equipment. Therefore the selection of the appropriate size of equipment for a given farm will further the goal of profit maximization.

## Objectives of the Study

Changing conditions in the agricultural economy have resulted in increased variability of net farm incomes. In this environment, careful planning of machinery investment decisions can yield major benefits to farmers. Therefore, the overall objective of this study is to develop a machinery selection and financing model to assist farmers in southeastern South Dakota with these types of decisions. The specific objectives of this study are:

1. To determine the optimum machinery complements for farms of different size and crop enterprise combinations in southeastern South Dakota.
2. To examine the impacts of alternative financing, acquisition, and tax strategies on least cost machinery complement decisions.

The scope of this study is limited to family farm operations in southeastern South Dakota, more commonly called the cornbelt region. However, not all farms in this region require the same machinery complements to produce a crop most efficiently. Different sized farms have different equipment needs. The same analogy is true of farms producing different crop enterprise combinations. Some farm equipment can be used in the production of various crops whereas other crops require special equipment unique to their production. Farm cropping combinations will determine the type of machinery needed and farm size will determine the size of equipment needed. Along with farm size and crop combinations, the wide variety of machinery alternatives and final commodity prices will also influence machinery selection decisions.

Due to the constantly changing nature of the credit system, knowing the optimal financing alternative at the farm level can lead to a successful farm operation. The options of machinery purchase and lease can have different net present value(cost) figures when compared to each other. Recent tax credit and depreciation policy changes by the federal government will have differing effects on each financing alternative (option). The farm operation that only considers the effect of tax changes on the purchase alternative could pay more than if the lease alternative, with a purchase option at the end, were chosen.

Short term financial agreements with higher interest rates may be viewed as less attractive when compared to longer agreements with lower interest rates. Some people prefer the longer agreements because annual payments are lower even though they are paying more money overall. These people prefer the lower payment amount because it is less of a burden on cash flows. Other people do not worry about cash flows but prefer to get out of debt as quick as possible. Still, some people purchase equipment without analyzing the situation closely and realize they could lessen cash outflows by leasing. A financing system compatible with cash flow projections of the farm operation will greatly reduce the possibility of an excessive burden on cash flows.

## Procedures

Achievement of the overall objective of this study will involve the completion of several steps. Step one will be setting up assumptions relating to implements to be included, soil type, implement speeds, tillage depths, and crops to be grown. These variables will be used to calculate feasible tractor-implement combinations, based on drawbar horsepower and implement draft. Step two will incorporate the feasible tractor-implement combinations and relevant crop production data into a mixed integer linear programming(MILP) model of complement selection. At the same time a survey of implement dealers and bankers in eastern South Dakota will be conducted to determine common financial terms on leases and credit-purchase agreements. Step three will calculate annualized costs, using capital budgeting procedures, under the lease and purchase options for each piece of machinery and incorporate these figures into separate MILP models. Step four involves running the MILP model on a profit maximization format for different sizes of farms. In actuality three models will be run for each farm size. The first model will serve as a base model and uses annualized costs calculated from Allen's publication(9). The second and third models use the annualized costs calculated for the lease and purchase options respectively. The profit maximization format will select the least cost machinery complement while maximizing crop returns. When all four steps are completed both specific objectives will have been accomplished.

## Overview

Identification of the problem, justification for the research, the objectives of the study, and an outline of procedures which will be used to achieve the objectives were given in this chapter. Chapter II contains a review of literature relevant to the study. Specifically, similar machinery selection models are examined and this model is set up based on previous models strengths and weaknesses. Chapter III involves a discussion of farm machinery in U.S. agriculture. A summary of changes in the farm machinery industry that affect the farm and the future outlook for the machinery industry is given. Machinery financing alternatives are examined in Chapter IV. Methods of financing machinery along with the pros and cons of each method will be given. The results of a survey of financial options and terms available to South Dakota farmers will also be given. Chapter V contains a description of the machinery selection models and capital budgeting models. The assumptions, constraints, and activities of the selection model and the equations used in the capital budgeting model will be explained. Interpretation of the results, weaknesses of the model, and some recommendations for model improvement are given in Chapter VI. The final chapter contains a brief summary of the entire study and recommendations for further research on the topic of farm machinery selection models.

## LITERATURE REVIEW

The overall objective of this study is to develop machinery selection and financing models to aid farmers in the efficient operation of their enterprises. The idea of studying machinery selection and financing is not a new concept, and consequently research has already been conducted in other states. This study incorporates the findings of other researchers in order to better understand the problems involved and then build the models accordingly. The studies mentioned in the review are only some of the studies that have been carried out but are considered more appropriate in helping define the boundaries and methods of this study.

### Machinery Selection Studies

The first objective of this study is to determine the optimum machinery complements for farms of different size and crop enterprise combinations. A major step toward accomplishing this is to develop plans which represent a variety of farm resource situations.

Krenz and Micheel(27) considered several factors in their model on optimal tillage and planting equipment. Based on machine size, time available for field operations, and the sequence of operations, they prepared budgets(on a cost per acre basis) indicating the maximum acreage of cropland that could be farmed with with different sets of equipment and the costs of operation associated with the maximum acreage. The study indicated optimal machinery size by comparing machine plus labor costs per hour. The procedures were carried out for one and/or more operators and tractors. However, the study is limited because the machinery and labor costs are only for tillage and planting operations and does not include harvesting activities.

Steven Griffin(21) used a mixed integer programming technique to construct optimal machinery complement models for Oklahoma farms. The model consisted of an objective function where implement and tractor operating and ownership costs would be minimized along with labor, timeliness, and custom charges. The model's principal constraints matched equipment to operations to be performed, matched tractors to equipment, matched labor requirements to labor availability, and included some common sense managerial constraints.

The model was applied to six different sized farms ranging from 100 to 2000 acres. The model specified which implements and tractors would be an optimal mix and then calculated the annual average machine costs for each farm. In some cases two or more tractor/implement combinations were specified as optimal.

The model did have a few shortcomings. The failure to handle risk and uncertainty (weather is an example) meant a less than real world situation. Flexibility, when more than one complement has the same cost, is also lacking. Only the first complement of a particular cost is said to be optimal. Also crop production activities, tax effects (investment credit, depreciation, etc), capital requirements, cash flow requirements, and financial aspects were not included. In reality many farmers face these constraints when selecting farm machinery.

In their machinery selection model Danok, McCarl, and White (13) developed a mixed integer programming formulation to solve simultaneously for machinery selection, crop production, and labor hiring. In order to do this two submodels were used. Machinery was selected by an integer program and a linear program selected the best crop plan, given a set of machinery. Using Benders Decomposition, the iterative solution of the two submodels results in simultaneous optimization of machinery and crop plan.

The hypothetical farm was a Nai state farm in Iraq with approximately 2800 acres of cultivated land. Six cropping possibilities were considered, the production of each involving plowing, discing, planting, irrigation, and harvesting operations. Farm profit maximization was the objective of the model and various constraints on tractor-implement combinations, land limitation, field operations performed, time availabilities, irrigation, and labor were imposed.

After several model runs a check for model validity was done. Actual machinery and crop data from a farm were incorporated into the model. Compared to actual conditions the model forecast profit figures above what actually occurred. The reason for this was that model assumptions concerning labor were different from those actually encountered on the farm. After the labor assumptions were changed the model predicted profits very close to actual profits.

Researchers concluded that simultaneous consideration and optimization of machinery selection and crop planning is a good method, due to the fact that they influence each other, and research on this method should be continued.

In a later study Danok, McCarl, and White (14) again used a mixed integer programming (MIP) model to jointly select machinery and cropping plans. The model differed from other selection models because it incorporated weather probabilities (field time uncertainty) and selected sets of machinery rather than individual machines. The model maximized profit subject to various constraints 1) on resources linking machinery and crop activities, 2) linking machinery set purchase and use, 3) reflecting mutual exclusivity of machinery, and 4) on other cropping resources.

A 600 acre cash grain farm in Indiana considering four different crops was the hypothetical farm. The MIP was run, for different weather probabilities, assuming no machinery set on the farm and then assuming an existing machinery set. The MIP results for no machinery set indicate 1) that as weather probability (available field time) increases the optimum machinery set changes and decreases in size, and 2) as weather probability increases field time and machine capacity cease to be effective constraints for profit maximizing crop selection, given the resource constraints used to define the typical farm. As available field time increases the farm specializes in the crop with the highest return and the least cost machinery set for that crop is chosen. The combined effect is stabilization of net farm income.

The MIP also proved to be effective for evaluating modifications to the existing machinery set. However, since the model selected different machinery sets for different weather probabilities and farmers most likely want a machinery set that performs well under a variety of probabilities, stochastic dominance was used to select the one best machinery set. But stochastic dominance results indicate a machinery set not selected as optimal by the MIP model results. This left some doubt as to MIP usefulness in machinery selection with given weather constraints.

Baker and Edelman (7) conducted a study in which they analyzed tax policy effects on optimal machinery selection. Investment credit, accelerated depreciation, and the general rate structure of the income tax schedule were analyzed with regard to four different sized farms using a mixed integer programming algorithm. The results of the study indicated the income tax provisions did not induce crop farms to increase machinery size, even though investment tax credits and accelerated depreciation make larger machinery more profitable. The optimal machinery complement for each farm size remained optimal regardless of the income tax option.

## Machinery Replacement Studies

A study by Bradford and Reid (9) considered several problems that must be confronted when researching optimal farm machinery replacement decisions. The study pointed out that since replacement is sensitive to repair estimates, a realistic estimate of maintenance and repairs is vital. The estimation of salvage value and the opportunity costs of breakdowns are also quite important and the Agricultural Engineers Yearbook has various formulas for calculating these values. If the value estimates are not realistic then there is no way of knowing whether the optimal machinery set decision is correct.

Inflation will have an effect on costs of machinery ownership and the salvage value, so it must be considered. A study done by Leatham and Baker (28) considered the effect of inflation on salvage values of used tractors and combines and how this ultimately affects the optimal replacement of tractors and combines. In their study Leatham and Baker used a discrete replacement model that was modified to allow for inflation and depreciation. The results they obtained indicate annual ownership costs increase at low inflation rates due to the loss in value of the depreciation income tax shield and the increase in inflation tax ,but at high inflation rates the increase in the real salvage value overshadows the other effects and costs decrease. Consequently inflation has a minor effect on optimal replacement age with a slight tendency to decrease replacement age at higher inflation levels.

R.K. Perrin(30) derived replacement principles for assets, ranging from goods in process to capital equipment. The article, "Asset Replacement Principles," has become a base from which others have built their models.

Perrin assumed that the asset owners prime concern was to maximize the present value of earnings from an asset. The replacement age that maximized the present value was the optimum. From this assumption the replacement principles were derived. For self replacement the optimum replacement age was the age in which the marginal revenues equal the marginal opportunity costs (interest earned on the sale of the asset). For replacement with a technologically improved asset the old asset should be kept until marginal revenue equals the revenues from interest on the sale of the asset plus the capitalized value of the series of challengers. These replacement principles are similar to Faris' who said,

> The optimum time to replace is when the marginal net revenue from the present enterprise is equal to the highest amortized present value of anticipated net revenue from the following enterprise(18).

Perrin also concluded that higher discount rates do not always mean shorter replacement periods, it depends on the asset. Perrin compared the revenue generated over time for a particular asset with a non-discounted and discounted curve. Whether the discounted curve lies above or below the non-discounted curve, or whether they cross would determine replacement age. Perrin observed that,

> Some assets may be replaced earlier with rising discount rates while others may be replaced later; and in fact a given asset may be replaced later up to a given rate but earlier thereafter (the two curves cross).

## Models Incorporating Finance Terms

The second objective is to examine the impacts of alternative financing, acquisition, and tax strategies on least cost machinery complement decisions. Fortunately there have been numerous studies conducted in this area.

A study conducted by Watts and Helmers(35) examined commonly used budgeting techniques to determine their applicability and accuracy. The traditional budgeting and capital budgeting methods were compared on a cost equivalents basis under various discount and marginal tax rates. The study concluded that capital budgeting more closely estimates real world costs because it can consider income tax influences such as investment credit, additional first year depreciation, and differing depreciation methods. The traditional method was found to overestimate costs under these conditions.

One of the leaders in tax policy inclusions in replacement models was Anthony A. Chisholm (11). Chisholm's study analyzed the effects of income tax policy on the optimal replacement age of equipment. Specifically, the study considered the impact that different depreciation methods and investment incentives (credits) have on optimal replacement decisions. A discrete-time variable model was used since it would facilitate analyzing real world problems involving short-lived assets. The model was applied to both Australia and the United States, but only United States results will be given.

The model is based on the after-tax present value of a stream of costs for an infinite chain of identical machines, each replaced at age n years. The present value was then converted to an amortized cost equation basis. The equation included all tax policy effects and could be evaluated for different replacement years. The year which produced the minimum amortized cost would be the optimal replacement age. This procedure worked well with investment credit allowances but had to be changed in order to consider different depreciation methods. For this purpose a neutral depreciation schedule, permitting annual asset value declines to be deducted from taxable income in the year it occurred, was used for comparison. All methods were then converted to annuity values for comparison.

Chisholm assumed a 50 percent tax bracket, varying discount rates, and straight-line and sum-of-the-years-digits (both with and without additional first year depreciation and the investment credit). He found that requirements of ownership for a minimum time in order to get favorable tax treatment nullified other incentives for early replacement. Chisholm also concluded that changes in the time pattern of the tax deductibility of different depreciation methods have only a minimal affect on optimal replacement decisions, while higher discount rates had the most impact.

Ronald D. Kay and Edward Rister (26) extended Chisholm's study by using a different data set and calculating present values for each year, following Perrin's suggestion, instead of the marginal approach Chisholm used. The Kay and Rister model assumed all expenses occurred at year-end. Under this method the optimal replacement policy would be the one which minimized present value (cost).

Kay and Rister confirmed Chisholm's results that the after-tax discount rate had the greatest effect on optimal replacement age and that tax rates and the depreciation methods had little influence. However, Kay and Rister found that additional first year depreciation and investment credit did effect optimal replacement age, contrary to

Chisholm's findings. They stated that a possible reason for different conclusions could be the way the investment credit on a tax free exchange of a used asset for a new one was calculated. Chisholm may have errored and calculated only on the cash difference instead of cash difference plus the adjusted tax base on the traded asset. Using the latter method Kay and Rister found that inclusion of additional first year depreciation and the investment credit resulted in optimal replacement ages one to four years less at lower discount rates, with the largest differences at higher tax rates. The investment credit was responsible for most of the change. In addition, Kay and Rister included a repair cost function which caused up to a five year change in optimal replacement policy.

Although Kay and Rister did expand on some areas of Chisholm's study, they still observed replacement policies longer than normally observed on many United States farms. Possible explanations for this which the authors thought should be incorporated into a model are: repair cost patterns different from those already studied, reliability of a machine as it ages, desire or need to replace with larger machine, and utilize improved technology by replacing earlier.

Myles J. Watts (34) considered the impacts of tax policies on machinery investments. A capital budgeting model was used to estimate the net present cost of machinery under varying assumptions; 1) ignoring taxes, 2) assuming straight-line depreciation and 30 percent marginal tax bracket, 3) using additional first year depreciation and double declining balance depreciation, and 4) investment credit along with #3.

The results were then put in tabular form to show how long the trading period (in years) would be lengthened or shortened under the different assumptions. The 30 percent marginal tax rate coupled with straight-line depreciation discouraged trading relative to the no tax situation. Moving from straight-line depreciation to the faster methods of additional first year or double declining balance depreciation encouraged longer or lengthened trading strategies in years one to four and earlier trading in years six to fifteen. The inclusion of investment credit encouraged earlier trading when compared to the other three assumption cases.

A study on the effects of recent tax changes was done by Donald W. Lybecker (29). The purpose of his study was to analyze the purchase-sale (PS) versus purchase-exchange (PE) machinery acquisition decision. A model was set up in which the net present value of the PS and PE alternatives were calculated. The two alternatives were analyzed under tax law changes of the Economic Recovery Tax Act of 1981 and the Tax Equity and Fiscal Responsibility Act of 1982 to see which alternative had an advantage. Lybecker concluded that in general the advantage of the PS alternative has decreased with the 1981 and 1982 tax changes. However, the 1982 choice of a 10 percent credit with reduced depreciable basis is more advantageous to PS than the 8 percent credit with full basis. The movement to longer accelerated cost recovery periods moves the advantage to the PE alternative.

Herbert R. Allen (3) has conducted research in the area of machine costs. Using a computer program he has developed tables of machine costs per hour and per acre for a wide range of machine types and sizes. Included in these tables are depreciation, purchase costs, man hours, machine hours, etc. Allen has also included a budget form allowing farmers to set up crop budgets based on crop returns, machine costs, land and labor charges, and other production costs.

The sources cited in this review in no way exhaust the literature on the subject. The sources included here are felt to be the most helpful and appropriate for the purposes of this study.

## Summary

Many of the studies cited here were machinery selection or replacement models based on profit maximization. This study will try to select machinery complements on a least cost basis and unlike the Danok, McCarl, and White studies (13,14) will fix crop production. The model will select complements from the full range of field operations (plow through harvest) instead of just a few operations (tillage and planting) as in the Krenz and Micheel study (27). Machine hour requirements and availability as well as the variable costs of repairs, maintenance, fuel, etc will be included in the model due to their importance just as Griffin (21) and Bradford and Reid (9) did. Many of the variable cost and purchase price figures will be obtained from Allen's (3) pamphlet.

The final part of this study will examine different alternatives of machinery acquisition (lease vs purchase) using up-to-date tax law changes, such as the Lybecker study (29). The approach used is similar to the Baker and Edelman study (7) where the effects of alternative acquisition options on optimal machinery was examined.

# FARM MACHINERY IN U.S. AGRICULTURE

The purpose of this chapter is to summarize selected changes in the U.S. farm machinery industry and how these changes may affect farmers. First the changes which affect the farm operation will be examined. Specifically, technological changes, the value of machinery on the farm, price/cost trends, and taxation and financing of farm machinery will be considered. The farm equipment industry will be examined in terms of machinery sales and supplies, machinery distribution, and the industry outlook. Changes that have occured in each of these areas will be pointed out.

## Technological Changes and Size of Machinery

The constant flow of new machinery into the agricultural market almost always deals with a new labor saving technique. Thus, machinery is constantly replacing human labor in the agricultural sector.

Rapid changes in technology have made a great variety, in size and model, of power units and implements available to today's farmer for his/her selection. Annual model changes usually result in upgraded or technically superior equipment being introduced to the agricultural community. Sometimes new equipment changes the method in which a particular operation is done. An example would be the large balers that have come to dominate the market in the last few years. Farmers quickly adopted these balers because of timeliness and labor saving advantages. Another example is reduced tillage equipment. This equipment leaves a stubble covering on fields which reduces the possibility of extensive soil erosion. These are just two of the many cases in which technological improvements have changed the methods of farming.

Technology has also made it possible to build larger and more powerful equipment. Tractors with increased horsepower ,pulling larger implements, have drastically cut the time required for many field operations, leaving the farmer extra time for more pressing matters. Regional differences in field and farm size in the United States result in major differences in tractor size purchase(Table 3.1). In states like Georgia, where most farmers raise crops on small fields, or Texas, where most farms are livestock producers, the majority of their tractors are sizes less than 70 HP. However, wheat farmers in North Dakota and farmers in other grain producing states, who farm several hundred to several thousand acres, predominately use tractors with over 100 HP. Some of these tractors are four wheel drive with over 200 HP. Larger equipment has allowed wheat farmers to farm more efficiently in terms of the time required to plant and harvest their crop. Larger equipment has allowed them to farm more acres in the same amount of time and is one reason for increasing farm size.

There is no doubt that technological change will continue to bring agriculture new and alternative methods of producing a commodity.

TABLE 3.1

Tractor Sales by Horsepower, Selected States, 1983

First figure=% of the tractors sold in state which are in that HP range.
Second figure=% of U.S. tractors sold in that HP range which are sold in the state.

| State | Under 40 | 40-69 | 70-99 | Over 100 |
|---|---|---|---|---|
| South Dakota | 4.1 (0.1) | 4.8 (0.2) | 15.1 (1.5) | 75.9 (3.3) |
| North Dakota | 10.4 (0.3) | 3.4 (0.2) | 6.1 (0.7) | 80.1 (6.5) |
| Minnesota | 14.6 (1.0) | 11.3 (1.3) | 16.4 (4.0) | 57.7 (6.2) |
| Nebraska | 10.0 (0.5) | 5.2 (0.4) | 10.1 (1.9) | 74.6 (5.6) |
| Iowa | 13.1 (1.2) | 11.3 (1.8) | 12.3 (4.1) | 63.3 (9.3) |
| Pennsylvania | 54.3 (4.1) | 23.9 (3.2) | 12.0 (3.3) | 9.8 (1.2) |
| Georgia | 48.3 (3.9) | 30.6 (4.4) | 8.3 (2.5) | 12.7 (1.7) |
| Indiana | 35.9 (2.2) | 16.3 (1.8) | 8.4 (1.9) | 39.4 (4.0) |
| Missouri | 35.4 (2.4) | 23.4 (3.5) | 14.0 (3.5) | 27.2 (3.0) |
| Colorado | 44.9 (1.2) | 15.3 (0.7) | 6.9 (0.7) | 32.8 (1.4) |
| Texas | 45.9 (13.9) | 28.4 (15.2) | 7.8 (8.7) | 17.9 (8.8) |
| California | 50.0 (5.5) | 22.0 (4.3) | 15.8 (6.4) | 12.2 (2.2) |
| U.S. Totals | (40.8) | (21.9) | (12.1) | (25.2) |

Source: Farm and Industrial Equipment Institute. "U.S. Retail Sales of Wheel Tractors and Selected Farm Machinery." Chicago, Illinois. March 1984.

## Value of Machinery on the Farm

In the United States the value of farm machinery as a proportion of total farm assets has varied since 1950(Table 3.2). The data indicate machinery as a proportion of total farm assets has varied from 9.4-10.7 percent since 1977. However, machinery as a proportion of non-real estate assets has been considerably higher. The preliminary 1984 figures forecast machinery will account for 40.6 percent of non-real estate assets. This indicates that machinery is a major component of farm assets, excluding land, and therefore careful consideration should be used when investing in machinery.

The value of farm machinery as a proportion of total farm assets or non-real estate assets is quite different in South Dakota(Table 3.2). In South Dakota machinery as a proportion of total farm assets has on average been one or two percentage points above national levels. Thus, farm machinery in South Dakota accounts for more of total farm assets but a lesser proportion of non-real estate assets than machinery does in the nation as a whole.

TABLE 3.2

Machinery as a Proportion of Total Farm Assets and Non-real Estate Assets, United States, South Dakota, Selected Years, 1977-84.

| | National | | South Dakota | |
|---|---|---|---|---|
| Year | % of TA | % of N-R | % of TA | % of N-R |
| 1977 | 10.7 | 42.3 | 12.4 | 40.9 |
| 1978 | 10.5 | 42.4 | 11.6 | 40.8 |
| 1979 | 9.7 | 39.0 | 11.3 | 34.6 |
| 1980 | 9.6 | 38.8 | 11.7 | 34.0 |
| 1981 | 9.4 | 39.2 | 11.5 | 33.3 |
| 1982 | 10.0 | 41.1 | 12.3 | 37.3 |
| 1983 | 10.6 | 40.2 | 13.0 | 36.6 |
| 1984a | 10.5 | 40.6 | 13.0 | 36.2 |

Sources: Economic Research Service, Economic Indicators of the Farm Sector-Income and Balance Sheet Statistics-1983, U.S. Department of Agriculture, ECIFS 3-3 (Washington, D.C., September 1984), p. 103.; ECIFS 3-4 (January 1985), p. 192.
a--Preliminary Data

## Farm Machinery Price/Cost Trends

The cost of machinery to the farmer has risen steadily due to inflation and rising manufacturing and distribution costs(Table 3.3). The Table compares prices paid for tractors and other machinery to prices paid for all production items, plus interest, taxes, and wages. Column 4 represents prices paid for production items and column 5 adds the prices of interest, taxes, and wages to column 4 inorder to account for all production expenses. The interest column, in which prices paid by farmers has increased the most, is a main reason why column 5 prices are generally greater than column 4. Columns 2 and 3 represent prices paid by farmers for machinery. The data indicates that machinery prices have increased at the same, or reduced, levels as the prices of total production items(column 5) until 1982. From 1982-1984 machinery prices have increased at a faster rate than total production items. However, this does not necessarily indicate that machinery has become an increasing percentage of total production expense since fewer machinery items were purchased by farmers in these years.

From 1977 until the present machinery costs(acquisition and variable) as a percentage of total production expense has varied between 53.6-59.6 percent(Table 3.4). One must keep in mind that this machinery figure includes total acquisition costs plus fuel, lubrication, and repair costs. Otherwise, machinery acquisition costs have accounted for 20.7-33.8 percent and fuel, lubrication, and repair costs 25.3-33.5 percent of total production expense, respectively.

TABLE 3.3

Indexes of Prices Paid by Farmers, United States, Selected Years, 1975-84(1977=100)

| Year | Tractors & S-P Machinery | Other Machinery | Production Items | Production Items Plus Interest, Wages, & Taxes | Interest |
|---|---|---|---|---|---|
| 1975 | 82 | 80 | 91 | 89 | 77 |
| 1976 | 91 | 92 | 97 | 95 | 88 |
| 1977 | 100 | 100 | 100 | 100 | 100 |
| 1978 | 109 | 108 | 108 | 109 | 117 |
| 1979 | 122 | 119 | 125 | 125 | 143 |
| 1980 | 136 | 132 | 138 | 139 | 174 |
| 1981 | 152 | 146 | 148 | 151 | 211 |
| 1982 | 165 | 160 | 149 | 154 | 233 |
| 1983 | 174 | 171 | 153 | 159 | 251 |
| 1984a | 180 | 179 | 156 | 160 | 256 |

Sources: Statistical Reporting Service, Agricultural Prices-Annual Summary 1982, U.S. Department of Agriculture, Pr1-3(83), (Washington, D.C.: U.S. Government Printing Office, June 1983), p. 7.; Pr1(1-84), January 31, 1984, p. 7.; Pr1(11-84), November 30, 1984, p. 7.
a--Preliminary Data
Note--Prices paid by farmers as reported in USDA statistics are before-tax transaction prices.

TABLE 3.4

Farm Expenditures for Selected Production Items, United States, Selected Years, 1977-84,(Bil$)

1st % figure=machine acquisition costs as a proportion of total production expense.
2nd % figure=machine acquisition plus variable costs as a proportion of total production expense.

| Year | Machinery Purchases | Fuel,Lube &Repairs | Fertilizer | Seed | Total | Percent |
|---|---|---|---|---|---|---|
| | - - - - - - - - - Billion of Dollars - - - - - - - - - | | | | | |
| 1977 | 8.6 | 7.2 | 6.3 | 2.5 | 27.5 | 31.3(57.8) |
| 1978 | 10.8 | 8.1 | 6.4 | 2.6 | 32.0 | 33.8(59.1) |
| 1979 | 12.0 | 10.0 | 7.2 | 3.0 | 36.9 | 32.5(59.6) |
| 1980 | 10.9 | 12.0 | 9.5 | 3.4 | 40.9 | 26.7(56.0) |
| 1981 | 10.6 | 13.4 | 9.6 | 3.9 | 43.1 | 24.6(55.7) |
| 1982 | 8.4 | 13.2 | 9.0 | 4.0 | 40.3 | 20.8(53.6) |
| 1983a | 7.9 | 12.3 | 7.6 | 3.5 | 36.7 | 21.5(55.0) |
| 1984b | 8.6 | 13.7 | 8.7 | 4.3 | 41.5 | 20.7(53.7) |

Sources: Economic Research Service, Inputs-Outlook & Situation, U.S. Department of Agriculture, IOS-4, (Washington, D.C.: U.S. Government Printing Office, April 1984), p. 4.; IOS-5, August 1984, p. 27.
a--Preliminary Data
b--Projected Levels

## Taxation and Financing of Farm Machinery

In 1981, with the passage of the Economic Recovery Tax Act of 1981, the United States Congress made some of the most sweeping tax cuts in history. Farmers were particularly affected by changes in investment tax credits, tax depreciation policy, and expensing options. Since farm equipment is generally classified as 5 year property, only data relating to this category will be given.

The old system allowed a 10 percent investment tax credit on reduced amounts of the investment, depending on its useful life(Table

3.5). Under the new system a 10 percent investment tax credit can be taken on the full amount of any investment with a useful life greater than three years. The new system grants the farmer a larger investment tax credit for property with a 5 year useful life. New and used machinery and equipment qualify for the investment credit(17).

TABLE 3.5

Economic Recovery Tax Act of 1981, Changes Affecting Farmers, United States, Investment Tax Credit(ITC)

| Old | | New | |
|---|---|---|---|
| The amount of investment in property eligible for the tax credit dependent on useful life. | | Tax credit on full investment amount and dependent on useful life only. | |
| 10% ITC of: | useful life(yrs) | ITC | useful life(yrs) |
| 2/3 of investment | 5-6 | 10% | 5 |
| Entire investment | ≥ 7 | | |

Source: Economic Research Service-National Economic Division, The Economic Recovery Tax Act of 1981: Provisions of Significance to Agriculture, Staff Report AGES 810908 (Washington, D.C.: U.S. Government Printing Office, September 1981), p. 11.
Note--Prior to 1981 machinery was classified as having an 8-10 year useful life.

The accelerated cost recovery system (ACRS) went into affect in 1981. Prior to this assets were depreciated over their entire useful life by one of three depreciation methods: 1) straight-line, 2) sum of the years-digits, or 3) declining-balance. There were limits as to what depreciation methods could be used on certain types of prop-erty(new,used,personal,etc). The accelerated cost recovery system specified recovery periods, in years, for machinery and established percentage amounts of machinery cost that could be deducted as depreciation each year(Table 3.6). ACRS gives farmers larger depreciation deductions in the early years of machinery life. The farmer can use either the ACRS or straight-line depreciation methods.

TABLE 3.6

Economic Recovery Tax Act of 1981, Changes Affecting Farmers, United States, Accelerated Cost Recovery System(ACRS)

Annual percentage depreciation deductions for five year property placed in service, based on recovery periods.

| Recovery Year | Dec.31,1980 Jan.1,1985 | During 1985 | After 1985 |
|---|---|---|---|
| 1 | 15 | 18 | 20 |
| 2 | 22 | 33 | 32 |
| 3 | 21 | 25 | 24 |
| 4 | 21 | 16 | 16 |
| 5 | 21 | 8 | 8 |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | | | |
| 10 | | | |

Prior to 1981 machinery was classified as having a useful life of 8-10 years and was depreciated throughout that period.

Source: Economic Research Service-National Economic Division, The Economic Recovery Tax Act of 1981: Provisions of Significance to Agriculture, Staff Report AGES 810908 (Washington, D.C.: U.S. Government Printing Office, September 1981), pp. 37-8.

Prior to 1981 additional first year depreciation was allowed. ACRS replaced additional first year depreciation with the expensing option. Under this option farmers are allowed to expense the cost of new or used personal property, the amount being $5,000 in 1982-3, $7,500 in 1984-5, and $10,000 after 1985(17). However, any property that is expensed is ineligible for the investment tax credit and in most cases the investment tax credit gives the farmer a bigger tax reduction.

The major effect of recent Federal tax policy and regulatory changes is to give those who replace equipment a greater tax reduction and lower the net present value(cost) of any replacement alternative. The farmer can buy labor saving machinery and get very favorable tax treatment, especially in high income years when large first-year tax deductions are possible(25). The overall effect of the tax credit and five year write-off period is to lower the after-tax cost of owning farm machinery, thus facilitating its purchase. This has encouraged the trend towards larger equipment and the consequent substitution of machinery for labor.

## Manufacturing Sales and Supplies

Although the farm equipment industry had record sales in 1979, manufacturers have watched business decrease steadily since that time. The major factors contributing to the decline are decreases in net farm income, higher interest rates and tighter credit, rapidly rising machinery prices, and the 1983 drought and PIK program(16).

Net farm income of operator families per farm was at a high of $13,293 in 1979 but declined to $6,793 in 1983(15). These figures do not include off-farm income, which has been increasing, or reflect how inflation has reduced purchasing power. Since farmers historically make machinery purchases out of net farm income this can partially explain why machinery sales are down(2). Rising production expenses, higher costs of living, and low farm returns have reduced net income and left farmers with cash flow problems, resulting in an unwillingness to take on additional debt.

The substantial increase in real after-tax interest rates over the past few years, along with tighter credit conditions, have also caused machinery sales to decline. The real after-tax interest rate is important because farmers receive tax deductions for interest payments, thus offsetting part of the interest cost. The real after-tax interest rate is calculated using the equation $N(1-T)-I$, where N is the nominal interest rate, T is the marginal tax rate, and I is the inflation rate. Since 1979, the real after-tax rate of interest has increased substantially due to the simultaneous rise(10.6 to 14.5 percent) of nominal interest rates and fall(13 to 4 percent) of the inflation rate(25). Add to this the fact that lenders have adopted tighter credit policies, due to an increase in the number of loans not repaid, and farmers unwillingness or inability to buy becomes clear.

Average machinery prices have increased more than five times since 1960 because of inflation and rising manufacturing and distribution costs(25). Farm machinery prices have risen at a faster rate than the prices of other production items(Table 3.3).

The 1983 drought and PIK program reduced the need for machinery during that year. The reduction in acres planted, by itself, would have decreased sales of equipment somewhat but the drought made the decrease in sales more pronounced. For example, farmers in drought effected states had no need for harvesting equipment when there was little crop to harvest.

The four factors mentioned above had the combined effect of decreasing machinery sales since 1979. The decrease in sales was accompanied by slow production adjustments by manufacturers and increased machinery importation, which resulted in growing machinery supplies(inventories). For example, as of December 1983 there was a 300-day supply of both tractors and combines(2). Inventories such as these have been cut somewhat by plant production cutbacks(some plants operating at less than half of capacity) and various sales promotions of interest-free periods, discounts, and rebates. However, these tactics have not yet reduced all inventory levels to normal, some have actually grown. Specifically, inventories of tractors in the under 40 HP category have grown because of increased imports from Japan(16). The combined effects of a strong U.S. dollar and Japanese manufacturers viewing the U.S. as a good market for their tractors have contributed to increased imports in the under 40 HP category.

## Farm Machinery Distribution

Manufacturers have depended on independent franchise dealerships for the bulk of their sales. Many of these dealerships traditionally handled only one manufacturer's product line and were that manufacturer's representative for a specific geographic region. The dealerships also offered credit to their customers through the manufacturer's own credit corporations. But with the decline in machinery sales some dealerships have had to acquire additional manufacturers product lines in order to add to their selection of machinery, or face the possibility of going out of business. In fact, since 1979, over 1000 dealerships(about one tenth of all dealerships) have gone out of business(2).

Several reasons can be given for the reduction in the number of dealers(16). First, the depressed state of the agricultural economy has decreased dealer before-tax profits to less than one percent of sales in 1982, the lowest in 35 years. Second, the consignment period of manufacturers has been shortened from 9-12 months to 30-60 days. If machinery is not sold in that period a monthly interest charge is assessed to the dealer. Third, the trend toward larger farms and the importance farmers place on good service and repair departments favor larger dealers. Finally, the transportation networks of today reduce the need for as many dealers.

## Industry Outlook

Increases in farm size, reduced farm numbers, and other economic changes will cause the overall demand for machinery to decline. However, these changes will cause demand for certain types of large equipment to increase somewhat but not enough to guarantee adequate profit margins to some full-line manufacturers. Machinery sales of the magnitude in 1979 may in all probability never happen again.

The combined effects of specialization of demand in certain types of equipment and increased competition from foreign producers will cause many manufacturers to narrow their product lines. Specializing in certain types of equipment and buying equipment from other suppliers for their product line will help manufacturers streamline operations. The possibility also exists of manufacturers entering joint agreements with other domestic and foreign manufacturers(16).

As manufacturers narrow their product lines and specialize in certain types of equipment, so too will dealers. Instead of carrying a diverse product line of several manufacturers, dealers will specialize in a few brands of specific equipment types. For example, a dealer may specialize in under 40 HP tractors and carry two or three brands. Dealers will also have to assume more responsibility in marketing and financing their products because this will be too costly for manufacturers to do(16).

## MACHINERY FINANCING ALTERNATIVES

This chapter focuses on machinery financing alternatives available to farmers in eastern South Dakota. The study considers the two main machinery financing alternatives of credit-purchase and leasing. The alternative of renting machinery on a yearly basis was not considered. Each financing alternative will be explained and the major advantages and disadvantages of each will be given. Finally, survey results indicating the finance terms and arrangements offered by implement dealers and banks in eastern South Dakota will be reported.

### Credit-Purchase Agreements

Of all the machinery financing alternatives available to farmers the credit-purchase alternative remains the most popular. Most farmers consider machinery ownership essential to the success of their operation. Whether owning machinery is more important to the success of the farm or the pride and prestige of the farmer is not the point. The most important fact is that many farmers purchase machinery, for whatever reasons, instead of acquiring machinery through other alternatives.

Most credit-purchase agreements between farmers and creditors contain common elements that need to be decided upon before the agreement is signed by both parties. First, there is usually a downpayment amount on the purchased machinery. The downpayment is commonly expressed as a percentage of the purchase price of the equipment, to be paid at the beginning of the agreement. The downpayment is subtracted from the purchase price and the difference becomes the amount of the actual loan. Thus, downpayment amounts will have an impact on how large the loan and subsequent payments will be. Next, the interest rate of the agreement will be determined by the creditor. Fixed or variable rate agreements can be used, the actual percentage amount dependent on various factors such as the creditor's required rate of return and rates offered by other creditors.

The length of the agreement and the frequency of payments are usually dictated by the creditor but in some cases are the choice of the customer. Some caution should be exercised so that the customer does not automatically decide on rapid repayment periods. Creditors will generally push for shorter loan periods because they receive their money quicker for use elsewhere. However, the farmer can achieve greater cash flow flexibility with longer repayment periods(Table 4.1). Using the 60 percent loan portion of the table compare a three year 10 percent loan with a five year 12 percent loan(longer repayment periods usually mean higher interest charges) and the difference is $4,337 more to repay with the longer loan. But Iowa State University economist Mike Boehlje points out that the shorter term loan has a $2,993 higher annual payment, which acts like a tourniquet to cut off cash flow(31). The actual added cost to the borrower of assuming the longer term loan is probably less since interest payments are a tax-deductible expense.

TABLE 4.1

Annual Payments for a $40,000 Tractor

| Years To Repay | 80% Loan Interest Rate 10 | 12 | 15 | 60% Loan Interest Rate 10 | 12 | 15 |
|---|---|---|---|---|---|---|
| 3 | $12,868 | $13,323 | $14,015 | $9,651 | $9,992 | $10,512 |
| 5 | 8,442 | 8,877 | 9,546 | 6,331 | 6,658 | 7,160 |
| 7 | 6,573 | 7,012 | 7,692 | 4,930 | 5,259 | 5,764 |

Source: Reichenberger, Larry. "Machinery Financing: Gear Down Your Payments So You Don't Bog Down in Debt." Successful Farming, Feb. 1979, p. 23.

There are a number of sources where financing the purchase agreement can be obtained. Banks, implement dealers, insurance companies, and other lenders offer different financing packages. Banks and implement dealers are probably the most used financing sources and although both offer similar financing terms, dealers also offer manufacturer sponsored interest-free periods up to nine months. This can add up to considerable savings as the majority of these contracts are paid off as interest charges begin to accrue(31). So by checking different financial sources farmers can, in most cases, reduce their annual payments.

## Advantages of Purchasing Farm Machinery

Most of the financial advantages of purchasing farm machinery are related to tax benefits(chapter three). The accelerated cost recovery system(ACRS) and investment tax credit(ITC) can be used by the farmer who purchases equipment. The ACRS allows farmers to fully depreciate equipment in the first five years of its useful life. This rapid depreciation can be very valuable to farmers in high income tax brackets because it gives them larger deductions to reduce taxable income. In addition, the 10 percent ITC can be used to reduce the amount of taxes owed and can be carried forward 15 years. The combined use of ACRS and ITC will generate major tax savings, thus lowering the after-tax cost of owning machinery.

Two other advantages of purchasing farm machinery are the residual value of machinery and the value of machinery as equity. The residual value is what the machinery is worth at the end of the purchase agreement. The farmer can sell or trade the equipment and get back some of the money he/she paid to buy it. The value of the machinery as equity can be used for acquiring additional financing for the farm operation. In this case the machinery can be used as collateral for other loans, up to its residual value.

### Disadvantages of Purchasing Farm Machinery

An obvious disadvantage of purchasing(owning) equipment is that the farmer is responsible for all operating and maintenance charges. Fuel, lubrication, and repair costs can be quite extensive on machinery used frequently and for long periods of time. There are also housing and insurance costs. Not providing adequate housing for machinery can lead to faster breakdown and deterioration. Most of the costs are assumed by the lessee(farmer) in a financial lease too, but there are instances where the lessor agrees to pay major repairs and insurance costs. However, such arrangements are rare.

Obsolescence is an often overlooked disadvantage of owning machinery. New technological developments during the time of the credit-purchase agreement may have rendered the machinery outdated and reduced its residual value to almost zero. When the credit-purchase agreement terminates the farmer is left with no way to recoup the monetary investment. Thus, obsolescence increases the risk of ownership.

The advantages and disadvantages given here are the most important, but not all possibilities.

## Lease Agreements

Leasing machinery has not yet become a widely used financing alternative by farmers, but its usage is growing. Many farmers are realizing that leasing will free up money they can use elsewhere. Instead of making a $30,000 downpayment on a combine, that money can be used to lease the combine, buy 1000 gallons of fuel, fill the LP-gas tank twice, and buy 15 tons of anhydrous in the first year alone(22). The burden on cash flows from leasing is not as severe when compared to purchasing the machinery. When considering the entire repayment period, leasing could result in significant savings(Table 4.2). The total cumulative savings figure in the last column of the table is the future value of the savings that could be realized at the end of the lease period. However, Table 4.2 is only a cash flow analysis and does not account for the equity value of machinery ownership at the end of the 5 year period. Realistically the farmer would have to make a purchase payment at the end of the lease or lease a new piece of machinery. In either case some cash outlay would occur in year 5.

TABLE 4.2

Purchase vs Lease on a $50,000 Tractor

Finance payments--30 percent down and 18 percent interest.
Lease payments--payments made at first of year and are based on a 45 percent residual value.

| Year Downpayment | Finance Payments | Lease Payments | Pre-tax Cash Flow Savings | Cumulative Savings At 16% Loan Rate |
|---|---|---|---|---|
| 0 | $15,000 | $10,120 | $4,880 | $4,880 |
| 1 | 11,192 | 10,120 | 1,072 | 6,733 |
| 2 | 11,192 | 10,120 | 1,072 | 8,882 |
| 3 | 11,192 | 10,120 | 1,072 | 11,375 |
| 4 | 11,192 | 10,120 | 1,072 | 14,267 |
| 5 | 11,192 | 0 | 11,192 | 27,742 |
| | -------- | -------- | -------- | -------- |
| | $70,960 | $50,600 | $20,360 | $27,742 |

Source: Hoffman, Robin. "Use a lease to..Free Up the Cash You've Locked Into Machinery." Farm Journal, August 1982, pp. 7.

Leasing agreements are setup similar to purchase agreements. The length of the agreement and frequency of payments are determined by both parties based on type of equipment and the financial position of the lessee. The amount of the lease payment and the interest rate charged(payment factor) are determined in a different manner than in the purchase agreement. First, the type of lease written has a major impact on the size of the lease payment. Some leases can be setup where the lessee keeps the investment tax credit and as a result is charged higher interest rates. However, in most leases the lessor keeps the investment tax credit and in turn offers lower interest rates to the lessee. These leases also establish a purchase price(as a fixed percent of original cost) at the end of the lease and this too affects the payment amount. Higher lease termination purchase prices in most cases mean lower lease payments. The type of lease a farmer enters into could contain a wide variation of terms and options depending on how the lease is written.

## Advantages of Leasing Farm Machinery

The major financial advantages of leasing are primarily tax related and will be examined for the lessee initially. First, the greatest advantage is that the lease payments are tax deductible as business expenses(1). The total payments are deductible, not just the interest portion as in the purchase agreement. Second, a lessee receiving the investment tax credit(ITC) benefits by having a deduction from taxes owed. However, the property being leased has to be new before the ITC can be passed to the lessee(24).

Additional advantages of leasing are the residual value, if the machinery is purchased at lease termination, and freeing up money for cash flow. Of course if the machinery is not purchased then no risk of machinery obsolescence is an advantage.

The lessor of a lease agreement receives some major advantages too. The lessor receives the depreciation deduction and, in most cases, the ITC which they can use to reduce business income and taxes. With passage of the 1981 Economic Recovery Tax Act leveraged leases have become more profitable for lessors too. The 1981 tax cuts lowered the minimum amount of equity a lessor must have in the leased property to 10 percent(36). Lessors can now enter an agreement with a third party who loans 60-90 percent of the money to the lessor and receives lease payments, an assignment of the lease, and a collateral lien on the equipment as security(24). The lessor receives all the tax benefits that go along with ownership. If a lessor uses maximum leverage(10 percent) they can recoup their entire expenditure in the first year by using the 10 percent ITC. In a sense lessors then receive free use of the depreciation deductions.

## Disadvantages of Leasing Machinery

The lessee does not receive the benefit of depreciation deductions or, in most cases, the ITC. Obsolescence also becomes a concern if the lessee purchases the machinery at lease termination, which most farmers do because they place a high value on ownership. The possibility that leases with purchase options will not free up as much cash as those without purchase options exists too.

The lessor's greatest disadvantage is that of obsolescence when the machinery is not purchased at lease termination by the lessee.

## Financing Arrangements In South Dakota

A survey of implement dealers and banks was conducted for eastern South Dakota. Appendix A contains a copy of the questionnaire sent to bankers. A similar questionnaire was sent to implement dealers. The survey focused on various financial terms in credit-purchase and lease agreements. Questions ranged from asking about common finance practices to inquiring about specific options on either agreement. The survey was sent to sixty-five dealers and sixty-five banks located in towns and cities east of the Missouri river in South Dakota. A range of small to large agricultural communities was included so that overall financial conditions in this part of the state could be better documented. Furthermore, questionnaires were sent to implement dealers and banks in the same town or city thus facilitating a comparison of contract terms available to farmers in a specific area. The survey period was from October to December of 1984. Questionnaires were sent to implement dealers in late October and to banks in late November. The number of implement dealers and banks responding were 27 and 23, respectively.

The first part of the survey dealt with general questions on leases, receivables of the firm, and agreements customers arrange. Almost all dealers responding offered the lease option while only 39 percent of the banks responding made this option available to their farm customers. However, in both cases, on average about 5 percent of their agricultural customers arranged a lease agreement and receivables from leasing reflected this. It appears that agricultural customers still prefer to purchase any equipment they may need. One possible explanation for the low lease use rate is that 70 and 91 percent, respectively, of dealers and banks felt both parties of the agreement needed to be better informed about leasing, citing a lack of understanding as their major reason for lower use of leasing.

## Credit-purchase Terms

Common financial terms of a purchase agreement offered by dealers and banks are given in Table 4.3 . The downpayment amount required by dealers was 5-10 percent higher than that required by banks and the annual percentage rate of interest(APR) was 0.5-1.5 percent higher than what banks would charge. Speculation might lead one to think the banks greater loan volume(including loans outside agriculture), larger asset value, and various sources of funds could account for their APR being somewhat less than the dealers rate. There is also the possibility that dealers do not want to be in the lending business except to sell, so the dealers take on loans the banks refuse. Dealers and banks seemed to have the same policy regarding length of agreement and frequency of payments.

Interest-waiver periods of some kind were offered by all dealers, the waivers usually extending until next year's use date, depending on company programs. Banks almost never offered an interest-waiver period. In addition, only 1/4 of the dealers and banks responding offered a deferred first payment option, most required payment when the agreement was made.

TABLE 4.3

Comparison of Financial Terms Offered by Dealers and Banks in a Credit-Purchase Agreement.

| | Dealers | | Banks |
|---|---|---|---|
| Downpayment % Of Purchase Price | 30-35% range<br>30% common | | 20-30% range<br>25% common |
| Length Of Loan | 3-5 years<br>7-10 years | most equipment<br>irrigation | 3-5 years<br>7-10 years |
| Payments Are Made: | | | |
| Annually | 76% | | 65% |
| Semi-Annually | 8% | | 13% |
| Quarterly | 0% | | 0% |
| Monthly | 8% | | 4% |
| Customer Choice | 8% | | 17% |
| Annual Percentage Rate Of Interest | 15.5-16.5% range | | 14-15% range |

Source: Machine Finance Survey, October-December 1984.

Just over one-half of the dealers(53 percent) said the APR was variable while 50 percent of the banks said the APR was fixed or variable depending on customer choice, loan amount, loan length, and other terms. If a fixed rate loan was arranged the bank charged an interest rate 1/4 to 1 percent higher than on a comparable variable rate loan. Dealers and bank officers agreed if the interest rate was variable the rate could change monthly. Dealers(53 percent) had a limit on the amount the APR could change(5-20 percent of the initial interest rate) while the majority of bankers(85 percent) said there was no limit on the amount of possible change.

When the dealer arranged a credit-purchase agreement the loan paper was usually sold to a manufacturer-credit corporation or the local commercial bank.

## Leasing Terms

A comparison of leasing terms offered by dealers and banks shows more diversity than with the credit-purchase agreements(Table 4.4). There was a much broader range in the first payment percentage and the remaining payment factor percentage offered by banks than those offered by dealers. The probable reason is that some banks allow lease payments to be made more frequently than once per year. The payment factors are similar when expressed on an annual basis. The length of the agreement tended to be nearly the same between the two institutions but most dealers wanted payments on an annual basis while banks set payments to meet customer cash flow conditions. Although few dealers and banks had a minimum dollar value before a lease was written, some banks responding indicated they prefered to lease "big ticket" items with a purchase price valued over $25,000.

Just as in the purchase agreement most dealers(87 percent) and all banks required the first lease payment at the time the lease was made. Dealers and banks also agreed that the payment factor on subsequent payments was fixed for the life of the agreement. In addition, all dealers and most banks offered a purchase option at the end of the lease, the majority of both had the purchase price a fixed percentage of the original cost(usually 10-15 percent).

TABLE 4.4

Comparison of Financial Terms Offered by Dealers and Banks in a Financial Lease Agreement.

| | Dealers | | Banks |
|---|---|---|---|
| First Payment % Of Purchase Price | 20-25% range | | 10-25% range |
| Payment Factor % | 20-25% range | | 9-22.5% range |
| Agreement Length | 4-5 years | most equipment | 3-5 years |
| | 7-10 years | irrigation | 7-10 years |
| Payments Are Made: | | | |
| Annually | 75% | | 43% |
| Semi-Annually | 5% | | 0% |
| Quarterly | 0% | | 0% |
| Monthly | 5% | | 0% |
| Customer Choice | 15% | | 57% |
| Minimum Purchase Price Before A Lease Is Written | $10,000 | | $25,000 |

Source: Machine Finance Survey, October-December 1984.

Who received the investment tax credit(ITC) was an area of some uncertainty depending on which institution the farmer dealt with. Of the dealers responding, 77 percent said the lessor kept the ITC. Banks claimed the ITC could go to either party of the contract depending on customer need and the specific terms set forth in the lease.

Dealers and banks agreed that most of the time taxes, insurance, and repair costs were the responsibility of the lessee. The lessee benefited from lower payments by assuming these costs.

A basic set of financial statements were required in both instances(purchase or lease) regardless of who wrote the contract(Table 4.5). Credit references and past repayment records were also very important to dealers and banks no matter which agreement was made. Tax records, cash flow statements, and a courthouse search were considered more important by banks than dealers when deciding on entering an agreement with a customer. An interesting note was that in the majority of cases both institutions required a more thorough credit evaluation for leases than purchase agreements.

TABLE 4.5

Financial/Management Records Required by Implement Dealers and Banks, Based on Percentage of Respondents Checking the Appropriate Boxes. A=always S=sometimes N=never

| | Dealers(%) | | | | | | Banks(%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lease | | | Purchase | | | Lease | | | Purchase | | |
| | A | S | N | A | S | N | A | S | N | A | S | N |
| Financial Statements | 100 | 0 | 0 | 93 | 7 | 0 | 100 | 0 | 0 | 100 | 0 | 0 |
| Tax Records | 53 | 0 | 47 | 10 | 24 | 66 | 78 | 22 | 0 | 52 | 48 | 0 |
| Cash Flow | 27 | 32 | 41 | 25 | 33 | 42 | 44 | 56 | 0 | 62 | 33 | 5 |
| References | 90 | 10 | 0 | 96 | 4 | 0 | 89 | 11 | 0 | 71 | 29 | 0 |
| Courthouse Search | 45 | 40 | 15 | 39 | 48 | 13 | 67 | 33 | 0 | 86 | 14 | 0 |
| Past Record | 80 | 10 | 10 | 76 | 12 | 12 | 78 | 22 | 0 | 76 | 24 | 0 |

Source: Machine Finance Survey, October-December 1984.

# THE MACHINERY COMPLEMENT SELECTION MODEL

The structure and development of the machinery selection model are presented in this chapter. Section one contains a discussion of the assumptions and constraints of the model relating to the area of South Dakota involved, crops grown, field operations performed, and field working days available. The factors affecting tractor-implement combinations and the equations to calculate the combinations are examined. An explanation of the type of programming algorithm used and an equation representation of the model is also provided.

Section two contains a description of the basic structure of the model. The rows and columns of the model are broken into general categories and each of the categories is explained. The financial elements included in the model are examined along with an explanation of their use. The equations used to calculate the annualized cost coefficients used in the model are provided. Finally, an explanation of the model runs for each farm and the reason for these runs is given.

## Assumptions and Constraints

Descriptions of the area of South Dakota and the size of farms considered in the model, factors affecting tractor-implement combinations, crops grown, field operations performed, field working days available, and the programming algorithm used in the model are given in this section.

## Area of South Dakota and Size of Farms

The study will be confined to southeast South Dakota, more commonly known as the cornbelt region. This region of the state was chosen for various reasons. Various types of data needed for the model were available for the region or could be closely approximated from data available for adjacent regions of neighboring states. In addition, the southeast region of South Dakota has some of the most productive soils in the state. The superior soils mean crop yields in this region are usually greater than crop yields in other regions of South Dakota and the soils allow a wide variety of crops to be grown in the region.

The sizes of farms to include in the model were determined by an examination of agricultural census data(10). Data relating to the number of farms in specific farm size classifications, determined by the census, were examined for the counties of Bon Homme, Clay, Hutchinson, Lincoln, Turner, Union, and Yankton in southeast South Dakota. The numbers for each county were added so that the total number of farms in each farm size classification could be obtained. Based on the overall total number of farms in all counties combined the percentage of farms in each farm size classification was determined. From this data four estimations of typical farm sizes in southeast South Dakota were made. The specific farm sizes for model runs were 200, 400, 800, and 1600 cropland acres.

## Crops Grown, Field Operations, and Field Working Days

The crops grown on the farm determine which field operations will be performed. The field working days available during each month of the production season helped determine the tractor hours available each month.

### Crops Grown.

There are a variety of crops grown, or that can be grown, in the southeast region of South Dakota. Instead of considering all of the possible crops only those comprising the largest percentages of cropland harvested were included in the model. Information of this nature was obtained from Census data(10). Data on cropping pattern for the same counties in southeast South Dakota were examined. Although the crops grown in each county varied somewhat, all counties raised four crops(corn,oats,soybeans,and alfalfa) in very high percentages when compared to total cropland harvested. After analyzing the percentages for each crop harvested in each county a breakdown of 45 percent corn, 15 percent oats, 30 percent soybeans, and 10 percent alfalfa was chosen as the proportion of crops to be grown on each farm in the study.

Once the crops to be included in the model were determined the production costs per acre had to be calculated. For this purpose an extension report by Wallace Aanderud(6) was used. The report separated South Dakota into regions and provided cost figures for the common crops grown in each region. Costs for seed, fertilizer, insecticides, storage, and related costs were available so that the total variable production costs per acre could be obtained. Land and labor charges were not incorporated into the model. Costs related to machinery were not included in the crop production costs per acre because they were included elsewhere in the model.

**Field Operations.**

The field operations assumed in this model were the conventional methods of plowing through harvest, depending on the crops grown. Specifically, the operations of plow, chisel, disk, harrow, drill, plant, cultivate, swath, bale, and combine were considered. Although reduced tillage and no-till planting are becoming more popular, it was felt that the majority of farmers in southeast South Dakota still use the conventional methods. The determination of what month a particular operation would be performed was taken from a publication on crop budgets for South Dakota written by Allen and others(4). The publication specified the month a field operation was performed, for various crops, and breaks the state into regions. Information for this study was taken for the southeast region of South Dakota.

**Field Working Days.**

The determination of field working days available during each month of the production season were based on weather data gathered by agricultural experiment stations(20). Specifically, data on the probability of wet and dry days for each week of the production season in Yankton, South Dakota were used. Since the data varied for different definitions of a dry day, a dry day (field working day) in this study was defined as one in which less than one hundredth of an inch of precipitation occurs. Multiplying the probability of a dry day for each week of a specific month by seven and adding the expected field working days for each week, gives the total number of field working days expected for that month.

Based on the results of this method a different number of working days were assumed for each month of the production season. The range was from a low of 19.5 working days in June to a high of 25.7 working days in October. The additional assumption of a 14 hour work day resulted in the number of tractor hours available per month shown in Table 5.1. All tractor hour availabilities were rounded to the nearest ten.

TABLE 5.1

Field Working Days and Tractor Hours Available for each Month of the Production Season.

| Month | Working Days | Tractor Hours |
|---|---|---|
| May | 20.0 | 280 |
| June | 19.5 | 270 |
| July | 22.0 | 310 |
| August | 22.3 | 310 |
| September | 22.8 | 320 |
| October | 25.7 | 360 |

Source: Feyerherm, A.M., L.D. Bark, and W.C. Burrows. Probabilities of Sequences of Wet and Dry Days in South Dakota.
Agricultural Experiment Station, Bulletin 139h. Kansas State University, 1965.

## Factors Affecting Tractor-Implement Combinations

Soil type, implement speeds, and implement depths have a great impact on the size of implement a tractor can pull.

### Soil Type.

Soil type has a profound affect on the amount of draft a particular implement will have, and draft can be used to determine the size of implement a tractor can pull. For this reason the assumption of soil type became very important.

In the calculation of tractor-implement combinations the Agricultural Engineers Yearbook(5) gives equations to compute implement draft. The Yearbook specifies draft equations for different soil types. Since it is difficult to say there is one dominant soil type in southeast South Dakota, no particular draft equation could be used. Instead, values from the equations for specific soil types were averaged together in order to obtain one equation to compute an average draft figure. This draft figure provides a good basis on which to calculate tractor-implement combinations. It is true this draft figure will be low when compared to heavy textured soils but it will also be high when compared to light textured soils, it is a midpoint figure. But according to Dr. Douglas Malo of the Plant Science Department at SDSU the soils of southeast South Dakota could be roughly classified as being some type of loamy soil. Since the loam soils are somewhere between the heavy and light textured soils, the use of these average draft figures should provide a good approximation of actual conditions.

**Implement Speeds and Depths.**

Implement speeds and depth of field activity also have a major impact on the calculation of draft and the calculation of tractor pulling capacity. The calculation of draft and pulling capacity ultimately leads to the determination of tractor-implement combinations. Implement speeds assumed in this model were the same as those assumed by Allen(3) in his Machine Costs Phamphlet and are shown in Table 5.2. The speeds Allen assumed were well within the ranges used by farmers in southeast South Dakota. Assuming other implement speeds would change the tractor-implement combinations by greatly affecting tractor pulling capacity. Assuming the same speeds as Allen also eliminated recalculation of the machine hours per acre coefficients obtained from his pamphlet.

TABLE 5.2

Implement Speeds and Depth of Field Activities

| Activity | Speed(mph) | Depth(inches) |
|---|---|---|
| Plow | 4.5 | 6 |
| Disk | 4.8 | 4 |
| Chisel | 4.1 | 8 |
| Harrow | 5.3 | 2 |
| Plant | 5.0 | 2 |
| Drill | 4.0 | 2 |
| Cultivate | 3.8 | 3 |

The depth of field activities are also shown in Table 5.2. Field depths are used in the calculation of implement drafts and have an affect upon power requirements for a specific implement size. Deeper field activity depths mean more power is needed to pull a specific size of implement. The figures in Table 5.2 were arrived at by interviewing farmers and implement dealers in the geographic region of the study. It is felt that these figures are representative of farm practices in the region.

## Calculation of Tractor-Implement Combinations

Before tractor-implement combinations could be calculated the determination of tractor sizes to include was made. Based on 1982 retail sales of farm tractors by horsepower(19) and discussions with farmers five typical sizes were chosen. The five sizes were 80, 100, 125, 165, and 220 horsepower. These tractor sizes were commonly used on various sizes of farms in this region.

The assumptions of soil type, implement speeds, and depth of field activity were incorporated into several equations(Appendix B). One equation was used to calculate tractor pulling capacity in pounds of force. The other equations, one for each field operation being considered, were used to calculate implement draft in pounds of force per unit of implement size. By dividing implement draft into tractor pulling capacity the maximum size of implement a tractor could accomodate was determined, given the assumptions of tractor speed, soil, and depth.

Once maximum implement size was determined for each tractor, tractor-implement combinations were developed. When possible, each tractor was assigned two implement sizes for the field operations it could perform. In some cases only one implement size could be pulled by a specific tractor so only that one size was assigned to the tractor. In other cases a specific size of implement was used with more than one tractor. The end result of these tractor-implement combinations was a broad range of tractor and implement sizes representative of those used by South Dakota farmers.

## Programming Algorithm Used

The mathematical programming technique known as mixed-integer linear programming(MILP) was used in this study.

Formally, linear programming is a planning method used in decisions requiring a choice among a large number of alternatives(8). Linear programming selects the most profitable or least cost combination of alternatives given the restrictions placed on the model. However, LP solutions are only as good as the coefficients and assumptions used in the model. If unrealistic values are incorporated into the model, then unrealistic or nonsense results will be obtained. Careful consideration of all coefficients and assumptions, closely resembling actual or expected happenings, will result in solutions that farmers or others can put faith in and take the appropriate steps to achieve those results.

Machinery selection models are most realistic if tractors and implements selected cannot come into the solution in fractional units. The model was designed to use mixed-integer linear programming so tractors and other machinery would enter the solution in whole number values. Using the mixed-integer approach also meant that annualized costs would enter the model in their entirety and not fractions, like they would in the LP approach.

The mixed-integer LP algorithm was used to maximize profits of the farm. The profit function(a) represents gross returns less all fixed and variable costs. Fixed costs were annualized for use in this model. This profit function was subject to various constraints; matching tractors to implements(b), restricting total hours of labor per month(c), restricting maximum hours of tractor use per month(d), restricting implement hours of use(e), restricting each crop's acreage planted(f), and restricting tractors and implements to integer values(g). Maximizing the profit function results in selection of the least cost machinery complement.

## Model Setup

The basic structure of the machinery selection model and the financial aspects included in the model will be given in this section of the chapter. The model will be described with the aid of a diagram and the coefficients comprising different parts of the model will be explained.

### Stage I--Machinery Selection Model

The rows and columns sections of the model will be described first. Each section will be broken into various subsections and each subsection will be explained.

$$\text{Maximize} \quad R - AC_t - AC_m - VC_{tm} - PC_c \qquad \text{(a)}$$

Subject to:

$$T_t - M_m \leq 0 \qquad \text{(b)}$$

$$L_j \leq H_j \qquad \text{(c)}$$

$$LT_{tj} \leq HT_{tj} \qquad \text{(d)}$$

$$LM_m \leq HM_m \qquad \text{(e)}$$

$$XC_c \leq A_c \qquad \text{(f)}$$

$$T_t, M_m \leq 0,1,2,\text{etc.} \qquad \text{(g)}$$

Where:

$R$ = gross returns from crop sales

$AC_t$ = annualized costs of all tractors selected

$AC_m$ = annualized costs of all implements selected

$VC_{tm}$ = variable costs per acre of all tractor-implement combinations selected

$PC_c$ = crop production costs per acre

$T_t$ = tractor size $t = 1$ to $5$

$M_m$ = implements to be used only with $\text{tractor}_t$

$L_j$ = hours of equipment use in month j

$H_j$ = total hours of equipment use available in month j

$LT_{tj}$ = hours of use for tractor t in month j

$HT_{tj}$ = total hours of use available for tractor t in month j

$LM_m$ = hours of use for implement m during the year

$HM_m$ = total hours of use available for implement m during the year

$XC_c$ = acres planted of crop c

$A_c$ = maximum acres to be planted of crop c

**Rows Section.**

The rows section of this model consisted of the objective function and the constraints imposed on the model. The rows section contained eight general subsections: costs, total hours, tractor hours, implement hours, tractor supplies, field operations, transfer rows, and the profit objective(Figure 5.1).

The costs subsection contained all the costs incurred by the farm in the production of the four crops mentioned earlier. Specifically, annualized ownership costs for tractors and implements, variable costs per acre for tractors and implements, and crop production costs per acre were contained in this subsection. The sum of these costs, along with an interest charge on the production costs making up the operating loan, comprise the total cost computations of the model.

The total hours subsection specified the maximum man hours available to run the farm each month. The monthly figures were for a one man operation supplying 14 hours of labor per day. On the larger acreage farms it was possible that more than one tractor would be needed during a specific month. One man cannot operate more than one tractor at a time so the total hours were linked with labor hiring activities in case someone else was needed to operate another tractor.

The tractor and implement hours subsections constrained the hours of use per month and per year, respectively, that each machine could be used. For example, when a specific tractor entered the solution set in May the tractor could only be used a maximum of 280 hours. If more hours were required to produce the crops another

Figure 5.1 Description of Machinery Selection MILP Matrix
(+,- are sign of coefficient in model)

| Rows \ Colns | Row Type | Tractors | Implements | Tractor-Implement Combinations | Crops | Crop Sales | Labor Hiring |
|---|---|---|---|---|---|---|---|
| Costs | N | (+) Annualized | (+) Annualized | (+) Variable Costs Per Acre | Prodn. Costs | | (+) Per Hour |
| Total Hours | L | | | (+) | | | (-1) |
| Tractor Hours | L | (-) ← | Hours Provided By Machine | (+) ← Machine Hours Per Acre | | | |
| Implement Hours | L | | (-) | (+) | | | |
| Tractor Supplies | L | (-) | (+) | | | | |
| Field Operations | E | | | -1 -1 +1 +1<br>-1 -1 +1 +1<br>-1 -1 +1 +1<br>-1 -1 | (+1) | | |
| Transfer Rows | E | | | | (-) | (+1) | |
| Profit | N | (-) | (-) | (-) | (-) | (+) | (-) |

tractor, of the same or different size, supplying additional hours had to be acquired. The same rationale applied to the implements in the model although implement hours available were generally less than those of tractors.

The tractor supplies subsection constrains the model from selecting more than one implement for a specific field operation to be used with a tractor. For example, when a tractor is selected it supplies plowing capacity. The model can then select one of two sizes of plows to use with the tractor, not both sizes. This constraint prevents the model from selecting two plows to be used with a particular tractor at the same time. This same rationale applies to all field operations performed by the tractor; plow, chisel, disk, harrow, plant, drill, cultivate, and bale.

Field operations(plow,chisel,disk,harrow,plant,drill,cultivate, swather, baler,and combine) were included in the sixth subsection of the model. The model was set up so that the completion of one field operation led to the next field operation in the logical sequence of activities needed to produce specific crops. The field operation rows were linked with the appropriate tractor-implement combinations so the required machinery for each field operation performed would be selected. The field operation rows were also dependent on the acreage of each crop so that the variable costs per acre, of implements unique to a specific crop, were calculated only for its acreage planted, not total farm acreage.

The final two subsections related to transfer rows and the objective of profit maximization. Transfer rows for each crop produced were used to link crop production and sales activities. The field operation rows were essentially transfer rows too since they transferred one acre of plowed land to one acre of disked land, etc. The profit row was similar to the total cost row except that returns from crop sales were included in it. Therefore, maximizing profit accounted for all costs and returns expected on the cash grain farm.

**Columns Section.**

The columns section of the model contained all the activities under consideration. The activities could be separated into six basic categories: tractors, implements, tractor-implement combinations, crop production, crop sales, and labor hiring(Figure 5.1). The tractor, implement, and tractor-implement activities were all linked by machine hours per acre coefficients. This was done so that tractors would be matched only with implements they could pull and the appropriate annualized and variable cost would be matched accordingly for use in the profit maximization procedure. In other words, when a specific tractor was chosen the model was limited to certain sizes of implements to use with that tractor. These tractor and implement activities enter the model as integer units. However, the tractor-implement combination activities contain per acre variable machine costs which are multiplied by the appropriate number of acres. Therefore, one unit of a tractor-implement activity is required for each acre of crop produced.

Crop production and sales activities were included in the profit function and determined how many acres tractors and implements would be used on. In fact, the crop activities determined the acreage of each field operation and the model selected machinery partly based on these constraints. The number of acres tractors and implements would be used for each field operation affected the total variable costs included in the total profit amount because some field operations have higher variable costs per acre than other field operations. So the crop activities included in the model affect profits in more ways than just entering the model as crop production costs per acre.

The labor hiring activities were included in case more man power was needed during any month, as was explained in the total hour rows section. The labor hiring activities could be used to hire all the labor required by the model. If the farm manager/operator set a price his/her labor and hired labor were worth, a better documentation of labor costs for the entire year could be obtained.

Overall there were 182 activities and 208 constraints in the model.

### Stage II--Inclusion of Financial Aspects

To analyze the impact of finance terms on tractor and implement combinations this study incorporated the concept of annualized costs. Annualized costs were calculated using capital budgeting procedures for analyzing investments. The concept of annualized cost is analogous to the average annual cost of owning an asset over its useful life with the exception that annualized costs also account for the time value of money. Annualized costs were calculated for purchase, lease, and other fixed ownership costs such as depreciation. Since this study was based on a single period model, using annualized costs was the only way to ensure realistic results. If a multiperiod model had been developed, the varying yearly costs of owning machinery could have been used.

The model was first solved for the situation in which all machinery was owned by the farmer. The annualized costs were made up of depreciation, interest, insurance, and housing. The appropriate data were obtained from Allen's machine costs publication(3). In the publication Allen had calculated annual depreciation using the straight-line method. Costs per hour for interest, insurance, and housing combined and the annual hours of use per implement were given. Adding the depreciation, interest, insurance, and housing costs produced the annual costs of ownership. However, the annualized costs were not calculated with capital budgeting procedures, as was done with the purchase and lease annualized costs, and as a result these annualized costs were not discounted by the farm's after-tax rate of return. The solutions obtained from these runs were used as the basis for comparison to other solutions. Other model runs would change only the annualized ownership costs and would leave machinery variable costs, other production costs, and all other coefficients unchanged.

The other solutions incorporated survey data on the financial terms of purchase and lease agreements in eastern South Dakota. Using current figures for interest rates, payment factors, agreement length, downpayment amount, etc., new annualized costs were calculated. The annualized costs for acquiring machinery by purchase were calculated on the AGNET computer system based in Lincoln, Nebraska. The AGNET system contains many computer packages related to agriculture that farmers can use on their home computers via telephone hookup. The specific program used to calculate these annualized costs was the BUYORLEASE program in the FINANCE package. The BUYORLEASE program used capital budgeting techniques to calculate the annualized costs(see appendix C). The program saved a great deal of time calculating the costs, versus calculating them by long hand.

The annualized costs for machinery acquisition by leasing were calculated on a program written for this project by Randy Van Beek and this author. The equations which the program is based on are shown in appendix C.

The specific finance terms of the purchase and lease agreements and the equations used in the calculations are shown in appendix C. The annualized costs for purchase and lease agreements were felt to better depict the actual farm costs of farmers who do not hold machinery until it is worthless, but trade or upgrade every few years. The annualized costs calculated from Allen's publication(3) were used strictly as a base model for comparison with the purchase and lease models and are also shown in appendix C. Based on these assumptions three models were built to examine the impact of finance terms on the size of tractor and implement combinations. Each of the four farm sizes will be run for the base, purchase, and lease models, so a total of 12 model runs will be undertaken. The results of these runs will indicate whether purchasing or leasing machinery will lead to more profits for the farm and whether the optimum machinery complement will change depending on how machinery is acquired.

# MODEL RESULTS

Results of the mixed integer linear programming(MILP) model runs will be interpreted in this chapter. The specific machinery complements selected for each farm size will be reported. A sample model solution and interpretation for the 1600 acre farm are provided in appendix D. The effect that differing financial arrangements have on the results and the effectiveness of the model as a decision making tool will be explored. Finally, weaknesses of the model will be pointed out and recommendations for further research will be made.

## 200 and 400 Acre Farms

The model results for the 200 and 400 acre farms were not those expected. The base, lease, and purchase models all selected the same machinery complements for the respective farms but the size of machines in the complements were not consistent with what was anticipated for those particular farm sizes.

Table 6.1 contains the complements selected and the number of acres each implement was used on for the 200 and 400 acre farms. The implements selected by the model are given in the first column. The slash with a number following it indicates which tractor the implement was used with. Under the acres columns the slash between numbers means the implement was used on two different occasions. The table shows a

100 HP tractor and the smallest implements that could be used with the 100 HP tractor were selected for the 200 acre farm. However, the model selected a smaller 80 HP tractor and the appropriate sizes of implements for the 400 acre farm. Since the 200 and 400 acre farms are relatively small, the selection of one tractor to fulfill all operational requirements was not suprising, and in fact was expected. Selection of the smaller horsepower tractors was anticipated but the exact model results were opposite of what was expected, namely, that the 80 HP and 100 HP tractors be used with the 200 and 400 acre farms, respectively.

Additional checking of the program printouts revealed that the 200 acre farm results were not optimal integer solutions, like the results for the 400 acre farm, but were best integer solutions. Further study of the mixed integer programming manual(23) provided an explanation for this occurrence and possible actions to correct it. The manual stated that best integer solutions result when two integer solutions are very close in value and therefore the program cannot specify the optimal solution. After several attempts to correct the problem the same results were obtained.

## 800 Acre Farm

The results for the 800 acre farm are given in Table 6.2. The base, lease, and purchase models selected identical machinery complements for the farm. The three models selected two tractors, an 80 HP and 125 HP, and specific implements to be used with the tractors. The process the model employed to select the complements and an example will be explained below.

Table 6.1 Results for 200 and 400 Acre Farms

| Selected | Basis 200 Units | Basis 200 Acres | Lease 200 Units | Lease 200 Acres | Purchase 200 Units | Purchase 200 Acres | Basis 400 Units | Basis 400 Acres | Lease 400 Units | Lease 400 Acres | Purchase 400 Units | Purchase 400 Acres |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 HP Tractor | | | | | | | 1.0 | | 1.0 | | 1.0 | |
| 100 HP Tractor | 1.0 | | 1.0 | | 1.0 | | | | | | | |
| Plow 5-16/80 | | | | | | | 1.0 | 340 | 1.0 | 340 | 1.0 | 340 |
| Plow 6-16/100 | 1.0 | 170 | 1.0 | 170 | 1.0 | 170 | | | | | | |
| Chisel 8 ft/80 | | | | | | | 1.0 | 60 | 1.0 | 60 | 1.0 | 60 |
| Chisel 9 ft/100 | 1.0 | 30 | 1.0 | 30 | 1.0 | 30 | | | | | | |
| Disk 10 ft/80 | | | | | | | 1.0 | 400 | 1.0 | 400 | 1.0 | 400 |
| Disk 10 ft/100 | 1.0 | 200 | 1.0 | 200 | 1.0 | 200 | | | | | | |
| Harrow 24 ft/80 | | | | | | | 1.0 | 400 | 1.0 | 400 | 1.0 | 400 |
| Harrow 30 ft/100 | 1.0 | 200 | 1.0 | 200 | 1.0 | 200 | | | | | | |
| Drill 10 ft/80 | | | | | | | 1.0 | 100 | 1.0 | 100 | 1.0 | 100 |
| Drill 10 ft/100 | 1.0 | 50 | 1.0 | 50 | 1.0 | 50 | | | | | | |
| Planter 4 row/80 | | | | | | | 1.0 | 300 | 1.0 | 300 | 1.0 | 300 |
| Planter 4 row/100 | 1.0 | 150 | 1.0 | 150 | 1.0 | 150 | | | | | | |
| Cultivator 4 row/80 | | | | | | | 1.0 | 300 | 1.0 | 300 | 1.0 | 300 |
| Cultivator 4 row/100 | 1.0 | 150 | 1.0 | 150 | 1.0 | 150 | | | | | | |
| Swather 16 ft | | | | | | | 1.0 | 40/60 | 1.0 | 40/60 | 1.0 | 40/60 |
| Swather 21 ft | 1.0 | 20/30 | 1.0 | 20/30 | 1.0 | 20/30 | | | | | | |
| Baler Small/80 | | | | | | | 1.0 | 40 | 1.0 | 40 | 1.0 | 40 |
| Baler Medium/100 | 1.0 | 20 | 1.0 | 20 | 1.0 | 20 | | | | | | |
| Combine 13 ft | 1.0 | 90/90 | 1.0 | 90/90 | 1.0 | 90/90 | 1.0 | 180/180 | 1.0 | 180/180 | 1.0 | 180/180 |
| Profit | -6676.63 | | -11550.09 | | -8885.96 | | 18218.12 | | 14064.96 | | 16346.82 | |
| Annualized Machine Costs | 27160.16 | | 32033.62 | | 29369.49 | | 23331.34 | | 27484.50 | | 25202.64 | |

The model worked backwards through the matrix and selected machinery complements based primarily on hours of use. This process was particularly important with the larger farms. In this study the model first considered the combine activities. Stage one consisted of studying annualized and variable costs for all combine activities and selecting the least cost combine. Stage two involved multiplying the machine hours per acre for the combine by the number of acres to be combined. If the calculated hours of use exceeded the total hours of available use per year for the combine, a different sized combine not exceeding hours of available use was chosen. If hours of available use was not exceeded then the original least cost combine was kept in the solution and the model proceeded to the next operation. The exact order was bale, swath, cultivate, plant, drill, harrow, disk, chisel, and plow.

The matrix structure of the MILP model resulted in a tractor-baler activity selected first. For example, the model could have selected an 80 HP tractor-small baler combination. This 80 HP tractor was kept in solution and the model proceeded to the next tractor-implement activity, which was cultivation, and selected the least cost implement to use with this 80 HP tractor. If the model could not find a specific 80 HP tractor-cultivator combination that satisfied the hours of available use constraint, it selected a new tractor-cultivator combination, possibly a 100 HP tractor-6 row combination. If no one tractor-cultivator combination satisfied the hours of available use constraint, the model selected another tractor-cultivator combination to go with the least cost 80 HP-cultivator activity and divided acres cultivated between them to satisfy the hours constraint. The model then had two tractors to use individually or in combination for all remaining field operations. In this study two tractors have been sufficient to satisfy all hours of available use constraints in a particular field operation.

The process described above was used in the plant and disk field operations for the 800 acre farm. The model selected an 8 row planter pulled by a 125 HP tractor so that the 60 hours of planting use per year constraint was not violated. Then in the disk operation acres were divided between two tractor-implement combinations so that the 100 hours of available use per disk was not exceeded.

Although two tractors being selected for an 800 acre farm was anticipated, the exact usage of the tractors was not. It was expected that the larger tractor would be used for heavy field operations such as tillage and the smaller tractor used for lighter operations like baling. However, profit maximization was the objective in this study and the models selected specific combinations based on that criterion.

### 1600 Acre Farm

Once again all three models selected identical machinery complements because all annualized costs were proportionately about the same. However, the machinery complements selected for the 1600 acre farm were closer to what was anticipated(Table 6.2). Two medium sized tractors, a 125 HP and 165 HP, were selected and they were used more

## Table 6.2 Results for 800 and 1600 Acre Farms

| Selected | Basis 800 | | Lease 800 | | Purchase 800 | | Basis 1600 | | Lease 1600 | | Purchase 1600 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Units | Acres | Units | Acres | Units | Acres | Units | Acres | Units | Acres | Units | Acres |
| 80 HP Tractor | 1.0 | | 1.0 | | 1.0 | | | | | | | |
| 125 HP Tractor | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | |
| 165 HP Tractor | | | | | | | 1.0 | | 1.0 | | 1.0 | |
| Plow 5-16/80 | 1.0 | 680 | 1.0 | 680 | 1.0 | 680 | | | | | | |
| Plow 10-18/165 | | | | | | | 1.0 | 1360 | 1.0 | 1360 | 1.0 | 1360 |
| Chisel 8 ft/80 | 1.0 | 120 | 1.0 | 120 | 1.0 | 120 | | | | | | |
| Chisel 10 ft/125 | | | | | | | 1.0 | 240 | 1.0 | 240 | 1.0 | 240 |
| Disk 10 ft/80 | 1.0 | 483 | 1.0 | 483 | 1.0 | 483 | | | | | | |
| Disk 12 ft/125 | 1.0 | 317 | 1.0 | 317 | 1.0 | 317 | | | | | | |
| Disk 15 ft/125 | | | | | | | 1.0 | 683 | 1.0 | 683 | 1.0 | 683 |
| Disk 19 ft/165 | | | | | | | 1.0 | 917 | 1.0 | 917 | 1.0 | 917 |
| Harrow 24 ft/80 | 1.0 | 800 | 1.0 | 800 | 1.0 | 800 | | | | | | |
| Harrow 66 ft/165 | | | | | | | 1.0 | 1600 | 1.0 | 1600 | 1.0 | 1600 |
| Drill 10 ft/80 | 1.0 | 200 | 1.0 | 200 | 1.0 | 200 | | | | | | |
| Drill 20 ft/125 | | | | | | | 1.0 | 400 | 1.0 | 400 | 1.0 | 400 |
| Planter 8 row/125 | 1.0 | 600 | 1.0 | 600 | 1.0 | 600 | 1.0 | 625 | 1.0 | 625 | 1.0 | 625 |
| Planter 8 row/165 | | | | | | | 1.0 | 575 | 1.0 | 575 | 1.0 | 575 |
| Cultivator 6 row/80 | 1.0 | 600 | 1.0 | 600 | 1.0 | 600 | | | | | | |
| Cultivator 12 row/165 | | | | | | | 1.0 | 1200 | 1.0 | 1200 | 1.0 | 1200 |
| Swather 16 ft | 1.0 | 80/120 | 1.0 | 80/120 | 1.0 | 80/120 | 1.0 | 160/240 | 1.0 | 160/240 | 1.0 | 160/240 |
| Baler Small/80 | 1.0 | 80 | 1.0 | 80 | 1.0 | 80 | | | | | | |
| Baler Big/125 | | | | | | | 1.0 | 160 | 1.0 | 160 | 1.0 | 160 |
| Combine 13 ft | 1.0 | 360/360 | 1.0 | 360/360 | 1.0 | 360/360 | | | | | | |
| Combine 20 ft | | | | | | | 1.0 | 720/720 | 1.0 | 720/720 | 1.0 | 720/720 |
| Profit | 52713.61 | | 46866.65 | | 49888.32 | | 124668.03 | | 116215.29 | | 120617.42 | |
| Annualized Machine Costs | 30580.69 | | 36427.65 | | 33405.98 | | 44606.76 | | 53059.50 | | 48657.37 | |

according to actual farm practices. The larger 165 HP tractor was used for the majority of the tillage work and the 125 HP tractor handled lighter work such as drilling and baling.

The method of selecting these complements was the same as explained earlier. The disk and plant operations both divided acres between the two tractors because of the hours of available use constraints.

## Overall Results--All Farms

The selection of swathers and combines was relatively unchanged for all farm sizes. Except for the 200 acre farm, which had a best solution, all the models selected the 16 foot swather. There was no reason to select a larger, more expensive swather since the 75 hours of available use per year was never exceeded. The same rationale applies to the combine, where a combine with a 13 foot head was selected for all farms except the 1600 acre farm. In the case of the 1600 acre farm the 13 foot combine could no longer complete all the combining in the 180 hours of available use per year. Therefore a larger combine requiring less time to complete the job had to be selected.

When combines and tractor-implement combinations, other than the least cost combination were chosen for a field operation, the models were accounting for timeliness considerations. By specifying an hours of available use per year for each implement in a particular field operation the author tried to minimize the time in which that particular field operation was completed. In some instances the models had to select two implements in order to minimize the time required to complete a particular field operation. Situations such as this were more common with the 800 and 1600 acre farms.

The MILP solutions for tractor-implement combinations for 200 acre and 800 acre farms were not expected. The size of tractor used for specific operations was not what actually happens. Small tractors doing the heavy field work is not usual practice. However, as explained earlier the 400 acre and 1600 acre farm did approximate actual practice in tractor usage.

The profit figures of the base, lease, and purchase models for each farm are as expected. The base model had the lowest annualized costs and thus should have the largest profit. The lease model had the highest annualized costs and the lowest profit. Profit in this study equals crop revenues minus annualized machine costs, variable machine costs, and crop production costs.

## Effect of Financial Arrangements

Based on study results differing financial arrangements had no effect on the selection of the optimal machinery complement. The three models(base,lease,and purchase) selected identical machinery complements, dependent on farm size.

A reason for financial arrangements having no effect on complement selection is the annualized costs for the three models were proportionately about the same. This suggests that the finance terms of the credit-purchase and lease agreements are relatively competitive.

The difference in finance terms was not significant enough to affect machinery complement selection. Instead, machinery complements in this study are primarily influenced by time considerations such as machine hours per acre and the hours of expected implement use per year. This suggests that farmers should select implements based on their time constraints for field operations and a machine's capacity to do work. Once implements have been selected then the farmer can examine least cost financing terms and decide what best meets their financial needs and situation.

Financial arrangements did have an impact on the final profit amount. The model with the lowest annualized costs, of the three models, would naturally produce the largest profit.

## The Model as a Decision Making Tool

The model presented in this study can be an aid in machinery investment decisions. It has already been shown how this model can select a machinery complement for a hypothetical farm. The model contains the basic components of annualized machine costs, variable machine costs, production costs, and crop returns. These components, together with the provisions for timeliness of operations, produce a model that is capable of aiding in many machinery related decisions.

The model built in this study can select the entire machinery complement for a farm. Tractors and the least cost implements to use with each tractor are selected, given the time constraints. Many of the previous models only selected from tractors that had fixed implement complements associated with them. In addition this model selects implements for all machine operations from field preparation to final crop harvest. The model is built so that any number of field operations can be considered.

This model also allocates the number of acres each implement should be used on in order to maximize profit. For instances where a farm has more than one tractor-implement combination to use for a particular field operation, this model can be extremely valuable in selecting the least cost combination. The model will reveal whether one or both combinations are needed to complete the job in the least cost way. But it must be kept in mind that the model results are only as realistic as the coefficients used in the model.

Whether the model, in this present state, can be used by the average farmer is questionable. Presently the matrix is very complex and requires the rather costly MILP solution technique. This technique is not readily available for the micro-computers normally used by farmers. Later simplification could make the model useable for farmers.

## Weaknesses of the Model and Possible Corrections

There are several areas in which the model could be improved. These areas will be discussed and possible corrections will be suggested.

A major weakness of this model is the inability to allocate field work by degree of difficulty. In the larger acreage farms field operations requiring more power, such as tillage, should be allocated to larger tractors. The model's inability to allocate field work in this way suggests the variable cost per acre coefficients for tractor-implement combinations may be in error. The relative costs of tractor-implement combinations should reflect the fact that larger tractor-implement combinations can perform a task quicker and at lower cost. Recalculation of variable cost coefficients to account for this situation may be needed.

A second major weakness involves time constraints. The current model has a specific number of hours of available use per year. If one implement supplying 100 hours of available use cannot complete all the acres of a particular field operation, due to its exceeding the hours of available use constraint, a second implement is selected to help complete the field operation. But each implement supplies 100 hours of available use, or 200 hours total. If the farmer feels all field work for that operation must be completed in 100 hours and both implements together require 130 hours, completion of the field operation will still take too long. In a month when many field operations are to be completed, some operations get delayed and timeliness is not achieved. In order to correct this weakness in the model it is suggested that a single time constraint for each field operation be imposed. Implements would no longer supply hours of available use but would use from the maximum time constraint. Then no matter how many implements the model selects to complete a field operation, the time constraint set by the farmer could not be exceeded. The model could still select complements based on machine hours per acre and least cost.

The third weakness of the model is that it is a single period model. Once the machinery complement has been selected, the use of transfers from one year to the next could be used to study the effect of different financial arrangements on farm profitabiltiy. In a multi-period model such as this leasing could very well prove to be the least cost method of acquiring machinery.

### Recommendations for Model Improvement

The model is presently setup so that additional tractors, implements, and revenue sources can be added easily. Expansion to include additional field operations would also be quite easy. For further research on this machinery selection model the weaknesses discussed earlier must be corrected. The timeliness, allocation of field work by degree of difficulty, and option of a multi-period model should be accomplished. These changes should produce a more reliable machinery complement selection model that can be used to aid farmers in investment decisions.

## SUMMARY AND CONCLUSIONS

Machinery is a major component of a modern farm operation. Machinery is important for performing the physical tasks of producing a crop and machinery is an important part of the financial structure of the farm. Machinery represents about 40 percent of non-real estate assets and over 50 percent of total production expenses in the United States farm economy. If machinery prices continue to increase faster than other production items, machinery could account for an even greater proportion of farm assets.

The method of financing machinery will affect the financial structure of the farm too. The financial terms of a lease or credit-purchase agreement will undoubtedly have an impact on the financial condition of the farm. When tax treatments such as ACRS and ITC are considered, along with machinery financing alternatives, the opportunity for substantial benefits for the farm business exists. In today's farm economy careful planning of machinery investment decisions can be the difference between success or failure of the farm operation.

Therefore, the overall objective of this study was to develop a machinery selection and financing model to assist farmers in southeastern South Dakota with these types of decisions. The specific objectives are:

1. To determine optimum machinery complements for farms of different size and crop enterprise combinations.
2. To examine the impact of alternative financing, acquisition, and tax strategies on least cost machinery complement decisions.

Achievement of the objectives of this study involved the completion of several steps. The calculation of all required model coefficients and a survey of implement dealers and bankers in eastern South Dakota was completed. Based on survey results annualized costs for lease and credit-purchase agreements were calculated using capital budgeting procedures. The annualized costs were incorporated into mixed-integer linear programming(MILP) models and profit maximization criteria was used to select the least cost machinery complements.

## Farm Machinery in the U.S.

As net farm incomes have fallen farm machinery sales have declined. Manufacturers were slow to react to the decline and faced growing machinery inventories. Plant cutbacks and sales promotions by manufacturer dealers such as interest-free periods, discounts, and rebates have been used to reduce inventories. In addition, changes in federal tax laws have allowed those who replace equipment to receive a greater tax reduction. The effect of the ITC and five year write-off period has been to lower the after-tax cost of owning farm machinery. The combined effects of these changes has been to facilitate machinery purchases.

The two main machinery financing alternatives are credit-purchase and lease. A survey of 65 implement dealers and 65 banks located in eastern South Dakota was conducted to obtain current information on farm machinery credit-purchase and financial lease agreements. Results of the survey indicate that leasing, while becoming more popular, is not used extensively in eastern South Dakota. The survey also revealed that the financial terms of the two agreements were very competitive with each other as well as between dealers and banks. Farmers and dealer lack of familiarity with leasing was one of the major reasons cited for low use.

## Machinery Selection Model

The model built in this study used MILP. Tractor-implement combinations were selected on a least cost basis dependent on various constraints; matching tractors to implements, restricting total hours of labor per month, restricting tractor and implement hours of use per month and per year respectively, and restricting acres planted.

Results for the 200 and 400 acre farms were just opposite of what was expected. The selection of a 100 HP tractor to be used on a 200 acre farm and an 80 HP tractor for the 400 acre farm was counter to any expectations or actual practices. However, machinery selections for the 800 and 1600 acre farms were similar to expectations but usage was different than actual practices. Particularly on the 800 acre farm the smaller of the two tractors selected did the majority of the heavier field work, such as tillage. On the 1600 acre farm the usage was more like actual practices with the larger tractor doing most of the tillage operations.

The results of all model runs indicated that machinery complements in this model were selected primarily based on timeliness considerations. Except for the smaller farms where least cost was the criterion used, the model selected machinery complements for larger farms based on hours of available implement use per year and machine hours per acre.

One of the strengths of this model is that it selects entire machinery complements and not just tractors with fixed complements associated with them. The model can also select complements for a wide range of field operations and allocate the number of acres each implement should be used on in order to maximize profit.

The weaknesses of the model have to do with the inability to allocate field work by degree of difficulty, the failure to fully account for timeliness of operations, and not being a multi-period model. Correction of these weaknesses should produce a valuable machinery investment decision aid.

## Recommendations for Further Research

After considering the results from this study and others, there are two suggestions for further research in the area of complement selection models.

The fact that the financial arrangements considered in this study had no effect on selection of the optimal machinery complements suggests that attention should be directed away from strictly building complement selection models. Perhaps researchers should turn their attention more toward studying the different variations of machinery financing alternatives and how they will affect farm profitability. In other words select a machinery complement based on the physical constraints deemed important by the farmer and proceed to analyze the impact that least cost financing alternatives have on farm profitability.

As the agricultural finance sector of the economy continues to change, so too will the terms and conditions of machinery finance agreements. In the last few years lease agreements have started to receive more recognition and use. These agreements have become more popular and many different variations of the lease agreement have developed. There are also different variations of credit-purchase agreements, depending on who the farmer does business with. What is needed is additional study examining how machinery acquisition under variations of these two agreements will affect farm profitability.

This type of study could be carried out for the situation in which a young farmer is just starting out and all machinery has an acquisition cost. The same analogy would also apply to the situation where a new piece of equipment is added to the complement or replaces an old piece of equipment. In either case the effect that the particular finance terms of an agreement have on farm profitability could be studied.

The second recommendation for further research deals with model simplification. The primary purpose of most models of this type is to provide a tool that will assist farmers in machinery related decisions. Since these models now select the proper complements to minimize cost and maximize farm profit, this suggests that it is time to make them usable by the farmer.

Perhaps the time has come to examine machinery selection models and try to simplify them to the extension level for practical use by farmers. This would entail reprogramming the models so that they are micro-computer adaptable. Providing a model that can be used on a farmers or anyone elses micro-computer means the ultimate goal of these models would be fulfilled. Farmers and other interested people could actually use these models to aid them in their farm operations.

The research on improving machinery selection models would continue and the farmer would finally have his/her decision making tool.

## Appendix A

## SAMPLE QUESTIONNAIRE

Dear Sir:

My name is Todd Lone and I am a research assistant in the Economics Department at SDSU. I am working with Prof. Herb Allen and Larry Janssen on a study of farm machinery selection and financing in eastern South Dakota. An important part of this study deals with the financial alternatives available to the farmer who intends to purchase or lease machinery. Since it is our intention to include the most up-to-date information we would appreciate your cooperation in filling out the attached questionnaire.

Information on farm machinery financing alternatives available in eastern South Dakota is valuable to bankers and farmers. Farmers can use this information to make better decisions on which financing alternative is best for them. Bankers can obtain added information on finance alternatives which can be used to better serve their customers.

Individual responses to all questions will be kept confidential. All information obtained will assist Economics Department staff in research and education programs. Summary information from the questionnaires returned will be published and copies will be available to interested parties.

If you have any questions concerning this study please contact Todd Lone or Dr. Larry Janssen, Department of Economics, South Dakota State University, (688-4141).

Sincerely,

Todd Lone

Todd Lone
Graduate Research Assistant

For the purposes of this questionnaire the following definitions apply.

Credit finance implies loans originated by your bank to customers purchasing new or used farm machinery or equipment.

Financial leasing implies a contract between the bank or a leasing company and the customer in which the customer agrees to specific financial terms in return for the use of a piece of machinery or equipment. This term does not apply to custom hire agreements or operating leases of one year or less.

---

1. Do your agricultural customers have the option to acquire equipment on a lease basis from your bank? Yes ___ No ___

2. Approximately what percentage of your agricultural customers set up the following machinery financing agreements?

   Credit finance agreements ____%
   Financial lease agreements ____%
   100 %

3. Approximately what percentage of your total agricultural loan volume do the following agreements account for?

   Machinery credit finance agreements ____%
   Machinery financial lease agreements ____%

4. In your opinion, during the past 5 years have financial lease agreements become more popular for your agricultural customers? Yes ___ No ___

   Why or why not?

5. Do you feel farmers and bankers need to be better informed about the benefits and costs of leasing? Yes ___ No ___

   Why or why not?

Credit finance agreement

1. On a credit finance agreement do you offer either of the following?

   Deferred first payment Yes ___ No ___
   Interest-waiver period Yes ___ No ___

   If yes, please comment on the details:

2. Currently, what are the typical provisions of your bank's credit finance agreement for farmers purchasing the following items? (Answer only for items for which you make loans)

| | Tractors | Tillage Equipment | Harvesting Equipment | Irrigation Equipment |
|---|---|---|---|---|
| Downpayment percentage of purchase price | ____% | ____% | ____% | ____% |
| Length of loan (months/years) | ____ | ____ | ____ | ____ |
| Total number of payments | ____ | ____ | ____ | ____ |
| Annual percentage rate of interest | ____% | ____% | ____% | ____% |

3. In the credit finance agreement is the annual interest rate fixed or variable for the life of the agreement? Fixed ( ) Variable ( )

   If both, please explain:

4. If the annual interest rate is variable:
   then how often can it change? ______________________

   Is there a limit on the percentage amount the interest rate can change?
   Yes ___ No ___ If yes, how much? ______________________

Financial lease agreements (Answer only those questions that apply)

1. What are the major provisions of your financial lease agreements?

   Company(ies) writing/sponsoring the lease ____________
   ____________
   ____________

   First payment is
   (Please check one) ( ) made at time of agreement
   ( ) deferred until ________

2. Does the option exist for the farm equipment to be purchased by the customer at the end of the lease? Yes ___ No ___

   If yes, is the purchase price a fixed percentage of the original cost?
   Yes ___ No ___ If yes, specify the fixed percentage. ____%

   If the purchase price is not a fixed percentage of the original cost, how is the purchase price obtained? Please explain:

3. For the following machinery and equipment:

| | Tractors | Tillage Equipment | Harvesting Equipment | Irrigation Equipment |
|---|---|---|---|---|
| What percentage of the original cost (purchase price) is the first lease payment? | ____% | ____% | ____% | ____% |
| What is the percent payment factor (% of purchase price) for the remaining lease payments? | ____% | ____% | ____% | ____% |
| Length of the agreement (months/years) | ____ | ____ | ____ | ____ |
| Payments are made (Please check) | | | | |
| monthly | ____ | ____ | ____ | ____ |
| quarterly | ____ | ____ | ____ | ____ |
| semiannually | ____ | ____ | ____ | ____ |
| annually | ____ | ____ | ____ | ____ |
| What, if any, is the minimum dollar value before a lease can be written? | ____ | ____ | ____ | ____ |

4. Is the lease payment factor fixed over the life of the agreement? Yes ___ No ___

   If no, please explain:

5. Who receives the benefit of the investment credit?

   ( ) Leasing company
   ( ) Customer

   Comment:

6. Who is responsible for payment of the following? (Check appropriate boxes)

| | Leasing Company | Customer |
|---|---|---|
| Insurance | ( ) | ( ) |
| Taxes | ( ) | ( ) |
| Repairs | ( ) | ( ) |

Comment:

(Start here if your bank offers no lease)

7. Since 1979, what has been the direction and percentage change in customer use of:

| Financial Equipment Leases | | Equipment Credit Finance | |
|---|---|---|---|
| ( ) increase | | ( ) increase | |
| ( ) no change | ____% | ( ) no change | ____% |
| ( ) decrease | | ( ) decrease | |

8. Since 1979, what significant changes (if any) have you seen in the following agreements and why do you feel these changes were significant?

Financial lease agreements: ______________________________
______________________________
______________________________

Why? ______________________________
______________________________

Credit finance agreements: ______________________________
______________________________
______________________________

Why? ______________________________
______________________________

9. What significant changes (if any) do you foresee in the next 5 years for the following agreements and why do you feel they will be significant?

Financial lease agreements: ______________________________
______________________________
______________________________

Why? ______________________________
______________________________

Credit finance agreements: ______________________________
______________________________
______________________________

Why? ______________________________
______________________________

10. Which financial/management records or procedures (if any) are required of your customers before they qualify for the following agreements? (Please check appropriate boxes) A=always S=sometimes N=never

| | Financial Lease Agreement A | Financial Lease Agreement S | Financial Lease Agreement N | Credit Finance Agreement A | Credit Finance Agreement S | Credit Finance Agreement N |
|---|---|---|---|---|---|---|
| Financial statements............... | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) |
| Tax records........................ | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) |
| Cash flow plan..................... | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) |
| Credit references.................. | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) |
| Courthouse record search for judgements, liens, etc......... | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) |
| Past repayment record with repeat customers............... | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) |
| Other (Please comment on)........ | ( ) | ( ) | ( ) | ( ) | ( ) | ( ) |

______________________

General information

Bank name ____________________

Your bank is (Please check one)
( ) branch
( ) independent
( ) other

Your present title/position ____________________

Your years of experience in agricultural financing _____

Approximate percentage of total bank loans to farmers _____%

Total asset size of your bank last year

( ) <$5 million
( ) $5-20 million
( ) $21-50 million
( ) $50+ million

## Appendix B

## CALCULATING TRACTOR-IMPLEMENT COMBINATIONS

Earlier in chapter five reference was made to equations for calculating tractor-implement combinations. The equations for that purpose will be given here. Specifically, equations for calculating tractor pulling capacity and implement draft will be given. An example will be provided for calculating the maximum size of plow a 100 HP tractor can pull.

The equations for calculating tractor pulling capacity are as follows:

Axle Power(AP) = .96 x PTO-HP

Draw Bar Power(DB) = .62 x AP

(.62 is the traction efficiency for tilled soil)

Pull(lbs of force) = {DB x 375}/Speed

The equations for calculating implement drafts are as follows:

Plow--4.93 + {.12 x $(\text{speed})^2$} = DI--draft(lbs of f/inch squared)

DI x square inches of moldboard = draft(lbs of f/moldboard)

Disk--5.5 + {.16 x $(\text{speed})^2$} = DI

DI x depth(inches) x 12(inches) = draft(lbs of f/foot)

Harrow--{30 - 50} = draft(lbs of f/foot)

use 40 lbs of f/foot

Chisel--{40 - 120} = draft(lbs of f/foot/inch of depth)

use 80 lbs of f/foot/inch x depth = draft(lbs of f/foot)

Planter--{250 - 450} = draft(lbs of f/row)

use 350 lbs of f/row

Drill--{30 - 100} = draft(lbs of f/opener)

use 65 lbs of f/opener x 4 inches = draft(lbs of f/foot)

Cultivator--{20 - 40} x depth = draft(lbs of f/foot)

use 30 x depth = draft(lbs of f/foot)

The equations were all used in a similar manner and this example will indicate the calculation for a plow only.

Tractor Pulling Capacity

.96 x 100 PTO-HP = 96 HP of AP

.62 x 96 = 59.5 DB

59.5 x 375/4.5 = 4958 lbs of force

Plow Draft

$4.93 + \{.12 \times (4.5)^2\} = 7.36$ lbs of f/ inch squared

7.36 x (16 inch moldboard x 6 inch depth) = 707 lbs of f/moldboard

Maximum Size Of Plow A 100 HP Tractor Can Pull

4958 lbs of f ÷ 707 lbs of f/moldboard = 7.01 or 7 bottom plow

This 7 bottom figure is not the absolute maximum because the equations are for typical gear usage by farmers. The very low range gears could be used to pull a slightly larger plow. In addition, speed, depth, and soil type will greatly affect these equations.

## Appendix C
## CAPITAL BUDGETING PROCEDURES

The capital budgeting procedures for calculating annualized ownership costs of the credit-purchase, lease, and base models will be given in this appendix. The specific factors used in the equations for the credit-purchase and lease models will also be given.

The credit-purchase agreement was setup for a 5 year period with a 30 percent downpayment and a 15 percent annual interest rate charge. The farmer was assumed to own the equipment for 8 years. Additional assumptions of annual payments, a 12 percent after-tax rate of return, ACRS depreciation, and 22 percent marginal tax bracket were also used. The general equations used to calculate the net present value and annualized ownership costs(excluding variable costs associated with per acre use) are as follows:

$$NPV = \Sigma PV =$$

$$= DP_0 + \{LP_1 - ITC - TS_1 + FC_1\}PVF_{.12,1}$$

$$+ \{LP_i + FC_i - TS_i\}PVF_{.12,i} \quad i = 2to5$$

$$+ \{FC_i - TS_i\}PVF_{.12,i} \quad i = 6to8$$

where:

NPV = net present value

PV = present value

$DP_0$ = downpayment in year 0

ITC = investment tax credit

$PVF_{.12,i}$ = present value factor of 12 percent for $i^{th}$ year

$LP_i$ = loan payment in $i^{th}$ year

$FC_i$ = fixed costs in $i^{th}$ year

$TS_i$ = value of tax shield in $i^{th}$ year(excluding ITC)

where:

$TS_i = \{FC_i + Depreciation_i + Interest_i\} \times MTR \quad i = 1to5$

$TS_i = \{FC_i\} \times MTR \quad i = 6to8$

MTR = marginal tax rate(22% or .22 in this model)

Annualized Cost = NPV x $[.12 \div \{1 - (1.12)^{-8}\}]$

The lease agreement contained the same assumptions pertaining to agreement length, equipment life, after-tax rate of return, ACRS depreciation after equipment is purchased, and marginal tax bracket. Additional assumptions of a .225 payment factor, the lessor keeping the investment credit, and payments made annually at the beginning of each year were also incorporated into the computations. The equations for calculating leasing annualized costs are as follows:

$$NPV = \Sigma PV =$$

$$LP_0 + \{LP_i + FC_i - TS_i\}PVF_{.12,i} \quad i = 1to4$$
$$+ \{LP_5 + FC_5 - TS_5\}PVF_{.12,5}$$
$$+ \{FC_i - TS_i\}PVF_{.12,i} \quad i = 6to8$$

where:

NPV = net present value

PV = present value

$LP_0$ = lease payment in year 0

$PVF_{.12,i}$ = present value factor of 12 percent for $i^{th}$ year

$LP_i$ = lease payment in $i^{th}$ year

$FC_i$ = fixed costs in $i^{th}$ year

$TS_i$ = value of tax shield in $i^{th}$ year

where:

$TS_1 = \{LP_0\} \times MTR$

$TS_i = \{LP_j + FC_j\} \times MTR \quad i = 2to5 \quad j = 1to4$

$TS_i = \{FC_j + Depreciation_j\} \times MTR \quad i = 6to8 \quad j = 6to8$

MTR = marginal tax rate(22% or .22 in this model)

$$\text{Annualized Cost} = NPV \times \left[.12 \div \{1 - (1.12)^{-8}\}\right]$$

The data for calculating annualized costs for the base model were available from Allen's publication(&bibl.). Straight line depreciation was used by Allen and a 10 year equipment life was assumed. The equations for calculating the annualized costs are as follows:

Housing, Insurance, and Interest = HII

HII Costs Per Hour x Implement Hours Of Use Per Year = HII Costs Per Year

Depreciation Per Year + HII Costs Per Year = Annual Cost

As mentioned earlier in chapter 5 these annualized costs were incorporated into separate models to be run for each farm size.

## Appendix D

## ANALYSIS OF A MODEL SOLUTION(1600 ACRE FARM)

This appendix indicates the major points to look at on a model solution, such as the one at the end of this appendix.

Section one of the solution lists the rows of the model and has three columns of particular importance; activity, slack activity, and dual activity. The activity column for the rows section indicates the amount in which a particular constraint or row entered the optimal solution. The slack activity column indicates how much of a rows supply or right hand side(RHS) went unused if one was specified or is simply a mirror of the activity column if no RHS was specified. For example, the JUNLAB row shows 136.88 units(hours) of that RHS was used and 133.12 units(hours) of the RHS went unused.

The dual activity column is also called the shadow price. This column indicates how much the objective function(profit in this model) would increase if one more unit of a resource(row) were brought into the solution. These values traditionally carry a negative sign when the solution is optimal. The negative 4.00 in the dual activity column for MAYLAB means profit will increase 4 dollars if one more unit of MAYLAB is brought into the solution.

The second section of the solution lists all the tractors and implements being considered in the model. The activity, input cost, and reduced cost columns are the important ones here. The activity column indicates the level at which a particular machine entered the optimal solution. The input cost column gives the amount the objective function(profit) will decrease when one unit of a machine enters the solution. The reduced cost column in this solution indicates how much profit would decrease if one more unit of a machine were brought into solution. These values should all be negative for the activities being considered by the model. Only revenue activities with fixed input levels should have positive values. For example, the BUY125 machine entered the solution at 1.0 unit, decreased profit by 6031.06 when it entered, and would subtract 6031.06 from profit if one additional unit entered the solution.

All the rows and columns in the model are listed in one of the two sections.

| NUMBER | ...ROW.. | AT | ...ACTIVITY... | SLACK ACTIVITY | ..LOWER LIMIT. | ..UPPER LIMIT. | .DUAL ACTIVITY |
|---|---|---|---|---|---|---|---|
| 1 | ANNUALTR | BS | 13565.18000 | 13565.18000- | NONE | NONE | . |
| 2 | ANNUALIM | BS | 35092.19000 | 35092.19000- | NONE | NONE | . |
| 3 | IMPVC | BS | 14996.00000 | 14996.00000- | NONE | NONE | . |
| 4 | TRACVC | BS | 9838.27294 | 9838.27294- | NONE | NONE | . |
| 5 | PROOCOST | UL | . | . | NONE | . | .14000- |
| 6 | TOTALC | BS | 194230.58092 | 194230.58092- | NONE | NONE | . |
| 7 | MAYLAB | UL | 280.00000 | . | NONE | 280.00000 | 4.00000- |
| 8 | JUNLAB | BS | 136.88000 | 133.12000 | NONE | 270.00000 | . |
| 9 | JULLAB | BS | 51.68000 | 258.32000 | NONE | 310.00000 | . |
| 10 | AUGLAB | BS | 227.60000 | 82.40000 | NONE | 310.00000 | . |
| 11 | SEPLAB | BS | 208.08000 | 111.92000 | NONE | 320.00000 | . |
| 12 | OCTLAB | BS | 355.68000 | 4.32000 | NONE | 360.00000 | . |
| 13 | MAYL80 | BS | . | . | NONE | . | . |
| 14 | JUNL80 | BS | . | . | NONE | . | . |
| 15 | JULL80 | BS | . | . | NONE | . | . |
| 16 | AUGL80 | BS | . | . | NONE | . | . |
| 17 | SEPL80 | BS | . | . | NONE | . | . |
| 18 | OCTL80 | UL | . | . | NONE | . | 9.70864- |
| 19 | MAYL100 | BS | . | . | NONE | . | . |
| 20 | JUNL100 | BS | . | . | NONE | . | . |
| 21 | JULL100 | BS | . | . | NONE | . | . |
| 22 | AUGL100 | BS | . | . | NONE | . | . |
| 23 | SEPL100 | BS | . | . | NONE | . | . |
| 24 | OCTL100 | BS | . | . | NONE | . | . |
| 25 | MAYL125 | BS | 65.00550- | 65.00550 | NONE | . | . |
| 26 | JUNL125 | BS | 237.20000- | 237.20000 | NONE | . | . |
| 27 | JULL125 | BS | 277.20000- | 277.20000 | NONE | . | . |
| 28 | AUGL125 | BS | 277.20000- | 277.20000 | NONE | . | . |
| 29 | SEPL125 | BS | 259.52000- | 259.52000 | NONE | . | . |
| 30 | OCTL125 | BS | 360.00000- | 360.00000 | NONE | . | . |
| 31 | MAYL165 | BS | 70.40000- | 70.40000 | NONE | . | . |
| 32 | JUNL165 | BS | 184.80000- | 184.80000 | NONE | . | . |
| 33 | JULL165 | BS | 310.00000- | 310.00000 | NONE | . | . |
| 34 | AUGL165 | BS | 310.00000- | 310.00000 | NONE | . | . |
| 35 | SEPL165 | BS | 320.00000- | 320.00000 | NONE | . | . |
| 36 | OCTL165 | BS | 151.92000- | 151.92000 | NONE | . | . |
| 37 | MAYL220 | UL | . | . | NONE | . | .84337- |
| 38 | JUNL220 | BS | . | . | NONE | . | . |
| 39 | JULL220 | BS | . | . | NONE | . | . |
| 40 | AUGL220 | BS | . | . | NONE | . | . |
| 41 | SEPL220 | BS | . | . | NONE | . | . |
| 42 | OCTL220 | BS | . | . | NONE | . | . |
| 43 | 4-16HR | UL | . | . | NONE | . | 5.48421- |
| 44 | 5-16HR | BS | . | . | NONE | . | . |
| 45 | 6-16HR | UL | . | . | NONE | . | 7.30554- |
| 46 | 7-16AHR | UL | . | . | NONE | . | 8.22379- |
| 47 | 7-16BHR | UL | . | . | NONE | . | 8.22379- |
| 48 | 8-16AHR | BS | . | . | NONE | . | . |
| 49 | 8-16BHR | BS | . | . | NONE | . | . |

| NUMBER | ...ROW.. | AT | ...ACTIVITY... | SLACK ACTIVITY | ..LOWER LIMIT. | ..UPPER LIMIT. | .DUAL ACTIVITY |
|---|---|---|---|---|---|---|---|
| 50 | 10-18HR | BS | 31.92000- | 31.92000 | NONE | . | . |
| 51 | 12-18HR | UL | . | . | NONE | . | 14.81671- |
| 52 | 14-18HR | BS | . | . | NONE | . | . |
| 53 | CHS8HR | UL | . | . | NONE | . | 3.03710- |
| 54 | CHS9HR | UL | . | . | NONE | . | 58.92800- |
| 55 | CHS10HR | BS | 39.52000- | 39.52000 | NONE | . | . |
| 56 | CHS12HR | UL | . | . | NONE | . | 4.51560- |
| 57 | CHS15AHR | UL | . | . | NONE | . | 2.08333- |
| 58 | CHS15BHR | BS | . | . | NONE | . | . |
| 59 | CHS17HR | BS | . | . | NONE | . | . |
| 60 | DSK10AHR | BS | . | . | NONE | . | . |
| 61 | DSK10BHR | BS | . | . | NONE | . | . |
| 62 | DSK12AHR | BS | . | . | NONE | . | . |
| 63 | DSK12BHR | BS | . | . | NONE | . | . |
| 64 | DSK15HR | BS | 5.80550- | 5.80550 | NONE | . | . |
| 65 | DSK17HR | BS | . | . | NONE | . | . |
| 66 | DSK19HR | UL | . | . | NONE | . | .78899- |
| 67 | DSK22HR | UL | . | . | NONE | . | 117.36945- |
| 68 | DSK25HR | BS | . | . | NONE | . | . |
| 69 | HAR24HR | BS | . | . | NONE | . | . |
| 70 | HAR30AHR | BS | . | . | NONE | . | . |
| 71 | HAR30BHR | BS | . | . | NONE | . | . |
| 72 | HAR36AHR | BS | . | . | NONE | . | . |
| 73 | HAR36BHR | UL | . | . | NONE | . | 4.96180- |
| 74 | HAR48AHR | UL | . | . | NONE | . | 6.10850- |
| 75 | HAR48BHR | BS | . | . | NONE | . | . |
| 76 | HAR66AHR | BS | 45.60000- | 45.60000 | NONE | . | . |
| 77 | HAR66BHR | UL | . | . | NONE | . | 7.50520- |
| 78 | HAR78HR | UL | . | . | NONE | . | 8.55250- |
| 79 | DRL10AHR | BS | . | . | NONE | . | . |
| 80 | DRL10BHR | BS | . | . | NONE | . | . |
| 81 | DRL20AHR | UL | . | . | NONE | . | 3.35526- |
| 82 | DRL20BHR | UL | . | . | NONE | . | 1.44737- |
| 83 | DRL20CHR | BS | 39.20000- | 39.20000 | NONE | . | . |
| 84 | DRL30AHR | UL | . | . | NONE | . | 7.36634- |
| 85 | DRL30BHR | UL | . | . | NONE | . | 35.66560- |
| 86 | DRL30CHR | BS | . | . | NONE | . | . |
| 87 | DRL40AHR | UL | . | . | NONE | . | 47.17810- |
| 88 | DRL40BHR | UL | . | . | NONE | . | 4.99873- |
| 89 | PLR4AHR | BS | . | . | NONE | . | . |
| 90 | PLR4BHR | UL | . | . | NONE | . | 16.52800- |
| 91 | PLR6AHR | UL | . | . | NONE | . | 1.10937- |
| 92 | PLR6BHR | BS | . | . | NONE | . | . |
| 93 | PLR6CHR | BS | . | . | NONE | . | . |
| 94 | PLR8AHR | UL | . | . | NONE | . | 3.02083- |
| 95 | PLR8BHR | BS | 4.80000- | 4.80000 | NONE | . | . |
| 96 | PLR12AHR | BS | . | . | NONE | . | . |
| 97 | PLR12BHR | UL | . | . | NONE | . | 82.69217- |
| 98 | PLR16HR | UL | . | . | NONE | . | 2.32329- |
| 99 | CUL4AHR | BS | . | . | NONE | . | . |
| 100 | CUL4BHR | BS | . | . | NONE | . | . |

| NUMBER | ...ROW.. | AT | ...ACTIVITY... | SLACK ACTIVITY | ..LOWER LIMIT. | ..UPPER LIMIT. | .DUAL ACTIVITY |
|---|---|---|---|---|---|---|---|
| 101 | CUL6AHR | BS | . | . | NONE | . | . |
| 102 | CUL6BHR | BS | . | . | NONE | . | . |
| 103 | CUL6CHR | BS | . | . | NONE | . | . |
| 104 | CUL8AHR | UL | . | . | NONE | . | 16.61500- |
| 105 | CUL8BHR | BS | . | . | NONE | . | . |
| 106 | CUL12AHR | BS | 14.80000- | 14.80000 | NONE | . | . |
| 107 | CUL12BHR | BS | . | . | NONE | . | . |
| 108 | CUL16HR | UL | . | . | NONE | . | 26.88040- |
| 109 | JUNSW16 | BS | 56.12000- | 56.12000 | NONE | . | . |
| 110 | JULSW16 | BS | 56.12000- | 56.12000 | NONE | . | . |
| 111 | AUGSW16 | BS | 27.80000- | 27.80000 | NONE | . | . |
| 112 | JUNSW18 | UL | . | . | NONE | . | 51.74733- |
| 113 | JULSW18 | BS | . | . | NONE | . | . |
| 114 | AUGSW18 | BS | . | . | NONE | . | . |
| 115 | JUNSW21 | BS | . | . | NONE | . | . |
| 116 | JULSW21 | UL | . | . | NONE | . | 61.45067- |
| 117 | AUGSW21 | BS | . | . | NONE | . | . |
| 118 | JUNBALSM | BS | . | . | NONE | . | . |
| 119 | JULBALSM | BS | . | . | NONE | . | . |
| 120 | AUGBALSM | BS | . | . | NONE | . | . |
| 121 | JUNBLMDA | BS | . | . | NONE | . | . |
| 122 | JULBLMDA | BS | . | . | NONE | . | . |
| 123 | AUGBLMDA | BS | . | . | NONE | . | . |
| 124 | JUNBLMDB | BS | . | . | NONE | . | . |
| 125 | JULBLMDB | BS | . | . | NONE | . | . |
| 126 | AUGBLMDB | UL | . | . | NONE | . | 12.29130- |
| 127 | JUNBLLGA | UL | . | . | NONE | . | 16.07020- |
| 128 | JULBLLGA | BS | . | . | NONE | . | . |
| 129 | AUGBLLGA | BS | . | . | NONE | . | . |
| 130 | JUNBLLGB | BS | . | . | NONE | . | . |
| 131 | JULBLLGB | BS | . | . | NONE | . | . |
| 132 | AUGBLLGB | BS | . | . | NONE | . | . |
| 133 | JUNBALBG | BS | 67.20000- | 67.20000 | NONE | . | . |
| 134 | JULBALBG | BS | 67.20000- | 67.20000 | NONE | . | . |
| 135 | AUGBALBG | BS | 67.20000- | 67.20000 | NONE | . | . |
| 136 | AUGCOM13 | BS | . | . | NONE | . | . |
| 137 | SEPCOM13 | BS | . | . | NONE | . | . |
| 138 | OCTCOM13 | UL | . | . | NONE | . | 61.73206- |
| 139 | AUGCOM20 | BS | 32.40000- | 32.40000 | NONE | . | . |
| 140 | SEPCOM20 | BS | 32.40000- | 32.40000 | NONE | . | . |
| 141 | OCTCOM20 | BS | 32.40000- | 32.40000 | NONE | . | . |
| 142 | AUGCOM27 | UL | . | . | NONE | . | 1.98830- |
| 143 | SEPCOM27 | BS | . | . | NONE | . | . |
| 144 | OCTCOM27 | UL | . | . | NONE | . | 3.24675- |
| 145 | PLOW80 | BS | . | . | NONE | . | . |
| 146 | CHIS80 | BS | . | . | NONE | . | . |
| 147 | DISK80 | BS | . | . | NONE | . | . |
| 148 | HAR80 | BS | . | . | NONE | . | . |
| 149 | DRILL80 | BS | . | . | NONE | . | . |
| 150 | PLANT80 | BS | . | . | NONE | . | . |
| 151 | CULT80 | BS | . | . | NONE | . | . |

| NUMBER | ...ROW.. | AT | ...ACTIVITY... | SLACK ACTIVITY | ..LOWER LIMIT. | ..UPPER LIMIT. | .DUAL ACTIVITY |
|---|---|---|---|---|---|---|---|
| 152 | BALE80 | BS | . | . | NONE | . | . |
| 153 | PLOW100 | BS | . | . | NONE | . | . |
| 154 | CHIS100 | UL | . | . | NONE | . | 5551.48000- |
| 155 | DISK100 | BS | . | . | NONE | . | . |
| 156 | HAR100 | BS | . | . | NONE | . | . |
| 157 | DRILL100 | BS | . | . | NONE | . | . |
| 158 | PLANT100 | BS | . | . | NONE | . | . |
| 159 | CULT100 | BS | . | . | NONE | . | . |
| 160 | BALE100 | BS | . | . | NONE | . | . |
| 161 | PLOW125 | BS | 1.00000- | 1.00000 | NONE | . | . |
| 162 | CHIS125 | BS | . | . | NONE | . | . |
| 163 | DISK125 | BS | . | . | NONE | . | . |
| 164 | HAR125 | BS | 1.00000- | 1.00000 | NONE | . | . |
| 165 | DRILL125 | BS | . | . | NONE | . | . |
| 166 | PLANT125 | BS | . | . | NONE | . | . |
| 167 | CULT125 | BS | 1.00000- | 1.00000 | NONE | . | . |
| 168 | BALE125 | BS | . | . | NONE | . | . |
| 169 | PLOW165 | BS | . | . | NONE | . | . |
| 170 | CHIS165 | BS | 1.00000- | 1.00000 | NONE | . | . |
| 171 | DISK165 | BS | . | . | NONE | . | . |
| 172 | HAR165 | BS | . | . | NONE | . | . |
| 173 | DRILL165 | BS | 1.00000- | 1.00000 | NONE | . | . |
| 174 | PLANT165 | BS | . | . | NONE | . | . |
| 175 | CULT165 | BS | . | . | NONE | . | . |
| 176 | BALE165 | BS | 1.00000- | 1.00000 | NONE | . | . |
| 177 | PLOW220 | BS | . | . | NONE | . | . |
| 178 | CHIS220 | BS | . | . | NONE | . | . |
| 179 | DISK220 | UL | . | . | NONE | . | 9675.32542- |
| 180 | HAR220 | BS | . | . | NONE | . | . |
| 181 | DRILL220 | BS | . | . | NONE | . | . |
| 182 | PLANT220 | BS | . | . | NONE | . | . |
| 183 | CULT220 | BS | . | . | NONE | . | . |
| 184 | BALE220 | BS | . | . | NONE | . | . |
| 185 | PLOWLAND | EQ | . | . | . | . | 5.68000- |
| 186 | CHISLAND | EQ | . | . | . | . | 2.71000- |
| 187 | DISKLAND | EQ | . | . | . | . | 2.22200- |
| 188 | HARWLAND | EQ | . | . | . | . | 2.83800- |
| 189 | DRILLAND | EQ | . | . | . | . | 6.78600- |
| 190 | PLNTLAND | EQ | . | . | . | . | 10.82200- |
| 191 | CULTLAND | EQ | . | . | . | . | 12.07200- |
| 192 | SWHOLAND | EQ | . | . | . | . | 8.75600- |
| 193 | SWHALAND | EQ | . | . | . | . | 12.69600- |
| 194 | BALELAND | EQ | . | . | . | . | 21.10600- |
| 195 | COMBLAND | EQ | . | . | . | . | 16.59200- |
| 196 | CMBLAND | EQ | . | . | . | . | 4.06000- |
| 197 | CROPLAND | BS | 1600.00000 | . | 1600.00000 | 1600.00000 | . |
| 198 | MAYHIR | BS | 144.59450 | 135.40550 | NONE | 280.00000 | . |
| 199 | JUNHIR | BS | . | 270.00000 | NONE | 270.00000 | . |
| 200 | JULHIR | BS | . | 310.00000 | NONE | 310.00000 | . |
| 201 | AUGHIR | BS | . | 310.00000 | NONE | 310.00000 | . |
| 202 | SEPHIR | BS | . | 320.00000 | NONE | 320.00000 | . |

| NUMBER | ...ROW.. | AT | ...ACTIVITY... | SLACK ACTIVITY | ..LOWER LIMIT. | ..UPPER LIMIT. | .DUAL ACTIVITY |
|---|---|---|---|---|---|---|---|
| 203 | OCTHIR | BS | . | 360.00000 | NONE | 360.00000 | . |
| 204 | TCORN | EQ | . | . | . | . | 2.70000- |
| 205 | TOATS | EQ | . | . | . | . | 1.60000- |
| 206 | TSOYBNS | EQ | . | . | . | . | 6.75000- |
| 207 | TALFALFA | EQ | . | . | . | . | 40.00000- |
| 208 | PROFIT | BS | 120617.41908 | 120617.41908- | NONE | NONE | 1.00000 |

| NUMBER | .COLUMNS | AT | ...ACTIVITY... | ..INPUT COST.. | ..LOWER LIMIT. | ..UPPER LIMIT. | .REDUCED COST. |
|---|---|---|---|---|---|---|---|
| 209 | BUY80 | BS | . | 3495.11000- | . | 1.00000 | . |
| 210 | BUY100 | BS | . | 5551.48000- | . | 1.00000 | . |
| 211 | BUY125 | EQ | 1.00000 | 6031.06000- | 1.00000 | 1.00000 | 6031.06000- |
| 212 | BUY165 | EQ | 1.00000 | 7534.12000- | 1.00000 | 1.00000 | 7534.12000- |
| 213 | BUY220 | BS | . | 9911.47000- | . | 1.00000 | . |
| 214 | BUY4-16 | BS | . | 1316.21000- | . | 1.00000 | . |
| 215 | BUY5-16 | LL | . | 1498.75000- | . | 1.00000 | 1498.75000- |
| 216 | BUY6-16 | BS | . | 1753.33000- | . | 1.00000 | . |
| 217 | BUY7-16A | BS | . | 1973.71000- | . | 1.00000 | . |
| 218 | BUY7-16B | BS | . | 1973.71000- | . | 1.00000 | . |
| 219 | BUY8-16A | LL | . | 2168.83000- | . | 1.00000 | 2168.83000- |
| 220 | BUY8-16B | LL | . | 2168.83000- | . | 1.00000 | 2168.83000- |
| 221 | BUY10-18 | EQ | 1.00000 | 3193.63000- | 1.00000 | 1.00000 | 3193.63000- |
| 222 | BUY12-18 | BS | . | 3556.01000- | . | 1.00000 | . |
| 223 | BUY14-18 | LL | . | 4546.92000- | . | 1.00000 | 4546.92000- |
| 224 | BUYCH8 | BS | . | 303.71000- | . | 1.00000 | . |
| 225 | BUYCH9 | BS | . | 341.32000- | . | 1.00000 | . |
| 226 | BUYCH10 | EQ | 1.00000 | 376.05000- | 1.00000 | 1.00000 | 376.05000- |
| 227 | BUYCH12 | BS | . | 451.56000- | . | 1.00000 | . |
| 228 | BUYCH15A | LL | . | 579.03000- | . | 1.00000 | 370.69667- |
| 229 | BUYCH15B | LL | . | 579.03000- | . | 1.00000 | 579.03000- |
| 230 | BUYCH17 | LL | . | 629.35000- | . | 1.00000 | 629.35000- |
| 231 | BUYDK10A | LL | . | 906.03000- | . | 1.00000 | 906.03000- |
| 232 | BUYDK10B | LL | . | 906.03000- | . | 1.00000 | 906.03000- |
| 233 | BUYDK12A | LL | . | 1086.94000- | . | 1.00000 | 1086.94000- |
| 234 | BUYDK12B | LL | . | 1086.94000- | . | 1.00000 | 1086.94000- |
| 235 | BUYDK15 | EQ | 1.00000 | 1358.76000- | 1.00000 | 1.00000 | 1358.76000- |
| 236 | BUYDK17 | LL | . | 1565.29000- | . | 1.00000 | 1565.29000- |
| 237 | BUYDK19 | EQ | 1.00000 | 1716.77000- | 1.00000 | 1.00000 | 1637.87092- |
| 238 | BUYDK22 | BS | . | 2061.62000- | . | 1.00000 | . |
| 239 | BUYDK25 | LL | . | 2226.32000- | . | 1.00000 | 11901.64542- |
| 240 | BUYHW24 | LL | . | 262.07000- | . | 1.00000 | 262.07000- |
| 241 | BUYHW30A | LL | . | 463.68000- | . | 1.00000 | 463.68000- |
| 242 | BUYHW30B | LL | . | 463.68000- | . | 1.00000 | 463.68000- |
| 243 | BUYHW36A | LL | . | 496.18000- | . | 1.00000 | 496.18000- |
| 244 | BUYHW36B | BS | . | 496.18000- | . | 1.00000 | . |
| 245 | BUYHW48A | BS | . | 610.85000- | . | 1.00000 | . |
| 246 | BUYHW48B | LL | . | 610.85000- | . | 1.00000 | 610.85000- |
| 247 | BUYHW66A | EQ | 1.00000 | 750.52000- | 1.00000 | 1.00000 | 750.52000- |
| 248 | BUYHW66B | BS | . | 750.52000- | . | 1.00000 | . |
| 249 | BUYHW78 | BS | . | 855.25000- | . | 1.00000 | . |
| 250 | BUYDL10A | LL | . | 1284.40000- | . | 1.00000 | 1284.40000- |
| 251 | BUYDL10B | LL | . | 1284.40000- | . | 1.00000 | 1284.40000- |
| 252 | BUYDL20A | LL | . | 2452.81000- | . | 1.00000 | 2117.28368- |
| 253 | BUYDL20B | LL | . | 2452.81000- | . | 1.00000 | 2308.07316- |
| 254 | BUYDL20C | EQ | 1.00000 | 2452.81000- | 1.00000 | 1.00000 | 2452.81000- |
| 255 | BUYDL30A | LL | . | 3566.56000- | . | 1.00000 | 2829.92634- |
| 256 | BUYDL30B | BS | . | 3566.56000- | . | 1.00000 | . |
| 257 | BUYDL30C | LL | . | 3566.56000- | . | 1.00000 | 3566.56000- |

| NUMBER | .COLUMNS | AT | ...ACTIVITY... | ..INPUT COST.. | ..LOWER LIMIT. | ..UPPER LIMIT. | .REDUCED COST. |
|---|---|---|---|---|---|---|---|
| 258 | BUYDL40A | BS | . | 4717.81000- | . | 1.00000 | . |
| 259 | BUYDL40B | LL | . | 4717.81000- | . | 1.00000 | 4217.93682- |
| 260 | BUYPR4A | LL | . | 991.68000- | . | 1.00000 | 991.68000- |
| 261 | BUYPR4B | BS | . | 991.68000- | . | 1.00000 | . |
| 262 | BUYPR6A | LL | . | 1606.25000- | . | 1.00000 | 1539.68750- |
| 263 | BUYPR6B | LL | . | 1606.25000- | . | 1.00000 | 1606.25000- |
| 264 | BUYPR6C | LL | . | 1606.25000- | . | 1.00000 | 1606.25000- |
| 265 | BUYPR8A | EQ | 1.00000 | 1826.62000- | 1.00000 | 1.00000 | 1645.37000- |
| 266 | BUYPR8B | EQ | 1.00000 | 1826.62000- | 1.00000 | 1.00000 | 1826.62000- |
| 267 | BUYPR12A | LL | . | 4961.53000- | . | 1.00000 | 4961.53000- |
| 268 | BUYPR12B | BS | . | 4961.53000- | . | 1.00000 | . |
| 269 | BUYPR16 | LL | . | 5821.43000- | . | 1.00000 | 5682.03241- |
| 270 | BUYCL4A | LL | . | 1127.87000- | . | 1.00000 | 1127.87000- |
| 271 | BUYCL4B | LL | . | 1127.87000- | . | 1.00000 | 1127.87000- |
| 272 | BUYCL6A | LL | . | 1378.27000- | . | 1.00000 | 1378.27000- |
| 273 | BUYCL6B | LL | . | 1378.27000- | . | 1.00000 | 1378.27000- |
| 274 | BUYCL6C | LL | . | 1378.27000- | . | 1.00000 | 1378.27000- |
| 275 | BUYCL8A | BS | . | 1661.50000- | . | 1.00000 | . |
| 276 | BUYCL8B | LL | . | 1661.50000- | . | 1.00000 | 1661.50000- |
| 277 | BUYCL12A | EQ | 1.00000 | 2176.33000- | 1.00000 | 1.00000 | 2176.33000- |
| 278 | BUYCL12B | LL | . | 2176.33000- | . | 1.00000 | 2176.33000- |
| 279 | BUYCL16 | BS | . | 2688.04000- | . | 1.00000 | . |
| 280 | BUYSWH16 | EQ | 1.00000 | 3228.79000- | 1.00000 | 1.00000 | 3228.79000- |
| 281 | BUYSWH18 | BS | . | 3881.05000- | . | 1.00000 | . |
| 282 | BUYSWH21 | BS | . | 4608.80000- | . | 1.00000 | . |
| 283 | BUYBLSM | LL | . | 992.46000- | . | 1.00000 | 992.46000- |
| 284 | BUYBLMDA | LL | . | 1229.13000- | . | 1.00000 | 1229.13000- |
| 285 | BUYBLMDB | BS | . | 1229.13000- | . | 1.00000 | . |
| 286 | BUYBLLGA | BS | . | 1607.02000- | . | 1.00000 | . |
| 287 | BUYBLLGB | LL | . | 1607.02000- | . | 1.00000 | 1607.02000- |
| 288 | BUYBLBG | EQ | 1.00000 | 1330.43000- | 1.00000 | 1.00000 | 1330.43000- |
| 289 | BUYCOM13 | BS | . | 11111.77000- | . | 1.00000 | . |
| 290 | BUYCOM20 | EQ | 1.00000 | 14854.86000- | 1.00000 | 1.00000 | 14854.86000- |
| 291 | BUYCOM27 | LL | . | 17301.29000- | . | 1.00000 | 16358.97968- |
| 292 | 4-16/80 | LL | . | 7.23000- | . | NONE | 8.11331- |
| 293 | 5-16/80 | LL | . | 6.19000- | . | NONE | 3.83035- |
| 294 | 6-16/100 | LL | . | 6.27000- | . | NONE | 2.67938- |
| 295 | 7-16/100 | LL | . | 5.80000- | . | NONE | 2.14305- |
| 296 | 7-16/125 | LL | . | 6.17000- | . | NONE | 2.51305- |
| 297 | 8-16/125 | LL | . | 5.69000- | . | NONE | .01000- |
| 298 | 8-16/165 | LL | . | 6.33000- | . | NONE | .65000- |
| 299 | 10-18/16 | BS | 1360.00000 | 5.68000- | . | NONE | . |
| 300 | 12-18/22 | LL | . | 5.82000- | . | NONE | 2.02172- |
| 301 | 14-18/22 | LL | . | 5.79000- | . | NONE | .11000- |
| 302 | CH8/80 | LL | . | 2.29000- | . | NONE | .53365- |
| 303 | CH9/100 | LL | . | 2.57000- | . | NONE | 16.30091- |
| 304 | CH10/125 | BS | 240.00000 | 2.71000- | . | NONE | . |
| 305 | CH12/165 | LL | . | 2.91000- | . | NONE | 1.14828- |
| 306 | CH15/165 | BS | . | 2.36000- | . | NONE | . |
| 307 | CH15/220 | LL | . | 3.33000- | . | NONE | .62000- |
| 308 | CH17/220 | LL | . | 2.95000- | . | NONE | .24000- |

| NUMBER | .COLUMNS | AT | ...ACTIVITY... | ..INPUT COST.. | ..LOWER LIMIT. | ..UPPER LIMIT. | .REDUCED COST. |
|---|---|---|---|---|---|---|---|
| 309 | DK10/80 | LL | . | 1.67000- | . | NONE | .27600- |
| 310 | DK10/100 | LL | . | 2.06000- | . | NONE | .66600- |
| 311 | DK12/100 | LL | . | 1.76000- | . | NONE | .23000- |
| 312 | DK12/125 | LL | . | 2.02000- | . | NONE | .49000- |
| 313 | DK15/125 | BS | 682.56881 | 1.67000- | . | NONE | . |
| 314 | DK17/165 | LL | . | 1.87000- | . | NONE | .13600- |
| 315 | DK19/165 | BS | 917.43119 | 1.70000- | . | NONE | . |
| 316 | DK22/220 | LL | . | 2.06000- | . | NONE | 11.32601- |
| 317 | DK25/220 | BS | . | 1.82000- | . | NONE | . |
| 318 | HW24/80 | LL | . | .67000- | . | NONE | .42600- |
| 319 | HW30/80 | LL | . | .56000- | . | NONE | .24000- |
| 320 | HW30/100 | LL | . | .70000- | . | NONE | .38000- |
| 321 | HW36/100 | LL | . | .58000- | . | NONE | .21200- |
| 322 | HW36/125 | LL | . | .67000- | . | NONE | .60963- |
| 323 | HW48/125 | LL | . | .51000- | . | NONE | .35899- |
| 324 | HW48/165 | LL | . | .66000- | . | NONE | .22800- |
| 325 | HW66/165 | BS | 1600.00000 | .48000- | . | NONE | . |
| 326 | HW66/220 | LL | . | .67000- | . | NONE | .47385- |
| 327 | HW78/220 | LL | . | .57000- | . | NONE | .34248- |
| 328 | DL10/80 | LL | . | 3.96000- | . | NONE | 1.22400- |
| 329 | DL20/80 | BS | . | 2.83000- | . | NONE | . |
| 330 | DL10/100 | LL | . | 4.52000- | . | NONE | 1.78400- |
| 331 | DL20/100 | BS | . | 3.12000- | . | NONE | . |
| 332 | DL20/125 | BS | 400.00000 | 3.34000- | . | NONE | . |
| 333 | DL30/125 | BS | . | 2.80000- | . | NONE | . |
| 334 | DL30/165 | LL | . | 3.10000- | . | NONE | 3.15823- |
| 335 | DL40/165 | LL | . | 2.76000- | . | NONE | 2.70154- |
| 336 | DL30/220 | LL | . | 3.69000- | . | NONE | .23118- |
| 337 | DL40/220 | BS | . | 3.20000- | . | NONE | . |
| 338 | PR4/80 | LL | . | 1.95000- | . | NONE | .39400- |
| 339 | PR6/80 | BS | . | 1.65000- | . | NONE | . |
| 340 | PR4/100 | LL | . | 2.30000- | . | NONE | 3.83474- |
| 341 | PR6/100 | LL | . | 1.89000- | . | NONE | .09800- |
| 342 | PR6/125 | LL | . | 2.08000- | . | NONE | .28800- |
| 343 | PR8/125 | BS | 625.00000 | 1.63000- | . | NONE | . |
| 344 | PR8/165 | BS | 575.00000 | 1.92000- | . | NONE | . |
| 345 | PR12/165 | LL | . | 2.05000- | . | NONE | .00200- |
| 346 | PR12/220 | LL | . | 2.42000- | . | NONE | 5.71827- |
| 347 | PR16/220 | BS | . | 1.96000- | . | NONE | . |
| 348 | CR4/80 | LL | . | 2.01000- | . | NONE | .76000- |
| 349 | CR6/80 | LL | . | 1.37000- | . | NONE | .12000- |
| 350 | CR4/100 | LL | . | 2.42000- | . | NONE | 1.17000- |
| 351 | CR6/100 | LL | . | 1.64000- | . | NONE | .39000- |
| 352 | CR6/125 | LL | . | 1.85000- | . | NONE | .60000- |
| 353 | CR8/125 | LL | . | 1.42000- | . | NONE | 1.93119- |
| 354 | CR8/165 | LL | . | 1.75000- | . | NONE | .50000- |
| 355 | CR12/165 | BS | 1200.00000 | 1.25000- | . | NONE | . |
| 356 | CR12/220 | LL | . | 1.66000- | . | NONE | .41000- |
| 357 | CR16/220 | LL | . | 1.30000- | . | NONE | 1.50154- |
| 358 | SWTH16 | BS | 160.00000 | 5.91000- | . | NONE | . |
| 359 | SWTH18 | LL | . | 6.75000- | . | NONE | 6.42871- |

| NUMBER | .COLUMNS | AT | ...ACTIVITY... | ..INPUT COST.. | ..LOWER LIMIT. | ..UPPER LIMIT. | .REDUCED COST. |
|---|---|---|---|---|---|---|---|
| 360 | SWTH21 | LL | . | 6.69000- | . | NONE | 6.49491- |
| 361 | SWTH160 | BS | 240.00000 | 1.97000- | . | NONE | . |
| 362 | SWTH180 | LL | . | 2.25000- | . | NONE | .28000- |
| 363 | SWTH210 | LL | . | 2.23000- | . | NONE | .26000- |
| 364 | BLSM/80 | LL | . | 4.65000- | . | NONE | 1.92000- |
| 365 | BLMD/80 | LL | . | 4.74000- | . | NONE | 2.01000- |
| 366 | BLMD/100 | LL | . | 5.64000- | . | NONE | 8.82212- |
| 367 | BLLG/100 | LL | . | 4.18000- | . | NONE | 6.80138- |
| 368 | BLLG/125 | LL | . | 4.68000- | . | NONE | 1.95000- |
| 369 | BBIG/125 | BS | 160.00000 | 2.73000- | . | NONE | . |
| 370 | COMB13 | LL | . | 5.40000- | . | NONE | 19.95521- |
| 371 | COMB20 | BS | 720.00000 | 4.52000- | . | NONE | . |
| 372 | COMB27 | BS | . | 4.02000- | . | NONE | . |
| 373 | CMB13 | LL | . | 4.71000- | . | NONE | .65000- |
| 374 | CMB20 | BS | 720.00000 | 4.06000- | . | NONE | . |
| 375 | CMB24 | BS | . | 3.72000- | . | NONE | . |
| 376 | CORN | EQ | 720.00000 | 92.00000- | 720.00000 | 720.00000 | 99.92800 |
| 377 | SCORN | BS | 59040.00000 | 2.70000 | . | NONE | . |
| 378 | OATS | EQ | 240.00000 | 50.65000- | 240.00000 | 240.00000 | 70.73300 |
| 379 | SOATS | BS | 21600.00000 | 1.60000 | . | NONE | . |
| 380 | SOYBNS | EQ | 480.00000 | 46.20000- | 480.00000 | 480.00000 | 133.70000 |
| 381 | SELLBNS | BS | 14400.00000 | 6.75000 | . | NONE | . |
| 382 | ALFALFA | EQ | 160.00000 | 30.20000- | 160.00000 | 160.00000 | 92.46600 |
| 383 | SELLALF | BS | 592.00000 | 40.00000 | . | NONE | . |
| 384 | OPCOST | BS | 105404.00000 | .14000- | . | NONE | . |
| 385 | HLAB/MAY | BS | 144.59450 | 4.00000- | . | NONE | . |
| 386 | HLAB/JUN | LL | . | 4.00000- | . | NONE | 4.00000- |
| 387 | HLAB/JUL | LL | . | 4.00000- | . | NONE | 4.00000- |
| 388 | HLAB/AUG | LL | . | 4.00000- | . | NONE | 4.00000- |
| 389 | HLAB/SEP | LL | . | 4.00000- | . | NONE | 4.00000- |
| 390 | HLAB/OCT | LL | . | 4.00000- | . | NONE | 4.00000- |

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