THE DEVELOPMENT OF A COMPUTERIZED ALGORITHM TO MEASURE THE INDIVIDUAL MACHINE COST

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CHAPTER I

THE PROBLEM AND OBJECTIVES

Introduction

Within the past few years, agricultural research and extension economists have increasingly employed electronic data processing systems. The primary emphasis by agricultural research economists has been in developing and utilizing techniques to analyze farm data. To a large extent, the efforts of extension economists have been toward developing the methodologies to obtain the traditional accounting records for farmers. This situation has created a discontinuity between the development of electronic data processing methodologies and their application to analytical techniques developed by research personnel. With proper development, an electronic data processing system should provide additional data which could be useful to the farmer in making economic evaluations between enterprises, between purchase or renting of land and machinery, and between holding or replacing machinery.

Specialization and commercialization best describe the changes in the type of farming during recent years. As a result today's farms are market oriented. These are drastic changes from the small, self-sustaining farm unit of the past. With these conditions facing present day farm managers, improved farm records are also required. Farmers can more properly manage aggregate units of production with records which provide tools to aid in the decision making process.

The organizational structure of input resource combinations upon farms has changed greatly within recent years. Many of the changes in the combinations of resources have been due to changes in prices paid for inputs and prices received for products produced. Other changes have been due to research contributing to the level of technology and the development of new products to aid in production.

The realization of additional production capabilities and greater economies have also resulted in the increased use of machinery substituting for labor. Labor has a higher cost as a production input than capital in the form of machinery. An additional primary reason for a machinery-for-labor substitution has been the declining labor supply created by the outward migration of the rural population from the farm and the decline in the average family size and its contribution of family labor. The increased substitution of machinery for labor has reduced the demands for large quantities of seasonal labor on very large farms and allowed farms with one to two man-year equivalents of labor available to increase in size. These increases in size of production units have allowed farm managers to benefit more from increasing economies of size with respect to management, but have resulted in larger total farm machinery investment values. The increased machinery investments have been in the form of larger and more expensive pieces of equipment and more specialized in use type of equipment.

The commercial farm unit has increased in size and total value, as well as undergone adjustments in the employment of resources. The increases in size have not involved proportional increases in each type of resource. Measurement of growth of farms may be classified in terms of units of physical measure or dollar value of total worth. In either situation, the growth of resource categories has not been proportional. The growth in employment of machinery has occurred so extensively that machinery costs in many enterprises are the largest single cost per unit of production.

The research conducted within this study is concentrated upon the development of a methodology to obtain measurements for one segment of the agricultural production costs. The algorithm developed obtains the individual costs of each machine within the machinery investment structure. The measurements and results of this study are detailed and identified in order that they may be applied to established analytical procedures for solutions to problems encountered by farm managers. By summarizing data for the farms, aggregate data should be available for research personnel to evaluate and use in applying analytical techniques to research problems.

Statement of the Problem

Farm managers have measurable levels of the resources such as land, labor, and capital initially available at an opportunity cost for each additional level up to a limit determined by the farm manager's net worth. If farm managers are to approach an optimum combination of resource inputs and achieve their goal of maximizing profits per unit of enterprise produced, a system of farm records which measure the costs for each unit of resource employed is a necessity.

The capital required for machinery investment has become the largest non-real estate use of capital within the investment structure of the farm firms. Non-real estate capital investments of this type are not divisable and employable at the last dollar level, and must be employed in integer units which require aggregate lumps of capital. Resources of this type are termed discontinuous and if farm managers are to make the correct investment decisions for purchasing farm machinery, they must have records which will enable them to budget and forecast returns for each dollar's value of the machinery employed. Only in very unique situations will the farm manager be able to employ machinery investments at the level where the last dollar value has a return greater than the employment of a dollars worth of any other variable resource. A measurement of cost per unit of use is employed to evaluate the returns to the machinery resources. The increased machinery investment structure has created an awareness by farm managers of economies of scale with respect to total farm machinery investments. Because of the conditions and the situation which surrounds the machinery investment structure of farming, farm managers need a system of records which will provide them the costs per unit for which the machinery resources are employed. In order for these records to be adaptable to all enterprises and to accurately reflect the costs for the many different uses, the unit of measurement for costs will need to be a common denominator; the measurement will be cost per hour of usage for each machine. The costs per hour should be divided into two types of costs, fixed costs per hour and variable costs per hour. The system of records must also measure the hourly requirement for each machine to perform all of the operations. By further division into these two types of costs, farm managers can determine the ownership costs per unit and the operational costs per unit. Farm managers can use the fixed costs per unit and the operational costs per unit or the custom costs per unit to budget the unit cost requirements to employ the machine in the production process of an alternative enterprise.

Measurements of this type will enable farm managers to obtain the optimum machinery combination per unit of an enterprise. With a system of farm records thatprovides these answers, farm managers can use this data to employ analytical tools, such as linear programming, to obtain a greater level of returns from the resources employed.

Objectives of the Study

The primary objective of this study was to develop an algorithm to analyze farm records yielding the individual measurements of fixed costs and operational costs per hour for each piece of machinery on an individual farm. A secondary objective of this study was to also develop an algorithm to determine the total machinery cost per unit of enterprise for all machines employed within the production process.

Two unstated objectives were remembered throughout the development of this system of analysis. The first of these was to design the algorithm in such a manner that the application would be as simple as possible. The second unstated objective was to create one step in a bridge for the gap between development of analytical procedures and application to the farm operator's problems.

In order to arrive at meaningful objectives of this study, certain assumptions were necessary. The first assumption was that in order for a farm manager to successfully achieve his goals, he would attempt to minimize costs per unit of production with respect to the dollar value of machinery investment. The second assumption was that constant levels of technology were employed with respect to all other variable resources employed within an individual farm firm. A third assumption was that constant prices were paid and received by farm managers for inputs and products produced respectively within a time period. A fourth assumption was that a farm manager can contract any custom operation in any quantity at a linear rate for the next time period after making the decision to liquidate a machine from the machinery investment structure. The final assumption was that the decrease in capital value of the machines within the machinery investment structure would be equivalent to the depreciation costs for the period of analysis. The decrease in capital value will be estimated using equations from previous research. This technique avoids evaluation errors by farm managers.

Since the analysis of costs for the machinery investment structure of the farm is for a period of one year, the frequency of machinery replacement decisions could not be determined within this time period. A one year time period is sufficient to be considered because it contains a complete production cycle and all purchased inputs will be expended with the exceptions of the real estate and the machinery investments.

Organization of Remaining Chapters

Chapter II is primarily comprised of three topics. The first of these is a review of the importance of farm records. The second topic discussed is a review of relevant economic principles. The third topic is a review of previously developed analytical procedures which contributed to this study.

A description of the design by which the system of analysis was developed is presented in Chapter III. Also, a discussion of the empirical cost equations used to develop the algorithm procedure is presented in Chapter III. A presentation and description of the data input methods for the algorithm of analysis concludes Chapter III.

Two important areas are discussed in Chapter IV. The first of these is a discussion of the applicable uses of the stated objectives of the study. The results derived within the algorithm procedure also create a demand for additional computer software to extend the application of these results to other analytical procedures developed. The final area of discussion in Chapter IV is the need for further research. The discussion of further research views additional applicable uses of the results within other computer softwares which could be developed.

CHAPTER II

A REVIEW OF THEORY AND CONTRIBUTING LITERATURE

Relevant Economic Theory

A critique of the economic principles employed will assist in the delineation of the objectives of this study.

Fixed resources are defined to be those resources whose quantities are employed in the production process at a constant level. The level of employment is predetermined for these resources because the time period of the study is insufficient in length to allow management the option of varying the levels of use in the production process. Variable resources are not employed at predetermined levels and may be employed at adjustable levels in the production process within the time period of the study. The costs associated with each of these types of resources are termed fixed costs and variable costs. The quantities of resources which are considered as fixed resources determine the size of the individual farm. The resources identified as fixed in quantity and quality for this study are land, management, and the total machinery investment structure of the firm.

The results of this study are not an attempt to measure costs of production for proportional levels of these fixed resources as aggregate units. The measurement of costs will be short-run average costs per hour per year for each machine within the machinery investment structure. The measurement of costs will be to measure and identify that part of the short-run average costs due to short-run average fixed costs per hour and operational costs per hour. These measurements will allow a farm operator to identify the machines employed which have short-run average costs per unit greater than the prevailing custom rate per unit. From a historical standpoint, a farm operator will be able to make decisions to gradually achieve economies of scale in future time periods with respect to the total farm machinery investment structure.

In order for the farm operator to minimize costs per acre of production in the future time periods and eliminate a machine from the machinery investment structure, the following identity will have to be true:

$$\text{Custom Rate} \leq \text{Short-Run Average Costs Per Unit}$$
$$\pm \text{ Capital Charge Per Unit.}$$

The capital charge per unit represents either a capital loss or gain and is defined as the difference between remaining undepreciated value and selling price when a machine is liquidated. A capital loss on a per unit basis should be added to short-run average costs per unit, whereas a capital gain on a per unit basis should be subtracted from short-run average costs per unit. If the identity is true, the operation can either be custom hired or substituted for with the operation of a similar machine whose short-run average costs do not exceed the prevailing custom rate in future time periods. Further conditions which should exist before a farm operator makes the decision to liquidate a machine from the farm machinery investment structure will be discussed more thoroughly later in this chapter.

In an optimum economic situation disregarding timeliness of operation, short-run costs per hour or the adjusted to short-run costs per unit for each operation will always be equal to or less than the prevailing custom rates for any operation regardless of the level of employment of a machine within the production process. In Figure 1, the optimum short-run average cost curve for a farm operator is illustrated. Point X_1 on the figure is identified as the level of employment for a machine at which the short-run cost, OA, for the machine is equal to the custom rate. At any level of usage less than the amount identified at Point X_1, the short-run cost measurement will be somewhere above and to the left of this Point B. For a level of usage greater than the level represented at X_1 the short-run cost measurement will be to the right and less than the amount identified at Point B. The short-run average cost curve is optimal for each operator within the range of relevant usage. No attempt will be made to illustrate the theoretical short-run average cost curve, although other research studies readily indicate a uniform downward slope to the right with a possibility of a change in slope to zero or positive [15, p. 20].

In the event a capital loss or unemployment of a fixed resource is incurred when a farm operator liquidates a machine from the machinery investment structure, these costs can be quantified and added to the short-run average costs which would cause a shift in Point B to the right and increase the level of usage necessary to justify farm operator ownership of the machine.

For custom operations pertaining to harvesting operations the charge is commonly a minimum amount plus incremental charges depending upon the yield. In these instances the farm operator can estimate

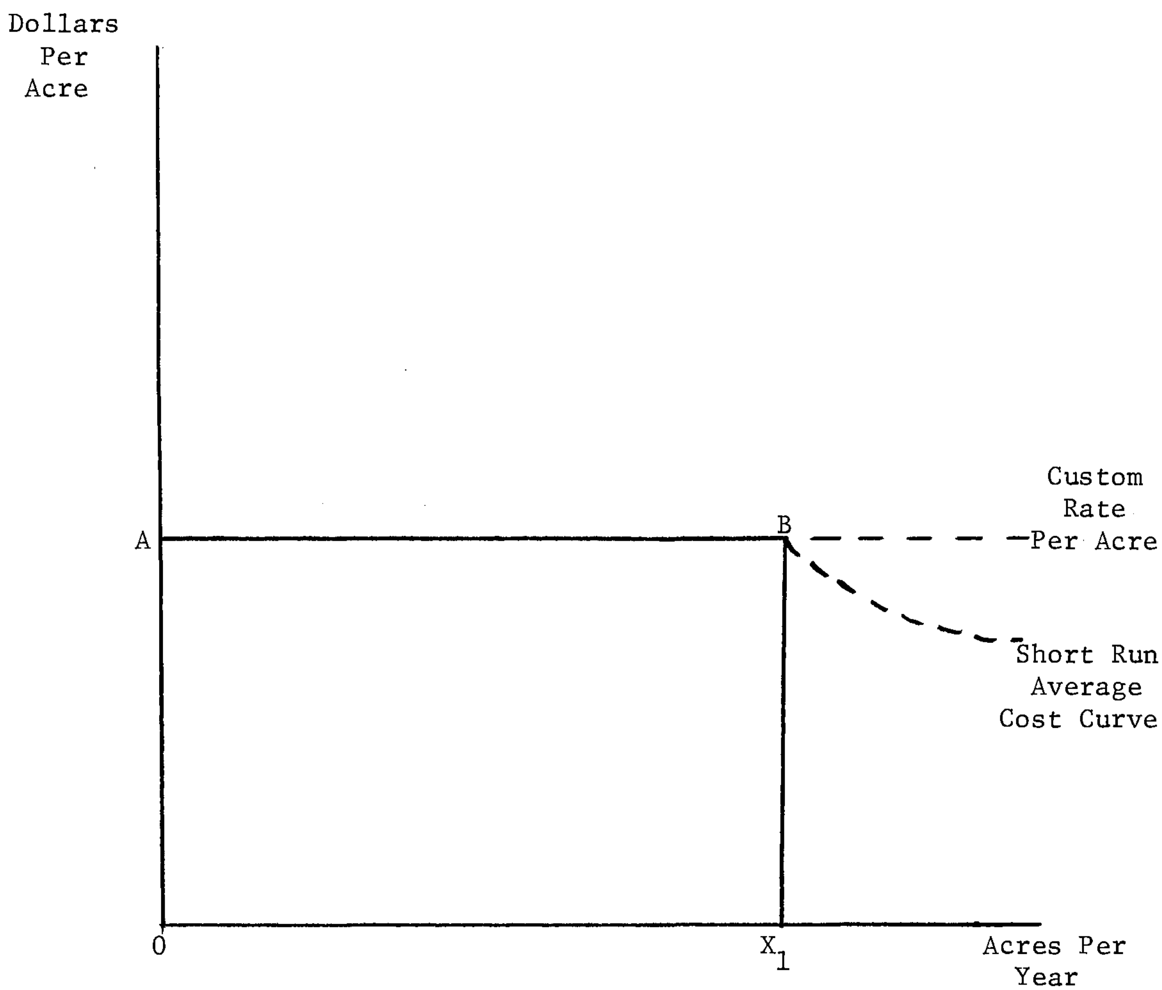

Figure 1. Optimum Short Run Average Cost Curve for Each Machine

the future custom charges by using an average yield of either his own or for the area.

With the measures of total short-run fixed costs and variable costs per unit, a farm operator can determine the level of usage represented at Point X_1 for each machine.

Review of Literature

Three prior studies in the area of machinery cost analysis provided the basis which contributed to the need for this study. The objective of each of these previous studies was different. A review of these studies will assist in identifying the differences of the objectives and recognize their contributions to this study. These three studies to be reviewed are: first, "Costs of Owning and Operating Farm Machinery," by Wendell Bowers; second, "Selection of a Farm Machinery Replacement Criterion Using Simulation," by Darrel Kletke; third, "Computerized Oklahoma State Farm Income and Detailed Expense Records" (COSTFINDER), by Ted R. Nelson.

The objective of the study by Bowers was to develop accurate methods of estimating the fixed costs and variable costs for ownership of farm machinery. The method of measuring depreciation costs was with the utilization of equations developed to estimate the remaining farm value of a machine at the end of each time period. The decrease in market value of a machine is equal to the estimated "as-is" value subtracted from the beginning value at the start of the time period. The equations developed by Larsen & Bowers have been determined to estimate an "as-is" value at the end of a time period within two percent (2%) of the actual market value for the first five years of the life of a machine [2, p. 4]. For the second five years, a slightly larger deviation in estimated remaining value and actual market value will occur. After ten years of machine life, the maintained condition and care received by the machine become the greatest determinants of actual market value, and the values of identical type machines will occur throughout a much wider range.

An additional objective of Bowers' study was to estimate the long-run average costs of a machine. Bowers' study assumes a constant level of usage per year for each machine. Also, Bowers assumes an initial value for each machine which is the list price of the machine. The results of Bowers' study are applicable for a farm operator considering an investment decision of a machine. The technique of determining when an investment is profitable for farm operators is by comparison of assimilated costs at the assumed level of usage to prevailing custom rates. The assimilated long-run average unit costs continue to decrease each year until it becomes equal or less than the prevailing custom rate. The year that the assimilated long-run average unit cost becomes equal to the prevailing custom rate is recognized as the minimum number of years necessary to employ the machines at the assumed level before it will become more profitable to own rather than employ on a custom basis.

The study by Bowers contributed to the additional research by Kletke. The equations to estimate repairs, taxes, insurance, and depreciation in Bowers' study were used by Kletke.

In Kletke's study an optimizing replacement criterion was developed to determine when the economic life of a machine had been reached [12]. Kletke defined the economic life of a machine as the interval of time necessary for the machine to reach its minimum amortized average costs. The minimum amortized average cost for each tractor was calculated using estimates of costs by types developed with the use of equations from Bowers' study.

The minimum amortized average cost for a machine will occur when the actual yearly cost first becomes greater than the amortized average cost. When these conditions exist, the economic life of a machine has been attained and theoretically replacement of the machine should occur.

However, due to large variations in repair costs each year, the actual yearly cost was frequently greater than the amortized average cost before the estimated minimum amortized average cost had been reached. If the farm operator replaces the tractor when these conditions exist, he would prematurely end the economic life of a machine. To prevent a premature replacement, two criteria were established: (1) an arbitrary limit for unexpected high repair costs, and (2) a three-year moving average of the immediate past two actual yearly costs and the expected actual yearly cost for the next year. In any year when the actual yearly repair cost exceeded the arbitrary limit, regardless of expected actual costs for the next year, the three-year moving average of actual and expected yearly costs would be equal to or greater than the estimated minimum amortized average costs for the tractor. By using the three-year moving average, repair costs could be unexpectedly high within one of the first two years and a premature replacement of the tractor would not be justified. Also, the expected repair costs could be sufficiently high to warrant replacement of the machine before the three-year moving average exceeded the minimum amortized average cost.

Although the optimum replacement criterion developed in Kletke's study was primarily for farm tractors, the theory and method of the study was also applied to cars, trucks, and combines as well.

One of the objectives of this study is to measure the actual yearly fixed and variable costs for each machine. Using cost simulation equations in the method developed within Kletke's study, it would be possible for a farm operator to estimate the minimum amortized average cost for each machine in the machinery investment structure. After the results of this study had been obtained for two or more continuous years, the optimum replacement criterion could be applied to each machine in the farm machinery investment structure.

The actual yearly cost of a machine is the total of all specific costs incurred due to a machine within a year. Division of the actual yearly cost by the number of hours the machine was employed yields short-run average cost per hour. The short-run average cost per hour may easily be converted to short-run average cost per unit for equivalent comparison to custom rates. When the short-run average costs exceed the custom rate of a machine, a farm operator may readily identify that portion of the cost due to depreciation and repairs, which are the two costs with the greatest variation within each time period. With the amounts of these costs known, a farm operator will be less likely to prematurely end the economic life of a machine. Also, a farm operator can readily identify the machines which should be sold because of excessive high short-run average costs or low usage levels.

The objectives of COSTFINDER are to provide farm operators with detailed expense and income records of the farm [19, p. 2]. These records provide farm managers with a detailed analysis of the farm income and costs by type and by enterprise. COSTFINDER fully serves the needs of farm operators with a system of farm records for institutional purposes and the necessary information for primary levels of management. However, COSTFINDER does not fully serve the needs of farm operators with a detailed analysis system of farm records which provide the necessary information for machinery management decisions or the application of developed economic tools.

COSTFINDER employs a numerical coding system to identify cost and income items by type. The numerical coding system was adapted and used as a means of identifying cost items by type for the computer algorithm developed in this study. The general type cost items could not be identified as a specific cost of an individual machine because of limitations in the numerical coding system of COSTFINDER. Since the results of this study are to measure the fixed and variable costs in a time period for each specific machine in the farm machinery investment structure, it was necessary that the coding system be extended to be capable of identifying all specific costs associated with each machine. An illustration of the technique used to extend the coding system of COSTFINDER for data inputs is presented in Appendix C.

Additional electronic data processing systems which were reviewed provide general type information of the primary level for management uses, however, none of these systems were as comprehensive as COSTFINDER. The information of this type which is generally provided by these systems is a transaction journal, checking journal, accounts receivable and payable, and enterprise summaries. Various other summaries of income and expense by type or time period may be provided for management purposes. Some examples are cash flows, production, inventory, labor, machinery and land use.

The technique of coding individual cost items by type varied for each electronic data processing system. The coding techniques employed to identify the costs provided for identity of costs by type, but were limited and did not allow costs to be identified by type for each individual machine or type of machine. The general type costs which are nominally classified as overhead or other fixed costs can not be identified with each specific enterprise. The coding technique used within these systems will have to be extended in order to accomplish identity of cost per item of machinery or per type of machine within the analysis systems.

Summary

Farm managers need a system of records which will measure incremental costs of machinery employed to determine the optimum level of machinery investment. A system of records which yields these answers will allow farm managers to estimate the incremental costs of larger, more expensive specialized types of equipment to be employed within the production process. Having an accurate estimate of the incremental costs will enable farm managers to determine the most profitable uses of capital they should employ in production processes.

The measurement of costs, which was defined within this chapter, is the short-run average cost for each machine. The short-run average cost consists of two component costs, short-run fixed costs and short-run variable costs. These results are necessary to employ the economic principle of marginal analysis as reviewed within this chapter.

Measuring the fixed machinery costs and variable costs will enable farm managers to make correct decisions relating to the employment of custom operations. With these costs available, farm managers can construct budgets to estimate returns per acre possible from alternative enterprises.

The research conducted in each of the reviewed studies established the beginning stages and facilitated this study. In the studies by Bowers and Kletke, a criterion was developed to assist in management decisions. Part of the components formulated to make these criteria applicable were adapted in this study.

The equations to estimate the value of each machine were adapted from Bowers' study. These equations enabled the depreciation of each machine for each year to be estimated with more reliability of actual decrease in value than was assumed of farm managers' capabilities. Two assumptions which were made in Bowers' study will be substituted for with actual measurements within this study. These two measurements are the level of usage which will be measured for each machine rather than assumed at a constant level, and the beginning value of a machine will be the actual cost to the farm operator rather than an assumed list price.

The optimum replacement criterion developed in Kletke's study was applied to the relationship of short-run average costs and prevailing custom rates. The prevailing custom rate was substituted for the minimum amortized average cost for comparison, because the prevailing custom rate is a benchmark and within the knowledge of farm managers. Within a profitable ownership situation of a machine, it is recognized that prevailing custom rates will be greater than minimum amortized average costs. Without the knowledge of the minimum amortized average cost of a machine, the prevailing custom rate of an operation is the next best measurement to use in management decisions.

In the study by Dr. Ted Nelson, the developer of COSTFINDER, the coding system and formats for data inputs of income and expense items were adapted and made the development of the computer algorithm within this study possible.

The algorithm developed within this study yields results for a time period of one year. The measurement derived is one value of the short-run average cost curve for each machine. The corresponding value on the long-run average cost curve may be derived using Bowers' equations with the assumed level of usage equal to the measured level of usage. These values may be compared to estimate the relationship of the short-run average cost curve for each machine at the measured level of usage for that year.

The total cost of ownership costs and operating expenses for the year represents the actual yearly cost of each machine. The actual yearly cost, or long-run marginal cost was estimated in Kletke's study. After the algorithm of analysis had been conducted for a minimum of two consecutive years, the replacement criterion developed by Kletke could be applied using the expected yearly cost for the third year. After several years, the actual yearly cost of each machine for each year could be plotted to determine the relationship of the long-run marginal cost curve with the estimated long-run average cost curve derived from Bowers' study.

CHAPTER III

DESIGN AND DEVELOPMENT OF THE ALGORITHM

Introduction

The algorithm to be explained within this chapter will provide a system of analysis of farm records to conduct two measurements; first, to measure the cost per hour of operation of each item of equipment within the machinery investment structure, and second, to measure the total machinery cost per unit on five selected enterprises.

The system of analysis developed within this study was designed to continue the analysis of farm records currently being processed by an electronic data processing system. The COSTFINDER electronic data processing system was selected for application with the algorithm of analysis. Any system which differentiates and identifies farm costs as to the types utilized within the algorithm procedure could use the system of analysis after making modifications to allow input of data.

System of Analysis

The system of analysis was developed by building a computer program consisting of six separate parts. The first part, entitled Control, controls the execution of the remaining segments of the program. The second part, entitled Main, controls the input and storage of data utilized by the remaining segments. The third part, entitled Depocost, utilizes the depreciation schedule data, and calculates the depreciation costs for each individual vehicle or machine inventoried in the depreciation schedule. Also, the output array of Depreciation Schedule Changes is constructed within this subprocedure.

The fourth subprocedure, entitled MRCOST utilizes the itemized current farm expense data and calculates the following costs for each machine: capital charge, repairs, taxes, insurance, fuel, and lube.

The fifth subprocedure, entitled VMUSE, utilizes the machinery and labor usage data set and calculates the total costs, units employed upon, hours used, cost per unit, and cost per hour for each machine. The MACHINERY LISTING AND COSTS array is completed for output within this subprocedure.

The sixth subprocedure, entitled ENTSUM, utilizes the cost per hour value calculated in the MACHINERY LISTING AND COSTS array and the machinery and labor usage data set. The costs calculated within this subprocedure are costs per operation for each machine and the total machinery cost per unit for the five selected enterprises.

The method of calculating each of the costs within the subprocedures will be illustrated in the description of the analytical model.

The Analytical Model

The computer algorithm procedure developed within this study consists of two sections. The first section utilizes the data of a farm to measure machine costs per hour of usage for each machine. The second section utilizes the measurements obtained within the first section and the data of a farm to calculate total machinery cost per unit of enterprise.

Machine Cost Per Hour of Operation Analysis

The analytical procedure of the first section was developed with the use of empirical cost equations to measure total costs, as it appears in Equation (3-1). Total costs for each machine may be subdivided into total fixed and total variable costs. Equation (3-2) calculates total fixed cost for each machine, and Equation (3-3) calculates total variable cost for each machine.

$$TMC_m = TFC_m + TVC_m \qquad (3\text{-}1)$$

Where:

TMC_m = total ownership and operating costs per machine,

TFC_m = total fixed costs per machine, and

TVC_m = total variable cost per machine.

$$TFC_m = DEPR_m + CAPCH_m + TAXES_m + INS_m \qquad (3\text{-}2)$$

Where:

$DEPR_m$ = decrease in "as-is" value for a period of one year,

$CAPCH_m$ = opportunity cost for the beginning value of the machine,

$TAXES_m$ = institutional cost of ownership, and

INS_m = insurance cost.

$$TVC_m = REPAIRS_m + FUEL_m + OLUBE_m \qquad (3\text{-}3)$$

Where:

$REPAIRS_m$ = operator cost due to replacement of parts,

$FUEL_m$ = fuel consumption costs of machine for period of one year, and

$OLUBE_m$ = oil and lubricant costs for machine for a period of one year.

The measurement or derivation of each component part of Equations (3-2) and (3-3) will be discussed before application of the results are illustrated in the section to calculate total machinery cost per unit of enterprise.

Fixed Costs

The fixed costs are those costs which are incurred due to ownership of a vehicle or machine. As expressed in Equation (3-2), the fixed costs to be measured within this system of analysis are depreciation, capital charge, taxes, and insurance. The depreciation cost is the most important ownership cost because it normally will be the largest of the fixed costs and part or all of the remaining costs are determined by the remaining value of the machine. Part of the insurance cost may be specifically identified to the machine which would not depend upon the remaining value of the machine. A cost for housing was not included in the total fixed costs for each machine. Machines which are not housed will have higher depreciation and repair costs [12, p. 34] and the housing cost will be reflected within these higher costs.

The DEPR cost was obtained by using an empirical cost equation of the following form:

$$RFV_n = ILP * SNPFC * YLRFC^n \qquad (3\text{-}4)$$

Where:

RFV_n = remaining farm value at end of year n,

ILP = initial list price of the machine,

SNPFC = the percent remaining value after immediate depreciation,

$YLRFC^n$ = the percent remaining value after one year's usage depreciation, and

n = age of the machine at the end of the year.

The source and development of Equation (3-4) for each type of vehicle or machine is explained further in Appendix A.

Since the initial list price (ILP) for each item of equipment was not known, it was assumed that the initial list price (ILP) had been discounted 12 percent to equal the original cost. A subtraction technique was used to estimate the depreciation cost for year n. For items of equipment less than three years old, the proportion of the yearly depreciation cost, which was accepted as a cost for the year, was determined by a quarterly schedule. The quarterly schedule was applied seasonally to consider the early quarter, the middle quarters, or the late quarter of the year purchased or sold. The quarter purchased and the quarter sold, or the late quarter, if still owned, was used in prorating the proportional part of the yearly depreciation cost. To determine separable parts of the yearly depreciation cost for prorating purposes, the equations were applied in stages. The example for an item of equipment purchased within the time period will be illustrated. In Equation (3-5) the remaining farm value (RFV1) is the initial list price (ILP) multiplied by the remaining percent factor after immediate depreciation (SNPFC).

$$RFV1 = ILP * SNPFC \qquad (3\text{-}5)$$

Where:

RFV1 = the remaining farm value.

In Equation (3-6) the remaining farm value at the end of the year is calculated.

$$RFV2 = ILP * SNPFC * YLRFC \tag{3-6}$$

Where:

RFV2 = remaining farm value or "as-is" value at the end of one year of use.

By subtracting the remaining farm value after one year of usage, RFV2, from the remaining farm value after the immediate depreciation, RFV1, the depreciation cost due to usage for the year may be obtained. The owner incurs the immediate depreciation when the item of equipment is purchased, however the quarter within which the item was purchased will determine the proportional share of the first year usage depreciation cost. The actual cost of the item of equipment was the original cost rather than the initial list price. The depreciation cost for the first year is calculated in Equation (3-7). The remaining farm value at the end of the time period after the incurrance of depreciation costs is determined in Equation (3-8).

$$TYD_1 = (OC - RFV1) + [PROFAC * (RFV1 - RFV2)] \tag{3-7}$$

Where:

TYD_1 = this years depreciation costs,

OC = original cost, and

PROFAC = quarter factor in which the item of equipment was purchased.

$$RFV3 = OC - TYD \tag{3-8}$$

Where:

RFV3 = remaining farm value after depreciation allowance has been taken out.

To calculate depreciation costs for a machine within the second time period, Equations (3-5) through (3-8) are applied to obtain the remaining farm value at the end of year one, RFV4, and the undepreciated value of the machine, RFV3. Equation (3-9) is then applied to calculate the proportion of the first year usage depreciation which was uncharged, $UNCTYD_1$.

$$UNCTYD_1 = (RFV1 - RFV2) - [PROFAC * (RFV1 - RFV2)] \qquad (3\text{-}9)$$

Equation (3-4) is then applied with n equal to two (n = 2) to obtain the remaining farm value at the end of year two, RFV5. The depreciation charge for year two is then calculated with Equation (3-10).

$$TYD_2 = [PROFAC * (RFV4 - RFV5)] + UNCTYD_1 \qquad (3\text{-}10)$$

In Equation (3-10) the PROFAC is the proportional rate of the usage cost which was also charged in year one. The undepreciated value of the machine at the end of year two is equal to RFV3 minus TYD_2. To calculate depreciation cost for year three, Equations (3-5) through (3-10) are applied in order that the remaining uncharged proportion of year two ($UNCTYD_2$) and the proportional rate (PROFAC) of year three usage cost will be calculated as the depreciation cost.

No consideration was made of the date of purchase for items of equipment with over three years of use. The general form of Equation (3-4) was applied to obtain the remaining farm value of the previous year (RFV_{n-1}) and the remaining farm value of the present year (RFN_n). The depreciation charge was then calculated by Equation (3-11).

$$TYD_n = RFV_{n-1} - RFV_n \qquad (3\text{-}11)$$

The capital charge (CAPCH of the total fixed costs Equation (3-2) was calculated as a direct function of the value of the vehicle or machine. Equation (3-12) illustrates how this value was calculated.

$$CAPCH = RFV_n * CCRATE \qquad (3\text{-}12)$$

Where:

CAPCH = opportunity cost for the investment value, and

CCRATE = capital charge rate.

A provision was built into the system of analysis to allow the capital charge rate (CCRATE) to be specified for each farm's data. A default value of five and one half percent was built into the system of analysis.

The taxes paid ($TAXES_n$) in Equation (3-2) are comprised of the cost due to personal property, licenses, and sales taxes. The licenses or sales taxes can be charged directly to the tax cost for each vehicle or machine due to the unique code of each. The amount of the personal property tax cost was a direct function of the amount of personal property taxes paid within the year in proportion to the value of the vehicle or machine. Equation (3-13) illustrates how the tax cost was computed for each item of equipment. It was assumed that 60 percent of the personal property taxes paid would be due to the value of the machinery investment structure of a farm.

$$TAXES = (PPTAX * .6) * (VM/TMV) + OTC \quad (3-13)$$

Where:

PPTAX = amount of personal property taxes paid within the year,

VM = value of the machine,

TMV = total value of the machinery investment structure, and

OTC = other tax costs of the machine, licenses, and sales taxes.

The last type of fixed cost included in Equation (3-2) was insurance (INS_m). The types of insurance costs which were considered within the system of analysis were general insurance for vehicles and machines and liability insurance. Equation (3-14) was applied to the general insurance costs of a farm to obtain the proportional insurance cost for each machine. The insurance cost which was identified by code to a specific vehicle or machine was charged directly to the vehicle or machine. The general insurance costs were prorated as a direct function of the value of the machine.

$$INS_m = GIC * (MV/TMV) + OIC \quad (3-14)$$

Where:

GIC = the general insurance cost for groups of vehicles or machines, and

OIC = other insurance costs, such as liability for a specific vehicle.

Variable Costs

The variable costs are those which vary with the amount of usage of each machine within the time period of analysis. The variable costs measured within this system of analysis are repairs, fuel, and oil and lube for each machine.

The extended code which was developed for this system of analysis allows for the variable costs to be identified to each vehicle or machine. Provisions were also made within the system of analysis to allow a variable cost to be less than fully coded and to be identified for a type of machine, a group of machines, or for vehicles and machines in general.[1] The total variable cost by type for each level of identification was proportionally prorated with respect to hours of usage among the vehicles or machines within the level of classification. Equation (3-15) was used to prorate the unallocated repair costs at each level of identification.

$$PRORC_m = TREPC_L * (FAC/TOFAC) \qquad (3\text{-}15)$$

Where:

$PRORC_m$ = proportional share of repair costs for each machine,

$TREPC_L$ = total repair costs at the level of identification,

FAC = hours of use of each specific machine, and

TOFAC = total hours of usage of machine within the level of identification.

The technique of prorating costs illustrated in Equation (3-15) allowed for the entire cost to be charged directly to a specific machine, if there was only one vehicle or machine within the level of identification.

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[1]Types of machines are denoted by the Detail Column of the COST_ FINDER Code, groups of machines are denoted by the General Column of the COSTFINDER Code.

The fuel costs which were unallocated to each specific vehicle were also prorated as a direct function of the hours of use of each vehicle within the level of identification. Equation (3-16) was used to prorate fuel costs.

$$PROFC_m = TFCST_L * (FAC/TOFAC) \qquad (3\text{-}16)$$

Where:

$PROFC_m$ = proportional share of fuel costs for each vehicle, and

$TFCST_L$ = total fuel costs for the level of identification.

Equations (3-17) and (3-18) were used to prorate the oil and lube costs which were unallocated to specific vehicles or machines, respectively. The assumption was made that 85 percent of the unallocated oil and lube costs would be expended for vehicles and 15 percent expended for machines. The prorated oil and lube charge was made as a direct function of the hours of use of each vehicle or machine.

$$PROOL = (TOOLC_L * .85) * (FAC/TOFAC) \qquad (3\text{-}17)$$

Where:

PROOL = proportional share of oil and lube costs for each vehicle, and

$TOOLC_L$ = total oil and lube costs at the level of identification.

$$PROOL = (TOOLC_L * .15) * (FAC/TOFAC) \qquad (3\text{-}18)$$

Measurement of Hours and Units Usage

The accumulation of hours of usage of each item of equipment within the machinery investment structure was made possible by the extended code employed within this algorithm procedure of analysis. The measurements were obtained from the data reporting this machinery and labor usage by the farm operator. To calculate cost per hour, the value obtained in Equation (3-1) was divided by the total hours usage reported for the machine.

The total hours usage was determined by the summation of the itemized usage reports for each machine within the machinery and labor use data set. A unique identification code was used for each machine and power source. This technique allowed for a separate vehicle employed as the power source to be identified.

To calculate cost per unit, the value obtained in Equation (3-1) was divided by the total number of units employed upon as reported in the machinery and labor usage data set. The accounting procedure to determine the total number of units was identical to the technique employed to determine the total number of hours for each vehicle or machine.

Total Machine Cost by Enterprise Analysis

Provisions were made within the algorithm of analysis to measure total machine costs per unit of enterprise for five or less identified enterprises. The technique developed to calculate total machine cost per unit of enterprise differentiated between the types of cost. The identification of each type of cost was made for adjustment costs, total fixed costs, total variable costs, total custom costs, and total freight costs. Equation (3-19) was used to calculate total machine cost per unit of enterprise.

$$TMCA = \sum_{i=1}^{n} FCPO_i + \sum_{i=1}^{n} VCPO_i + \sum_{i=1}^{n} CCPO_i + \sum_{i=1}^{n} FRCPO_i$$

$$+ \sum_{i=1}^{n} (AOJH_i * CPHO_j/UNITS) \qquad (3\text{-}19)$$

Where:

TMCA = total machinery cost per unit of enterprise,

$FCPO_i$ = fixed cost per unit for the i^{th} operation,

$VCPO_i$ = variable cost per unit for the i^{th} operation,

$CCPO_i$ = custom cost per unit for the i^{th} operation,

$FRCPO_i$ = freight cost per unit for the i^{th} freight cost,

$AOJH_i$ = adjustment hours for the i^{th} adjustment,

$CPHO_j$ = cost per hour of operation for the j^{th} vehicle or machine, and

UNITS = initial units of the enterprise.

The machine cost per unit of enterprise represents a cost based upon the initial number of units of the enterprise. The cost per unit represents a cost incurred for units of an enterprise which were either abandoned or lost.

The calculated cost per unit can be adjusted to an actual cost per unit of enterprise harvested by solving for actual cost per unit of harvested enterprise (ACPU) in Equation (3-20). No consideration was given within the development of the analysis procedure to income derived or yields harvested, therefore the adjustment was not made within the algorithm of analysis.

$$ACPU = \frac{CCPU * IUE}{HUE} \qquad (3\text{-}20)$$

Where:

CCPU = calculated cost per unit of enterprise,

IUE = initial units of the enterprise,

ACPU = actual cost per unit of harvested enterprise, and

HUE = units of the enterprise which was harvested.

Fixed Cost and Variable Cost Per Operation

To calculate total fixed cost and total variable cost, the data set reporting machine and labor usage was searched to identify the machine, operation, and hours for each operation employed upon the identified enterprise. Equations (3-21) and (3-22) were used to calculate the fixed cost per hour and the variable cost per hour for each machine.

$$\frac{\sum_{i=1}^{4} FC_i}{THU} = FCH \qquad (3\text{-}21)$$

Where:

FC_i = each cost identified as fixed for each machine,

THU = total hours of usage within the period of analysis,

FCH = fixed cost per hour for each machine,

VC_i = each cost identified as variables for each machine, and

VCH = variable cost per hour for each machine.

$$\frac{\sum_{i=1}^{3} VC_i}{THU} = VCH \qquad (3\text{-}22)$$

Equations (3-23) and (3-24) were used to calculate the fixed cost per operation and the variable cost per operation for each machine.

$$FCPO_i = HPO * FCH \qquad (3\text{-}23)$$

Where:

$FCPO_i$ = fixed cost per operation for the ith operation,

HPO = hours required per operation by each machine, and

FCH = fixed cost per hour of operation for the respective machine employed.

$$VCPO_i = HOP * VCH \qquad (3\text{-}24)$$

Where:

$VCPO_i$ = variable cost per operation for the ith operation, and

VCH = variable cost per hour of operation for the respective machine employed.

The results obtained in Equations (3-23) and (3-24) were applied to Equation (3-19).

Custom Cost and Freight Cost Per Operation

The itemized expense data set reporting hired custom operations and freight expenses was searched to identify each of these expenses with the selected enterprise. The custom operation expense and the freight expenses were then adjusted to a per unit cost by using Equations (3-25) and (3-26) respectively.

$$CCPO_i = CCHG/UNITS \qquad (3\text{-}25)$$

Where:

$CCPO_i$ = custom cost per unit for the ith operation,

CCHG = custom charge for the ith operation, and

UNITS = initial units of the enterprise.

$$FRCPU_i = FRCH/UNITS \qquad (3\text{-}26)$$

Where:

$FRCPU_i$ = freight cost per unit for the ith freight expense, and

FRCH = freight expense for the ith expense.

The values obtained in Equations (3-25) and (3-26) were applied to Equation (3-19).

Adjustment Cost

The section of the data reporting machinery and labor adjustments and repairs was searched to obtain each enterprise field adjustment identified to the selected enterprise. In Equation (3-27), the hours required per field adjustment were multiplied times the cost per hour of operation for the respective machine.

$$ADJA = \sum_{i=1}^{n} (ADJH_i * CPHO_j/UNITS) \qquad (3\text{-}27)$$

Where:

ADJA = field adjustment cost per acre,

$ADJH_i$ = hours required per ith field adjustment, and

$CPHO_j$ = cost per hour of operation for the jth machine.

The adjustment cost per adjustment was then divided by the initial units to connect the cost to a per unit basis. The resulting value obtained in Equation (3-27) was applied to Equation (3-19) for each field adjustment. A further explanation of the final results for the analytical models developed within this chapter is presented within the chapter summary.

Source and Description of Data Input Methods

Hypothetical data sets were constructed to test the computer algorithm developed to conduct the analysis of the farm records. The simulated data was obtained from a study by Strickland and Dunn [20, pp. 24-26, p. 76]. Three types of data sets were constructed. The data sets were a listing of all machines, an itemized listing of all labor and machine usage, and an itemized reporting of the farms current expenses. A thorough explanation of the construction of the data sets is presented in Appendix B.

The simulated data was prepared compatible with the reporting and coding system of COSTFINDER, an electronic data processing system for analysis of farm records [18, pp. 1-6]. A more thorough explanation of the adapted COSTFINDER code and reporting forms appears in Appendix C.

The numerical code employed within COSTFINDER was enlarged to enable this system of analysis to identify costs by type to each specific machine, to identify usage of each individual machine, and to identify each machine within the machinery investment structure. A review of the coding system employed within COSTFINDER will assist in delineating the enlargement of the code for this system of analysis. The basic COSTFINDER Code is a five digit numerical code, (Figure 2).

For the data sets, itemized machine list, and itemized machinery and labor usage, the code was extended to a six digit numerical code. This extension of the code is illustrated in Figure 3.

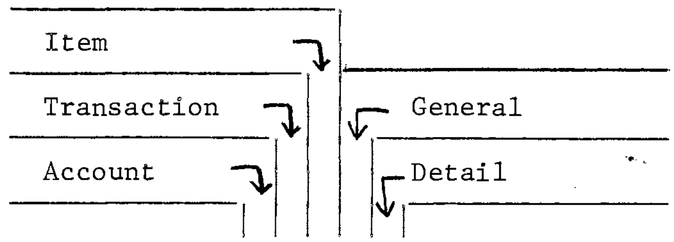

Figure 2. Basic COSTFINDER Code

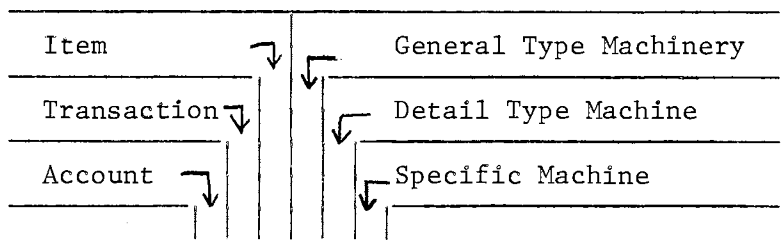

Figure 3. Itemized Machine Code

For the data set, itemized current farm expenses, the code was extended to a seven digit numerical code. An example of this code is illustrated in Figure 4.

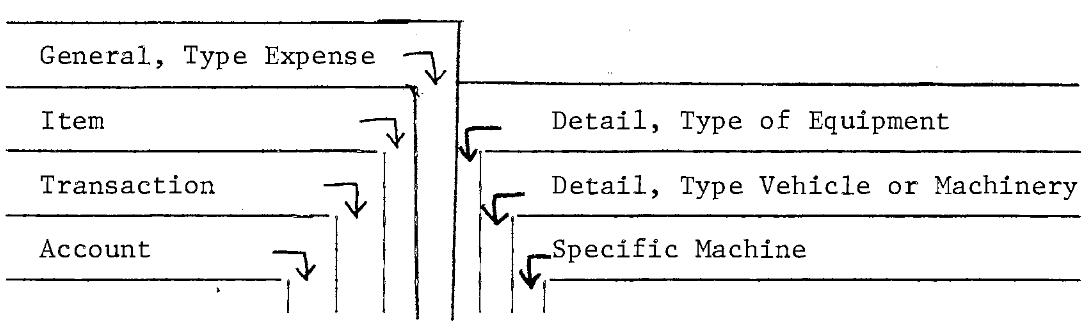

Figure 4. Itemized Expense Code

Summary

The results yielded by each analytical model developed within this chapter were printed for output. The three printouts developed were the Depreciation Schedule Changes, the Machinery Listing and Costs, and the Enterprise Cost Analysis Per Unit.

The values of the Depreciation Schedule Changes were developed from the status change records of vehicles and machines within the depreciation schedule. These values were derived within the segment entitled DEPCOST.

The segments DEPCOST, MRCOST, and VMUSE derive the results obtained within the Machine Cost Per Hour of Operation Analysis section. The identified and listed values for each part of Equations (3-2) and (3-3) are illustrated in the Machinery Listing and Costs output format of Appendix D.

The segment entitled ENTSUM derives the results obtained within the Machine Cost by Enterprise Analysis section. The identified and listed values for each part of Equation (3-19) are illustrated in the Enterprise Cost Analysis Per Unit output format of Appendix D.

Appendix D also contains a generalized flow chart of the computer software algorithm of analysis developed within this study.

CHAPTER IV

SUMMARY OF THE ALGORITHM OF ANALYSIS

The primary objective of this study was to develop an algorithm to calculate the cost per hour of operation for each item of equipment within the machinery investment structure of a farm. The secondary objective of this study was to also develop an algorithm procedure of analysis to calculate total machinery cost per unit for all of the machines employed within the production process of a selected enterprise. Due to the production cycle of the enterprises of a farm the time period for which these objectives would represent was a period of one year.

Results of Objectives

The objectives were accomplished by writing and constructing a computer program which would use the machinery investment structure, the itemized expenses, and the machinery usage of a farm as the required data. The COSTFINDER electronic data processing system numerical code and input formats were selected for adaptation as the method of identifying and reporting the data sets necessary for the computer program developed. The computer program developed could be utilized by any electronic data processing system which has a numerical or alphabetic code that differentiates and identifies the itemized expenses, the individual machines, and specific machine usage of a farm within a year. A slight revision of the data input section would be necessary to be adapted to the code and formats of the data of a different electronic data processing system.

The computer program developed allows for the itemized expenses to be identified to each of the following classifications: a specific machine, a specific type of machine or vehicle, a general group of machines or vehicles, or for vehicles or machines. In the condition that an itemized expense was not identified to a specific machine, the expense would be prorated to each of the machines or vehicles within the respective category. An itemized expense identified to a specific type of machine or vehicle would be charged completely to a single vehicle or machine if there was only one of the type within the respective category.

Applicable Uses of Results

The measurements obtained within the algorithm of analysis can be used with other analytical procedures to apply and make a greater application of these procedures to farm firms.

Within the study by Kletke, a technique was developed to estimate the minimum amortized average cost for a machine, and criteria to determine when replacement of the machine should occur were established. The technique to measure yearly cost developed within this study will allow more accuracy and provide assistance in applying these criteria for replacement of a machine. The technique developed to measure costs identified by type allows the total fixed cost and the total variable cost for each vehicle or machine to be obtained. The usage of these measured costs are applicable within an analytical technique for comparison of ownership costs to custom costs developed by Walker [22, p. 17]. The technique developed by Walker was as follows:

$$\frac{\text{Total Fixed Costs Per Year}}{\text{Custom Rate Per Unit - Total Variable Costs Per Year}} =$$

Minimum Number of Units to Employ the Machine Per Year Before Ownership Would be More Profitable Than Employing Custom Operation.

A farm operator who is willing to incur a cost for timeliness of operation may add the acceptable cost to the custom rate per unit. This will reduce the level of units necessary to employ the machine upon before ownership would be more profitable than hiring custom operations. By relaxing the assumption made in Chapter I, that a farm operator could hire any custom operation at any time it was needed, at a linear rate, the timeliness of operation would become a dynamic factor.

The measurement of the ownership cost per operation per unit of enterprise will be useful to farm operators constructing partial budgets for alternative enterprises. Although the calculated ownership cost per operation may vary due to the hourly requirement per unit of enterprise, the farm operator will be able to make an adjustment to more accurately represent the estimated cost. The calculated ownership cost per initial unit may be adjusted to take into consideration the expected rate of loss for the alternative enterprise being partially budgeted.

Need for Further Research

The scope of the algorithm of analysis developed within this study was limited to the costs associated with owning and operating farm vehicles and machinery. The computer program developed to perform the analysis was designed to allow an extension of the scope. The program was designed as special function segments with the capabilities of passing any set of calculated values or identified types of data to any other segment. Additional special function segments could be added and share all of the capabilities of the presently existing segments. Two additional specialized segments which would contribute significantly are a segment for a labor flow analysis and a segment for an enterprise budget generator. By the addition of these two segments the data of a farm could be processed and passed to LPFARM for analysis [11, pp. 1-5].

The total yearly ownership cost for each machine could be stored and passed to a computer program using the analytical procedures developed by Kletke to determine optimal replacement time for each machine.

The algorithm of analysis was developed to calculate total machinery cost per unit of enterprise for five selected enterprises. This capability should be expanded to a larger number to more fully serve the needs of farm operators.

A final special function segment which would classify and catalog data for storage in data sets could have a wide possibility of usage in other research problems. The classified data could be values derived in various segments of the algorithm of analysis or extended algorithm of analysis. The data could be cataloged by predetermined factors in relationship to the type of data represented. At the present time there definitely appears to be a need for this type of data in other research problems. This type of data availability could make other research proposals more feasible.

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APPENDIX A

APPENDIX A

DEPRECIATION COST EQUATIONS

Part of the equations used within this study to estimate yearly depreciation costs were taken from Bowers' work, and the remaining equations were developed. The general form of the equations with identification of variables is as follows:

$$RFV = ILP * SNPFC * YLRFC^{N}$$

Where:

RFV represents the remaining farm value,

ILP represents the initial list price,

SNPFC represents the immediate depreciation when purchased, or the shiney new paint depreciation,

YLRFC represents the percent rate of depreciation, and

N represents the age of the machine.

The following is a listing and identification of each equation used.

Automobile [16]

$$RFV = ILP * .810 * .790^{N}$$

Airplane [13]

$$RFV = ILP * 1. * .920^{N}$$

Farm Pickup [16]

$$RFV = ILP * .620 * .860^{N}$$

Farm Truck [16]

$$RFV = ILP * .670 * .860^{N}$$

Tractors, Motors, and Power Units [2]

$$RFV = ILP * .680 * .920^{N}$$

Combines [2]

$$RFV = ILP * .635 * .895^{N}$$

Cotton and Corn Pickers [2]

$$RFV = ILP * .585 * .875^{N}$$

Balers and Forage Harvestors [2]

$$RFV = ILP * .560 * .885^{N}$$

Swathers [2]

$$RFV = ILP * .660 * .880^{N}$$

All Non Self-Powered Machinery [2]

$$RFV = ILP * .600 * .885^{N}$$

For application of an equation to estimate yearly depreciation costs of a machine purchased used, the immediate depreciation (SNPFC) becomes a constant equal to .80 with the exception of airplanes where it remains 1.0.

The first four equations were developed for the study. The calculations necessary to develop the first one, for automobiles, will be shown as an example process for each equation.

Table I shows the percent remaining value of the initial list price for each listed make and model of automobile. For uniformity among the automobiles, each listed make and model was considered to be equipped with power steering and automatic transmission.

The average percent remaining value for each year was divided by the average percent remaining value of the next newer model year. These four values were then averaged to obtain the percent remaining value from initial list price for each year, or in the case of automobiles, the value was .7825 rounded upward to yield .790. The average percent remaining value of initial list price at the end of year one was 63.9 percent; yet this is equivalent to 79 percent of the initial list price minus the immediate depreciation cost at the beginning of the year. Therefore, the use of a ratio equation will yield the average percent remaining value of initial list price minus the immediate depreciation cost or in the example of an automobile, drive-around-the-block-depreciation.

$$\frac{.639}{.790} = \frac{X}{1}$$

$$.639 = .790X$$

$$.81 = X$$

Table II illustrates the average percent remaining values of initial list price for each selected make and model of pickups and trucks.

TABLE I

PERCENT REMAINING VALUES OF INITIAL LIST PRICE, AUTOMOBILES

Make	Year 1965	1966	1967	1968	1969
CHEVY					
Bel-Air, 4dr. Sd, V-8	.204	.256	.354	.460	.562
Impala, 4dr. Sd, V-8	.230	.296	.370	.458	.594
Impala, SS, 2dr. Ht, V-8	.269	.339	.400	.497	.640
Caprice, 4dr., V-8	.274	.320	.387	.482	.611
CHEVELLE					
300, Deluxe 6, 4dr. Sd.	.203	.308	.387	.442	.593
Malibu, V-8, 2dr. Ht.	.298	.413	.492	.563	.716
CHEVY NOVA - 6					
4dr. Sd.	.239	.312	.402	.508	.672
CAMERO, V-8					
2dr. Ht.	a	a	.496	.594	.724
PONTIAC					
Exec., 4dr. Sd.	.184	.265	.355	.468	.597
TEMPEST					
LeMans V-8, 2dr. Ht.	.297	.376	.439	.553	.687
OLDSMOBILE					
Delta 88, V-8, 4dr.	.186	.267	.377	.497	.604
F-85, Cutlass, V-8, 2dr.	.294	.397	.473	.553	.674
BUICK					
LeSabra, 4dr., Ht.	.221	.315	.399	.503	.630
Wildcat, 4dr. Sd.	.240	.309	.404	.468	.634
SKYLARK					
2dr. Ht., V-8	.316	.408	.482	.591	.711
CADILLAC					
DeVille, 4dr. Ht.	.255	.349	.471	.609	.739
FORD					
Custom 500, V-8, 4dr. Sd.	.185	.237	.333	.431	.561
Galaxie 500, V-8, 4dr. Sd.	.192	.260	.335	.446	.580
LTD, 4dr. Ht.	.203	.275	.349	.483	.629
XL, 2dr. Ht.	.213	.271	.355	.485	.618

TABLE I (Continued)

Make	Year 1965	1966	1967	1968	1969
FAIRLANE					
500, V-8, 2dr. Ht.	.257	.342	.422	.485	.644
500, V-8, 4dr. Sd.	.222	.305	.387	.456	.611
MUSTANG					
2dr. Ht., V-8	.278	.357	.468	.563	.712
FURY					
III, V-8, 4dr. Sd.	.194	.266	.359	.442	.576
VALIANT					
100, 4dr. Sd.	.183	.274	.393	.445	.650
TOTAL	5.637	7.517	10.089	12.482	15.968
AVERAGE	.235	.313	.404	.489	.639

[a]Not applicable.

TABLE II

PERCENT REMAINING VALUES OF INITIAL LIST PRICE, PICKUPS AND TRUCKS

Make	Year 1965	1966	1967	1968	1969
CHEVY					
Pickup, Fleetside, 6½'	.300	.363	.410	.464	.534
1 Ton, C30, Stake 9'	.332	.410	.470	.520	.592
1½ Ton, C50, Stake 9'	.290	.368	.429	.483	.563
2 Ton, C60, Ch. & Cab.	.294	.391	.416	.486	.545
2 Ton, Q60, Ch. & Cab.	.275	.361	.416	.488	a
FORD					
½ Ton, Style, 6½'	.290	.353	.407	.456	.533
F500, 1½ Ton, Stake 9'	.295	.361	.434	.469	.574
F600, 2 Ton, Stake 9'	.303	.372	.423	.485	.570
N6000, (89BBC), Stake 9'	.303	.371	.411	.496	.563
N7000, (89BBC), Ch. & Cab.	.276	.379	.455	.528	.587
GMC					
½ Ton, W. S. 6½'	.284	.355	.404	.455	.528
DOGE					
½ Ton, Sweptline, 6½'	.250	.319	.389	.442	.524
INTERNATIONAL					
½ Ton, Pickup	.288	.356	.408	.430	.500
ALL	.291	.366	.421	.477	.551
TRUCKS	.296	.377	.432	.449	.571
PICKUPS	.282	.349	.404	.494	.524

[a] Not applicable.

Table III illustrated the average percent remaining values of initial list price for the selected airplane makes and models. The makes and models of cars, airplanes, pickups and trucks were proportionally selected for representation of each group according to the number of units sold in 1969.

TABLE III

PERCENT REMAINING VALUES OF INITIAL LIST PRICE, AIRPLANES

Make & Model	Year 1968	1967	1966	1965	1964	1963
CESSNA						
310	.809	.739	.663	.559	.521	.480
PIPER						
Cherokee 140	.873	.777	.674	.595	.561	a
Cherokee 235	.818	.743	.711	.643	.611	a
Commanche 250	.828	.796	.761	.714	.682	.668
BEECH						
Super Musketeer	.734	.604	.573	.432	.416	.336
MOONEY						
Mark 21	.816	.777	.721	.696	.615	.569
ALL	4.878	4.436	4.103	3.639	3.406	2.053
AVERAGE	.813	.739	.684	.607	.568	.513

[a]Not applicable.

APPENDIX B

APPENDIX B

DEVELOPMENT OF TEST DATA

The values presented in Table IV are the enterprises selected and the units of each enterprise for construction of the hypothetical data sets. Also the identification number used to recognize each enterprise is listed in Table IV. Table V illustrates the machine requirements for each operation per acre of enterprise [20, pp. 24-26, p. 76]. The values in Table V were used to construct Table VI which illustrates the total machine hours required for each enterprise. The values of Table VI were used to construct the machinery and labor usage data. The total hours usage of each machine was multiplied by the assumed cost per hour to obtain the cost by type for each machine, which is represented in Table VII [20, pp. 24-26, p. 76]. The values of Table VII were used to construct the current farm expenses data. The costs of insurance, taxes, and lube were aggregated and prepared as a cost for all machines. Table VIII lists the machines and original cost which was used to construct the depreciation schedule data set.

TABLE IV

SELECTED ENTERPRISES

Enterprise	Acres	Identification Number
Cotton	100	93
Grain Sorghum	80	73
Wheat	120	76
Alfalfa Establishment	60	81
Peanuts	20	95

TABLE V

MACHINE HOUR REQUIREMENTS PER OPERATION PER ACRE

Machine	Cotton	Grain Sorghum	Wheat	Peanuts	Alfalfa Establishment
Tractor[a]	1.883	1.598	.849	1.663	.809
Cultivator	.25	.25		.25	
Planter	.21	.21		.21	
Spring Harrow	.14	.14	.14	.14	.14
Moldboard	.444	.444		.444	
Disc	.17	.17		.17	.17
Grain Drill	.285		.285	.285	.285
Stalk Cutter	.17	.17			
Chisel	.21	.21	.21		.21
Lister				.17	

[a]Tractor time includes 0.042 hours per operation for fertilizer application time.

TABLE VI

TOTAL MACHINE HOURS PER ENTERPRISE

Machine	Cotton	Grain Sorghum	Wheat	Peanuts	Alfalfa Establishment	Annual Hours Use
Tractor	229.62	132.72	156.68	48.82	59.10	689.63
Cultivator	75.00	40.00		10.00		125.00
Planter	31.20	16.80		4.20		52.20
Spring Harrow	14.00	11.20	16.80	5.60	4.20	51.80
Moldboard	13.32	10.64		8.88		32.84
Disc	17.00	13.60		10.20	20.16	60.96
Grain Drill	28.50		28.60	5.70	17.22	80.02
Stalk Cutter	17.00	13.60				20.60
Chisel (or Sweep)	29.40	23.52	100.80		12.48	166.20
Lister				3.40		3.40

TABLE VII

TOTAL COSTS BY TYPE PER MACHINE

Machine	Annual Hours Use	Insurance[a]	Taxes[b]	Repairs[c]	Oil & Lube[d]	Fuel[e]
Tractor	689.63	27.59	68.96	496.53	64.83	432.40
Cultivator	125.00	1.88	5.63	90.00	11.25	
Planter	52.20	1.98	5.74	37.58	4.70	
Spring Harrow	51.80	.52	1.50	37.30	4.66	
Moldboard	32.84	.59	1.77	23.64	2.96	
Disc	60.96	1.40	4.27	43.89	5.49	
Grain Drill	80.02	3.44	10.40	57.61	7.20	
Stalk Cutter	20.60	.35	1.03	14.83	1.85	
Chisel (or Sweep)	166.20	2.16	6.48	119.66	14.96	
Lister	3.40	.13	.37	2.45	.31	

[a]Rate of \$0.04 per hour of usage.

[b]Rate of \$0.10 per hour of usage.

[c]Rate of \$0.72 per hour of usage.

[d]Rate of \$0.09 per hour of usage.

[e]Rate of \$0.63 per hour of usage.

TABLE VIII

MACHINERY LIST PRICE SCHEDULE

Machine	Original Cost
Tractor	$7200
Cultivator	750
Planter	900
Spring Harrow	488
Moldboard	910
Disc	1135
Grain Drill	1033
Stalk Cutter	400
Chisel	650
Lister	900

TABLE IX

ADDITIONAL DEFINED CODE FOR VEHICLES AND MOTOR TYPES OF EQUIPMENT[a]

Code Number	Type of Vehicle or Equipment
696101	Automobiles
.	
.	
.	
696179	
696180	Airplanes
.	
.	
.	
696199	
696201	Pickups
.	
.	
.	
696249	
696251	Trucks
.	
.	
.	
696299	
696301	Tractors
.	
.	
.	
696399	
696401	Motors and Power Units
.	
.	
.	
696499	
696501	Combines
.	
.	
.	
696579	
696581	Cotton and Corn Pickers
.	
.	
.	
696599	
696601	Balers and Forage Harvestors
.	
.	
.	

TABLE IX (Continued)

Code Number	Type of Vehicle or Equipment
696679	
696681	Swathers
.	
.	
.	
696699	

[a]The ATI values of the depreciation schedule data are ATI = 696.

APPENDIX C

APPENDIX C

DATA ON COSTFINDER INPUT CODES AND FORMATS

The COSTFINDER code was extended to formulate a code capable of identifying specific machines and expenses of each specific machine.[2] An example of each method used to expand the code will be presented within this section.

The first example presented in Figure 5 will be for the identification of motorized types of equipment and will apply to the majority of the recognized ATI codes.

The example in Figure 5 illustrates the identification of each specific vehicle or motorized type of machine. This example is applicable to the following ATI numbers: 086, 096, 386, 966, 696, 042, 786, and 796.

The example illustrated in Figure 6 is for the identification of each specific machine. The example presented in this figure is applicable to the following ATI numbers: 087, 097, 387, 967, 697, 787, and 797.

The examples presented in Figures 5 and 6 have been with the employment of six numerical digit code. These examples are applicable for the identification of all vehicles and machines in the depreciation schedule data and the machinery and labor usage data. The itemized

---

[2]The COSTFINDER code is entirely compatible through general with the code formulated for this system of analysis.

expense data requires a seven numerical digit code in order to identify each expense for each machine. An application of the seven numerical digit code is presented as an example for a repair cost to a specific machine in Figure 7.

	General	Detail	Specific	
ATI	0	0	0	General Expense for All Vehicles and Motor Type Equipment
	1	0	0	General Expense for All Cars
			1	Car Number One or Expense for Car Number One

Figure 5. Detailed Illustration of the Vehicle Identification Code

	General	Detail	Specific	
ATI	0	0	0	General Expense for All Machines
	1	0	0	General Expense, All Livestock Feeding Equipment
	1	1	0	General Expense, All Feeders
	1	1	1	Feeder Number One or Expense for Feeder Number One

Figure 6. Detailed Illustration of the Machine Identification Code

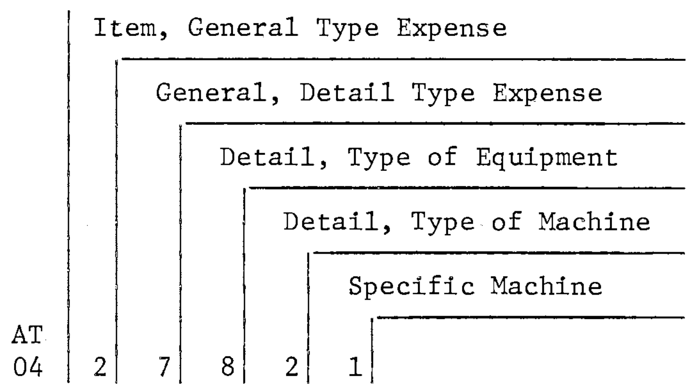

Figure 7. Detailed Illustration of the Itemized Expense Code

In Figure 7 a repair cost for rotary mower number one is coded. If the specific machine number had not been coded, the repair cost would have been prorated proportional to the hours of use for all rotary mowers within the depreciation schedule data of a farm. The example presented in Figure 7 is applicable to the following ATI numbers: 042, 052, 054, 055, and 057. The 047 and 058 ATI numbers did not require any additional extension in the code employed within COSTFINDER.

The COSTFINDER input data forms were selected for adaptation and use within this study.[3] Thus, changes were necessary in the forms in order that they would be compatible to either this system of analysis or COSTFINDER. The first change was the provision for the input of the extended code. The extended code is always right justified in the lot column of each data input form. The second change was the provision to identify the power source as well as the identified machine in the machinery and labor usage data. The power source is identified as the

[3]Forms CF-1, CF-2, and CF-4 of the COSTFINDER system of analysis.

General, Detail, and Specific code illustration in Figure 5 of this appendix. These code numbers are always right justified in the horsepower column of the machinery and labor use form (CF-4).

The application of the correct code number to identify each vehicle or machine is very important in the depreciation schedule data. The depreciation cost for each vehicle or machine is determined by the corresponding type equation listed in Appendix A. The COSTFINDER code for vehicles and motorized items of equipment was defined in more detail within this study to allow proper application of the respective equation to calculate depreciation costs. Table IX defines the code ranges which may be applied to each type of vehicle or motorized item of equipment.

Income
Expense ✓
Inventory ______ REPORT

Farm No. 0470
Month (Yr.) ______
Page ____ of ____ pages

Line	Oper	Lid	Month	Day	CODE Acct	Tran	Item	Gen	Det	Ent	Lot	Ext	Describe As Needed To Identify	Check	Hd. Bu. Tns (Quantity)	Q* Code	Price $	Pounds	Amount $
1					0	4	2	3	0		1		trans overhaul						24.34
2					1	4	2	3	0		1		Starter						22.40
3					1	4	2	3	0		1		Carb kit						7.96
4					0	4	2	7	5		21		planter gearbox						37.58
5					0	4	2	7	4		11		plow points						23.64
6																			
7																			

CAPITAL ASSET DEPRECIATION SCHEDULE

(Land, Machinery, and Buildings; Breeding and Workstock)

Farm No. 0470
Year 1969
Page 1 of 1 pages

Line	Oper	Lid	CODE Acct	Tran	Item	Gen	Det	Ent	Lot	Beg. Yr.	DESCRIPTION	Units	1 Date Bought Da	Mo	Yr	2 Orig. Cost $	3 Salvage Value $	4 7% or 20%	Met Used	Est. Life	5 Ann. Depr. $	6 Value Beg. of Year $
1			6	9	6	3	0		1		4020 SD tr		6	4	69	7200.00			0			
2			6	9	7	5	7		1		Cultivator			6	65	750.00			0			
3			6	9	7	5	2		1		Planter			3	65	400.00			0			
4			6	9	7	4	5		1		Spring harr			4	60	488.00			0			
5			6	9	7	4	1		1		turning plow			3	69	410.00			0			
6			6	9	7	4	3		2		Disc			2	69	1135.00			0			
7			6	9	7	5	1		2		grain Drill			3	67	1033.00			0			
8			6	9	7	8	2		2		Stalk cutter			8	67	400.00			0			
9			6	9	7	4	9		1		Chisel			4	67	650.00			0			
10			6	9	7	5	5		1		Lister			3	68	900.00			0			
11																						

Farm No. 0470
Qtr. (Year) ______
Page ____ of ____ pages

MACHINERY & LABOR USE REPORT

Line	Oper	Lid	Month	Day	Acct	Tran	Item	Gen	Det	Ent	Lot	Wkr. #	Job Performed	Tractor Unit No.	H.P.	Machine Size	Sz Code*	Acres Covered	Man Hours	Machine Hours	Gal. of Fuel	Type**
1			12	17	7	9	6	3	0	93	1		Broadcast ft		301			100.	5.	4.2	18	3
2			12	20	7	9	7	8	2	93	2		Shred stalk		301	4 row	6	100.	20.4	17.0	74	3
3			3	14	7	9	7	4	1	93	1		moldboard		301			33.	16.	13.3	58	3
4			4	30	7	9	7	4	5	93	1		springtooth		301			100.	16.8	14.	61	3
5			5	7	7	9	2	5	2	93	1		Plant		301			100.	25.2	20.8	90	3
6																						
7																						

Figure 8. Example Coding of Data Inputs

APPENDIX D

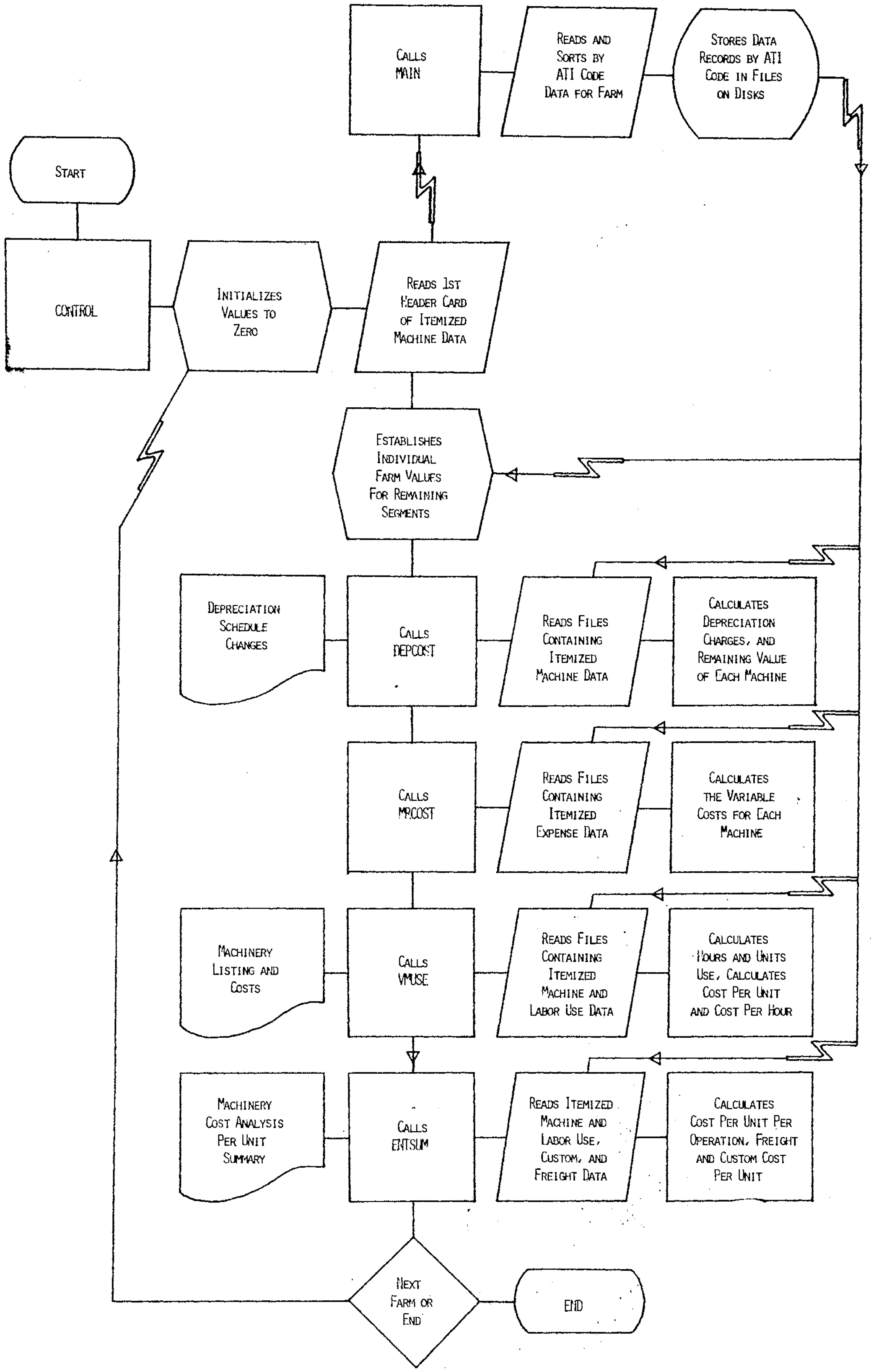

Figure 9. Generalized Flow Chart

TABLE X

MACHINERY LISTING AND COSTS, PAGE 1

Page-Line	Code	Description	Original Cost	Depreciation	Present Value	Interest	Repairs	Taxes
0101	696301	4020 JD Tr	7200.00	2081.18	5118.82	281.54	496.53	68.96
0102	697571	4 Row Cult	750.00	36.05	277.62	15.27	90.00	5.63
0103	697521	4 Row Planter	900.00	43.25	333.15	18.32	37.58	5.74
0104	697451	Spring Harrow	488.00	12.75	98.05	5.39	37.30	1.50
0105	697411	Moldboard	910.00	360.90	549.10	30.20	23.64	1.77
0106	697432	Disc	1135.00	450.14	684.86	37.67	43.89	4.27
0107	697512	Grain Drill	1033.00	63.39	488.23	26.85	57.61	10.40
0108	697822	Rotary Mower	400.00	24.54	189.05	10.40	14.83	1.03
0109	697491	Chisel	650.00	39.89	307.21	16.90	119.66	6.48
0110	697551	Lister	900.00	60.01	483.06	26.57	2.45	.37

TABLE XI

MACHINERY LISTING AND COSTS, PAGE 2

Page-Line	Insurance	Fuel	Lube	Total Costs	Units Used	Hours Used	Cost/Unit	Cost/Hour
0101	27.59	432.40	64.83	3453.03	3390	689.63	1.02	5.01
0102	1.88		11.25	160.08	500	125.00	.32	1.28
0103	1.98		4.70	111.57	250	52.20	.45	2.14
0104	.52		4.66	160.17	400	51.80	.40	3.09
0105	.59		2.96	420.06	80.3	32.84	5.23	12.79
0106	1.40		5.49	542.86	360	60.96	1.51	8.91
0107	3.44		7.20	168.89	280	80.02	.60	2.11
0108	.35		1.85	53.00	180	20.60	.29	2.57
0109	2.16		14.96	200.05	760	166.20	.26	1.20
0110	.13		.31	89.84	20	3.40	4.49	26.42

TABLE XII

MACHINERY COST ANALYSIS PER UNIT FOR ENTERPRISE 93

Operations	Hours Man	Hours Machine	Fixed Costs	Variable Costs
Shread Stalks	0.204	0.170	0.906	0.382
Disc	0.204	0.170	1.984	0.383
Moldboard	0.160	0.133	2.068	0.299
Chisel	0.353	0.294	1.165	0.662
Broadcast Fert.	0.050	0.042	0.143	0.058
Springtooth	0.168	0.140	0.554	0.315
Plant	0.252	0.208	1.019	0.468
Plant	0.126	0.140	0.510	0.234
Cultivate	0.300	0.250	1.010	0.560
Cultivate	0.300	0.250	1.010	0.560
Cultivate	0.300	0.250	1.010	0.560
Seed Rye Cover	0.342	0.285	1.388	0.641

Total Fixed Costs	Total Variable Costs	Total Machine Costs
12.77	5.12	17.89

Custom Costs	Costs/Unit
Spray Insecticide	2.00
Spray Insecticide	2.00
Spray Insecticide	2.00
Bulk Spreader	.15
Defoliant Spray	3.00
Hauling	.75
Ginning	6.30
Total Custom Costs	16.20
Freight Costs	Cost/Unit
Total Freight Costs	0.00
Total Machinery Costs Per Unit	34.09

VITA γ

John Edward Patton

Candidate for the Degree of

Master of Science

Thesis: THE DEVELOPMENT OF A COMPUTERIZED ALGORITHM TO MEASURE THE INDIVIDUAL MACHINE COST

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