A decision model of combine ownership
by Haifie Loo Lai

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Applied Economics
Montana State University

Abstract:
General characteristics of the harvesting operation for wheat and barley are explored. Data associated with harvesting variables are collected for the Triangle Area in Montana. A simulation model is constructed which incorporates the critical factors involved in the harvesting operation. Strategies for combine ownership are determined through cost calculation via the computer simulation model. It is found that for small farms partly own combining and partly custom combining is the best alternative. For larger farms, however, farmers are better off completely doing their own combining.

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Approved:

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ABSTRACT

General characteristics of the harvesting operation for wheat and barley are explored. Data associated with harvesting variables are collected for the Triangle Area in Montana. A simulation model is constructed which incorporates the critical factors involved in the harvesting operation. Strategies for combine ownership are determined through cost calculation via the computer simulation model. It is found that for small farms partly own combining and partly custom combining is the best alternative. For larger farms, however, farmers are better off completely doing their own combining.

CHAPTER I

INTRODUCTION

Problem Statement

Since World War II, through the rapid development of technology, there has been a trend toward mass production by substituting capital for labor. In agriculture, because of the seasonal character of production, this trend increases the penalties associated with untimely operations. The time limits involved in agricultural production do not allow extended usage of the larger investment for mass production. Farm management in developed countries has thus moved to a new stage requiring the discipline of business management to ensure minimum loss. Harvest, for example, has become one of the critical seasonal operations which needs detailed systems analysis. The total volume of the crop has expanded but time limits imposed by climate and quality considerations have not changed. Thus, selection of an optimum harvest system is of critical importance to farmers. An efficient selection and utilization of the harvesting machinery can contribute substantially to the minimization of total cost.

In Montana, where agriculture constitutes the most important sector of the economy, investigation of the most efficient farming system certainly cannot be neglected. For harvest, farmers in Montana have four different systems to choose from: (1) use of custom services to avoid the commitment of fixed costs; (2) purchase of large machines of higher capacity and higher fixed costs; (3) purchase of less costly, lower capacity machines; or (4) some combination of the above. The choice depends on the harvesting rate, fixed costs, and variable costs. Due to the uncertainty of the harvesting operation these costs are not some unique value. The cost varies with the physical and yearly environmental factors. For the per unit cost curve of a machinery system, a theoretical distribution exists due to all possible interactions between the probabilistic harvest variables. Traditional budgeting analysis provides only guidelines for farmers in selecting alternative machinery systems. More precise information is provided by a cost analysis which includes the dynamic nature of variables which vary year by year due to different environmental factors.

To determine strategies for harvesting machine ownership, the Triangle Area in Montana (northcentral Montana including part of Cascade, Teton, Pondera, Toole, Liberty, Hill, and Chouteau counties) was chosen. This area is a predominantly agricultural area specializing in grain production with rather uniform farming practices and climatic characteristics. The dynamics of the harvesting operation will be analyzed to give more details of a system's performance and behavior under changing environmental conditions. This information will place farmers in a better position for decision making.

Summary of Past Work

Several different methods have been used before to approach this specific machinery selection problem. Traditional budgeting analysis has been used widely to provide general guidelines in selecting alternative machinery systems. However, the dynamic nature of the critical variables involved suggests that the approach may omit important cost variables. In the United States, Heady and Krenz [11] have developed a modification of the traditional budgeting analysis. They categorized a historical weather sequence into five categories, then for each category they calculated the net returns for a machinery combination at various acreage levels. The return in each weather category was then weighted to obtain an expected value at each acreage level. This procedure provided more information than the traditional static cost analysis method but was still based on rather simplified assumptions.

A better approach that has been employed is systems analysis through simulation. In England, Donaldson [6] and Dalton [4] both used simulation to investigate the harvesting operation. Both were concerned mainly with the relationships between harvesting moisture content, dryer capacity, and combine header work rate. Donaldson included part of the dynamic effects of weather in the analysis. However, due to the lack of data, some probabilistic factors were still taken as assumptions. Dalton incorporated more detailed relationships between interacting variables in the analysis through mathematical equations estimated from experimental data.

Van Kampen [28] in the Netherlands also constructed a simulation model by including detailed relationships between the most critical interacting variables. He applied this model to study the chain of operations involved in the organization of harvesting, transportation, drying, and storage of the grains with a number of header widths and auxiliary equipment. The Australian model constructed by Ryan [22] is simpler. Due to the lack of experimental data, Ryan used agronomists' estimates of the dynamic variables. This simulation evaluated a contract harvesting system, a power take-off harvesting system, and a self-propelled harvesting system.

Proposed Problem-Solving Method

From the survey of past work investigating the machinery selection problem, simulation appears to be the most rewarding approach. Because of the complexity of the harvesting operation and the large number of stochastic variables involved, no other mathematical programming model is better suited. Systems simulation approach allows investigation of the complex harvesting operation by building into the computer model the dynamic aspects of harvesting. The stochastic variables are also specified as density functions, instead of as single-valued deterministic variables. This descriptive model of the actual harvesting system can then be run over a number of "years" to investigate the performance of each given machinery system at different acreage levels. Each "year" a new set of harvesting conditions is provided. Parameters may also be altered to test their effect on the system with little or no addition to the computational load of the researcher. In other words, simulation allows the researcher to try out a whole set of alterations to the existing state of affairs without much computational effort. Through such "experimentation," the interaction of the systems' performance can be made clear. Hence, this is the approach proposed here to analyze combine ownership strategies.

Objectives of the Study

The objectives of this study are:

1) To identify, and where appropriate estimate, the probability distributions of variables that affect the harvesting operation.
2) To estimate the cost curves of the harvesting operation under different machinery systems.
3) To identify the most critical elements which affect the cost of harvesting and reveal the characteristics of the system's performance.
4) To establish some criteria for selecting the optimal machinery system.

CHAPTER II

METHODOLOGY

Systems simulation approach is used in this study. A descriptive model of the actual harvesting system is first built into the computer. Experimentation to determine the system's behavior can then be easily performed. Building this descriptive model so that the results of the experimentation fit closely to reality is important. The characteristics of the actual system and its interacting environmental variables must be carefully investigated. In this chapter, the general characteristics of the problem area, the critical factors and variables involved, and the simulation model developed are discussed in Sections 1, 2, and 3, respectively.

1. Characteristics of the Farms in the Triangle Area

Farm Size

According to a survey [9] conducted in 1972, the average size of a farm in 1972 was 1,985 acres. The acreage planted was 48 percent of the acreage operated. In this area, due to relatively low annual moisture, crop-fallow rotation is almost a universal practice.

Major Crops

Three major crops in this area are winter wheat, spring wheat, and barley. Given no government intervention and the relative prices in the past, winter wheat is the major crop.

Machinery Use

According to the survey, out of 176 operators 92.6 percent own combines. Approximately 62 percent hired no custom combining during the six-year period, 1967-1972. Only 6 percent hired their entire crop combined each of the six years. The remaining 32 percent varied the amount of custom combining hired from year to year. It is usually possible to hire custom combining from the local area if a farmer is behind in harvesting, however, the possibility is rather low. Only very limited amounts of drying capacity are available in the area.

Farming Activities

For a winter wheat-fallow enterprise, the sequence of operations is depicted in Figure 2-1.

2. Critical Factors and Variables

Weather is the source of all changing environmental factors in harvesting operations. It affects the cost of combining directly through the length of harvest period, grain weather damage, and indirectly through biological factors such as crop yields and grain shatter losses. Under an optimal harvesting condition, gains can be obtained from a higher rate of work, longer working time allowed per day, and higher quality and larger quantity harvested. However, the longer harvesting is delayed waiting for an optimal harvesting day,

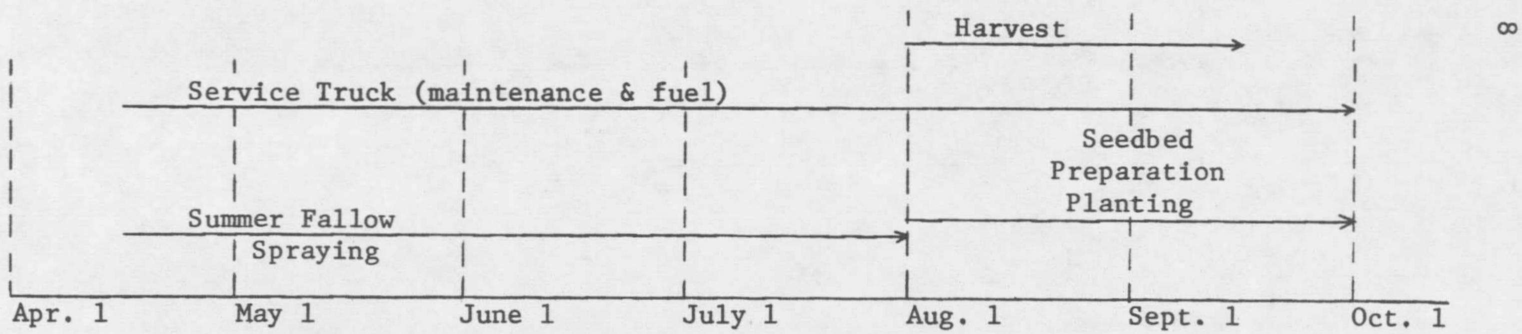

Figure 2-1. Sequence of Operations for Winter Wheat-Fallow Enterprise.

the higher the losses incurred from grain weather damage, grain shattering, and idle labor hours. Somewhere in between the two extremes there lies the minimum cost.

The selection of a particular combine depends not only upon the factors discussed above, but is also affected by the availabilities of custom services and the fixed and operating costs incurred by ownership. These relationships are illustrated in Figure 2-2.

The variables thus identified in the model are:

1) length of harvest period;
2) non-harvestable days within the harvest period;
3) grain-weather damage;
4) crop yield;
5) grain shatter losses;
6) fixed costs;
7) operating costs;
8) rate of work;
9) working time allowed per day; and
10) availability of custom combining.

3. Simulation Procedures

Estimates of the distribution of costs under alternative machinery systems are obtained through simulation. At the beginning of the simulation an acreage level is set. A specific combine size and the

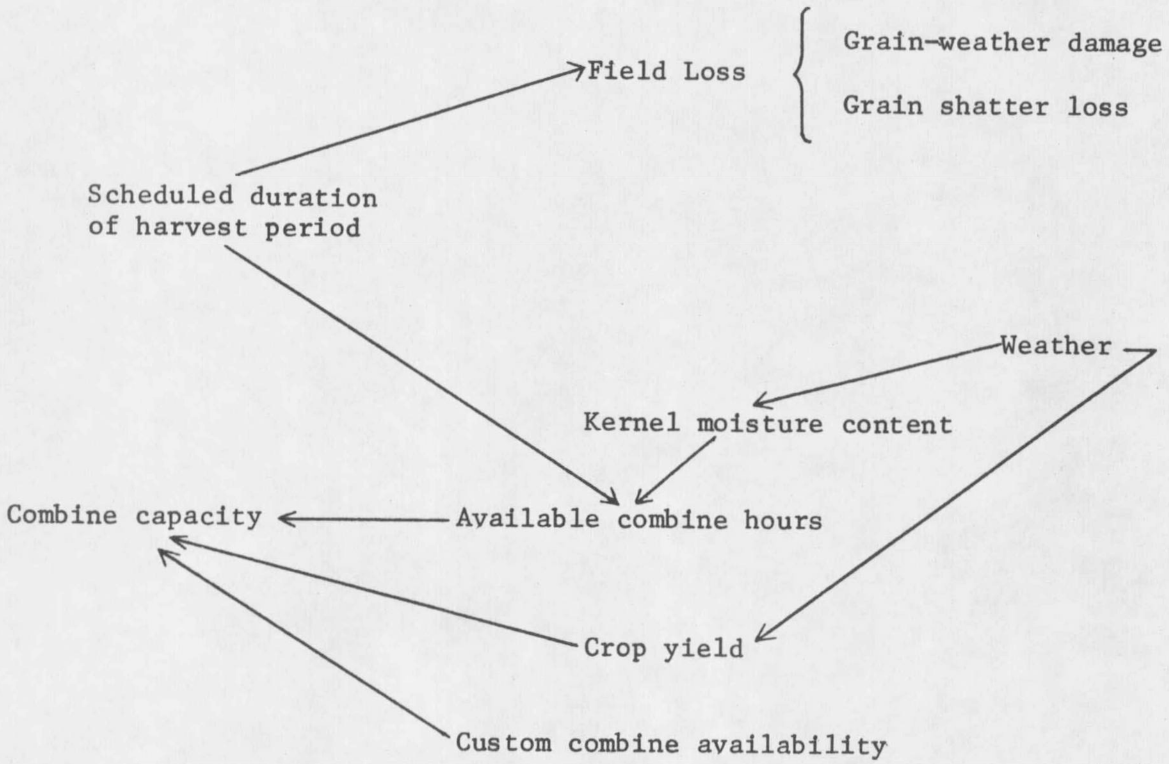

Figure 2-2. Relationships Between the Critical Factors.

harvesting system is selected. The simulation starts from the first day of the harvesting season on the first year. Each day the harvesting condition is examined to determine the number of work hours available on that day. According to the particular harvesting system selected, checks are then made to determine whether custom combine services are needed, and if so, the possibility of their availability. Then the operating cost incurred and the cost from shattering loss are calculated. This procedure moves on day by day until the last day of the season, or until the total acreage is harvested. Charges for repair, engine oil, and other lubricants are added next to the accumulated cost over the whole season. This procedure is repeated for the second year, third year, and so on to the fifteenth year. The present value of total cost is obtained by adding up the present value of each season's accumulated cost and the present value of the total ownership cost. This cost represents the present value of the accumulated total cost over 15 years. In this study the simulation is run for two acreage levels, 960 acres and 2,240 acres, and three different harvesting systems. The three different harvesting systems are as follows.

Harvest By Own Combine

These farmers have their own combine and utilize it to harvest the entire crop. They would hire custom combining only after half of the season has passed, and they have less than 40 percent of their acreage harvested. The only custom combining service they can possibly find is from their neighbors who have excess capacity. The simulation procedure of this harvesting system is illustrated in Figure 2-3.

Harvesting Partly By Own Combine And Partly By Custom Combine

These farmers hire some of their crop combined. In practice, the percentage usually varies year by year. Larger farms usually have a greater percentage of their crop custom combined than smaller farms. The time that the custom combiner will arrive is set in advance, however, it is still subject to change due to harvesting period weather and the level of yield for the year. The simulation procedure is illustrated in Figure 2-4.

Harvesting Entirely by Custom Combine

These farmers hire all of their crop combined. The time that the custom combiner will arrive is again set in advance, and it is still subject to change due to harvesting season weather. The simulation procedure of this system is illustrated in Figure 2-5.

The simulation of these three harvesting systems will consider two cropping patterns, 100 percent winter wheat, and 70 percent winter wheat-30 percent barley.