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A Multivariate Analysis of Factors Influencing Farm Machinery Purchase Decisions

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This paper presents a model of the farm management process. The model suggests that certain socioeconomic characteristics of farm managers will influence their decision-making process. Several characteristics are hypothesized and tested using multivariate techniques (multivariate analysis of variance, range tests, and multiple comparisons). The analysis indicates that the soil zone, value of machinery inventory, operator's age, and operator's education influence the importance placed on each of 20 factors. On the basis of the analysis it was concluded that such a model of the farm management process can contribute to an understanding of farm management decisions. In addition, it was concluded that farm managers, farm machinery dealers, and extension agents had significantly different perceptions of the importance of these factors to farm managers. This latter conclusion suggests that more research related to the actual process of decision making is warranted.

The selection of machinery that is suitable and profitable for their particular farm business is a recurrent, complex, and important decision confronting farm business managers. A conceptual model of the management process is presented that includes a criteria-based decision analysis introduced as a complement to neoclassical microeconomic theory. In a survey of farm business managers, machinery dealers, and agricultural representatives (extension agents), farmer respondents were asked to rate the importance of various factors in making machinery purchase decisions, and machinery dealer and agricultural extension agent respondents were asked to rate the importance of various factors to farmers making machinery purchase decisions. Multivariate analysis procedures are used to test whether certain characteristics of the farm and the farm business manager have an effect on the importance attributed to factors affecting farm machinery purchase decisions, and whether machinery dealers and agricultural extension agents differ significantly from farm business mangers in their rating of the importance of these same factors.

The objectives of the research were to: 1) test the relative importance of various socioeconomic characteristics on the decision to purchase machinery, and 2) to determine how accurately farm machinery dealers and agricultural extension agents understand the decision-making processes of farmers.

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The authors with to thank anonymous reviewers for their useful comments on an earlier draft.

Western Journal of Agricultural Economics, 10(2): 294–306
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Neoclassical Theory and Decision-Making Models

Neoclassical microeconomic theory proposes to predict the behavior of decision makers under a variety of circumstances, yet, by itself, it is lacking as a basis for predicting or even understanding routine farm management decisions. To understand the purchase of farm machinery and other day-to-day decisions of farm managers, neoclassical microeconomic theory should be supplemented with a vastly different approach. This approach must consider a number of questions. "How large a machine should be purchased?" "Should it be new or used?" "What special features should it have?" "When should it be replaced?" And, perhaps most importantly: "What will my friends and neighbors think of my decision?"

Effective management of a commercial farm requires the majority of these decisions to be correct. Farm managers require access to both information and a process. The information (or content of management) includes the myriad of technical, biological, economic, and sociological data related to a modern agricultural enterprise. The management process is the implicit or explicit method used by the manager to assimilate the information and arrive at an end, usually the accomplishment of predetermined goals. All managers, whether aware of it or not, necessarily employ a management process. The sophistication and nature of this process varies widely from one manager to another. Poor management results can occur because of inadequate content, an inadequate process, or some combination of both.

A management process outlined by Cromier, Mitchel, and McGiffin (based on concepts developed by Kepner and Tregoe) is a model of an actual management procedure which conveniently traverses the gap between microeconomic theory and real world situations. Figure 1 depicts the major components of this model, which include issue analysis, problem (opportunity) analysis, decision analysis, and action planning or potential problem analysis. Issue analysis is the usual starting place for the process and encompasses the formulation of business and personal goals and

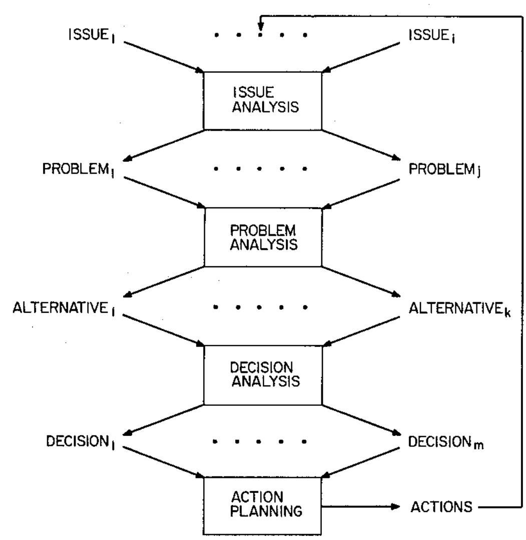

Figure 1. A Model of the Management Process.

the prioritization of issues. Problem (opportunity) analysis is the process of recognizing problems, specifying the what, where, when, and extent of the problem, analyzing for distinctions and changes, and finding and testing the cause. Decision analysis is the process of setting and classifying criteria, comparing and choosing among available alternatives based on the criteria, and assessing the adverse consequences associated with the choice. Finally, potential problem analysis and action planning outline the procedures to be taken to insure that decisions and problems are acted upon and that goals are met. This procedure includes the anticipation of potential problems and their possible causes, the taking of preventative action, and, in case this fails, the making of contingency plans. Each component of the management process can interact with any one of the other three components at any given time. For example, new priority issues may arise when business and personal goals change as a result of the problem solution, potential problem analysis, or decisions being made. In addition, decisions may trigger new problems and action plans and vice versa.

The decision analysis component is of particular concern in this paper; therefore, its description is expanded here. The manager begins decision analysis by stating as concisely as possible the decision that is to be made. For example, "What tractor size and type is best for my farming situation?" Next, the manager makes a list of the criteria upon which the decision will be based. Criteria usually include power and time requirements, model or make reputation, cash and credit constraints, and technological and other options. Some of these criteria are mandatory; others are desirable. Mandatory criteria must be objective, realistic, and measurable whereas desirable criteria can simply be statements of the manager's preferred results. Desirable criteria are personal and do not have to be objective, realistic or measurable, but they do have a potential influence on the decision choice. Each alternative—size and make of tractor, various financing arrangements—that meets the mandatory criteria is considered in terms of the desirable criteria. The desirable criteria are weighted according to importance, and each alternative is scored for each desirable criterion. Which criteria are included, and the weighting of each, is itself a decision variable. Managers, as circumstances change and as they acquire experience, will add and delete criteria and change the relative weighting. The alternative with the highest weighted score across all desirable criteria is the manager's preliminary choice.

Before making the final decision, the manager analyzes the risk involved. He considers the most dangerous scenario possible, and compares his preliminary choice with perhaps two of the next best alternatives. The dangers involved in choosing any one of these top alternatives are assessed in terms of the perceived probability and severity of their occurrence. For example, the first-chosen alternative could be manufactured by a company that has a high probability of going bankrupt and the manager might be afraid of a future lack of spare parts. The final choice is based on the results of the preliminary choice and the risk analysis.

TABLE 1. Factors a Farmer May Consider When Purchasing a Tractor or Combine.

1.	Change in Size of the Farming Operation
2.	Time Available Due to Weather
3.	Time Available Due to Labor Supply
4.	Time Available Due to Desire for Leisure
5.	Soil Texture
6.	Topography
7.	Size of Other Machinery Already Being Used
8.	Old Machine Wearing Out
9.	New Model has Improvements not on Old Model
10.	More Income Tax Deductions
11.	Money Available to Pay Cash
12.	Credit Available
13.	Custom Hiring of Machine Work for Others
14.	Fuel Efficiency
15.	Past Experiment Indicates the Benefits Outweigh the Costs
16.	Mental Calculation Indicates the Benefits Outweigh the Costs
17.	Written Calculation Indicates the Benefits Outweigh the Costs
18.	Farm Records Indicate the Benefits Outweigh the Costs
19.	Family Persuasion
20.	Friends' and Neighbors' Persuasion

Hypotheses

The value of the above model is that it stresses the preparatory stages of management, and suggests that management decisions are based on several factors whose relative importance varies among managers. Thus, it seems useful to gain a better understanding of the determinants of the factors used by farm managers in machinery purchase decisions. In this study, farmers were asked to rate a series of factors according to importance in their farm machinery purchase decisions (Table 1), and machinery dealers and agricultural representatives were asked to rate the importance of the same factors to farmers. These factors are interpreted as a list of possible desirable criteria for farm machinery purchases. The objective is to see if these selected factors are actually important in farm machinery purchase decision making and under what conditions that importance changes. The list does not include all possible criteria and does not cover the entire machinery purchase decision. Other decisions related to machinery purchases are not addressed: "Do I need a new machine in the first place?" "What specific set of characteristics should the maching have?" "From whom should I purchase the machine?" Also, each factor on the list would most likely be reworded in an actual decision analysis to more accurately reflect the manager's desired results. For example, "change in size of farming operation" could be reworded to "If I rented an additional 200 acres of land, would the combine be large enough to complete harvesting in good time?"

Each manager has a unique situation and conceptually weighs the various desirable factors differently when making a farm management decision. For example, some managers may feel that timeliness is of particular importance while, to others, cash flow considerations may be a greater concern. If farm managers maximize utility rather than profit, they may consider certain noneconomic factors important.

To the extent that the general characteristics of farms influence the economic forces acting on farm managers, these same forces may influence what farmers perceive as important considerations. Following this logic, it is hypothesized that the importance that farmers place on various considerations when purchasing farm machinery is influenced by:

1) the soil zone in which the farm is located;
2) the type of products produced on the farm;
3) the size of the farm;
4) the current value of the machinery inventory;
5) the operator's age; and
6) the operator's education.

Furthermore, it is hypothesized that machinery dealers and agricultural representatives understand the decision-making process which farmers employ and can accurately predict the factors that farmers consider important.

The Data

The data for this study were obtained from a mail survey undertaken in 1980 [Brown and Strayer]. The survey sample was drawn from those Saskatchewan farmers who registered a farm truck with a Gross Vehicle Weight of 11,000 pounds or greater, because, in the authors' experience, bona fide farmers almost always own their trucks and it was desirable to eliminate hobby farmers from the sample.

The survey questionnaire listed a number of factors which were hypothesized to be important in a farmer's decision to purchase a tractor, combine, or both (see Table 1). The farmer was asked to rate the importance of each factor in his decision-making process by responding with 1, 2, 3, or 4. (A "1" signified not important and a "4," very important.) In addition to rating these factors, the farmers were asked several questions with respect to the physical and socioeconomic characteristics of their farm operation.

A total of 4,939 farmers was sent the questionnaire in February 1980 and 1,482 responded. Of these, 577 responses were rejected because they were incomplete, leaving 905 responses for use in this study.

To supplement the responses by farmers, questionnaires were mailed to the 405 Saskatchewan members of the Saskatchewan-Manitoba Farm Implement Dealers Association and to all 42 Agricultural Representatives (extension agents) in the Saskatchewan Department of Agriculture. These extension agents and dealers were asked to rate the decision-making criteria in such a way as to describe what they perceived as most important/least important to the farm operators. A total of 132 machine dealers and 30 extension agents provided usable responses.

Multivariate Analysis

The purpose of this study was to test the null hypothesis that certain characteristics of the farm and socioeconomic characteristics of the farm operator have no effect on the importance that respondents attribute to the decision-making factors. Simply stated, do farmers facing different circumstances place different weights on farm machinery decision-making factors? While it would be rather straightforward to test for significant differences among groups on the basis of a single variable, our conceptual model predicts that many factors are weighted simultaneously; thus, multivariate analysis is more appropriate than the traditional univariate analysis since it considers the interdependency among these factors. A single multivariate analysis with many dependent variables incurs much less risk of committing a Type I Error than do several univariate analyses with one dependent variable each. For both heuristic and rigorous discussions of the appropriate applications of multivariate analysis, see Harris and Morrison.

In the first part of the analysis, six farm and socioeconomic characteristics are treated as independent variables. These are (1) soil zone, (2) farm type, (3) farm size, (4) present value of farm machinery, (5) operator age, and (6) operator education. Each of these variables is discrete.

The first step is to determine if any overall relationship exists between the decision factors and the six independent variables. Since all of the independent variables are discrete, multivariate analysis of variance (MANOVA) is most appropriate. For $k = 6$ discrete independent treatments, a six-way MANOVA is performed. Such a test indicates the amount of variation in the dependent variables, explained by the k treatments. If one of the k treatments is age, for example, MANOVA will indicate (at a given level of significance) if an operator's age influences his (her) system of weights.

Should any independent variable have a significant effect, then further analysis is required to determine which level or levels of that independent variable are significantly different from each other. To this end simultaneous multivariate multiple comparisons (SMMC) are employed. This method, for example, will determine, should the farmer's age be proven significant by the MANOVA, whether those farmers in any particular age group are significantly different from others in their overall rating of the decision-making factors.

The strategy of SMMC in this analysis involves the performance of several one-way MANOVAs for a given significant independent variable (such as age). The MANOVAs are achieved through multivariate regression with dummy variables. By successively removing different dummy variables, F statistics can be calculated for the marginal contribution of each level of the variable. If the F statistic is greater than the appropriate critical value, then the associated group or discrete value has a significant effect on the decision-making process. If the F statistic for farmers under 25 is significant, for example, the analyst can conclude that younger farmers make decisions on the bases of different factors.

At this point the analysis will indicate which independent treatment variables have a significant effect on the overall weighting, and, for those which are significant, which levels of the treatment have a significant effect on the overall weighting of factors. This knowledge in itself tells a great deal about the factors influencing an individual's decisions, but the analyst may want to know if this significant effect on the overall weighting is focused on any particular decision factor or group of factors. To this end, range tests—univariate or multivariate—may be

TABLE 2 Number of Observations in Each Level of the Six Independent Variables.

Variable	Response	Class	Number of Observations
Soil Zone	1	Brown	237
	2	Dark Brown	279
	3	Black	389
Farm Type	1	Grain	537
	2	Mixed	350
	3	Livestock	18
Farm Size	1	<640 Acres	216
	2	640–1,279 Acres	374
	3	1,280–1,920 Acres	192
	4	>1,920 Acres	123
Value of Machinery Investment	1	<$50,000	219
	2	$50,000–$149,000	487
	3	$150,000–$249,000	158
	4	$250,000–$350,000	29
	5	>$350,000	12
Operator Age	1	<25 years	34
	2	25–40 years	352
	3	41–65 years	493
	4	>65 years	26
Operator Education	1	<6 years	15
	2	7–9 years	240
	3	10–12 years	456
	4	Technical Diploma	108
	5	University Degree	86

used on each of the decision-making factors. The more tests run, the greater the chance that at least one leads to an incorrect conclusion. Thus, for more than one test, the univariate method underestimates the probability of a Type I Error in at least one test. The multivariate test considers the number of individual tests and is therefore less discerning.

Range tests construct a confidence interval (for a given confidence level) around the mean value of the dependent variable associated with each level of an independent variable. Should all mean values of the dependent variable fall within the same confidence interval, then it follows that the associated independent variable does not make its contribution through this particular dependent variable. For example, if the comparisons above indicate that age is a factor, and that younger farmers tend to make different decisions, then the range test can pinpoint which particular factors they consider more or less important. If the mean responses for all age groups fall into the same confidence interval, then it is possible to conclude that age does not have its effect in this factor (or factors). The multivariate test employs a procedure detailed in Morrison [pp. 194–204] and Heck [p. 627].

As noted earlier, the survey also included a sample of machinery dealers and agricultural extension agents. These two groups were asked to rate the importance of each factor in the farmer's decision-making process. Given these data, it is possible to test the null hypothesis that there are no significant differences between farmers, machinery dealers, and agricultural extension agents in their perception of the importance of each decision-making factor in the farmer's decision-making process. To test this hypothesis, a one-way MANOVA is performed in which the single treatment includes three occupations—farmer, extension agent, and machinery dealer.

Should the analysis indicate that any two of the three occupational groups are significantly different in their factor ratings, then it will be of interest to determine which of the dependent variables contribute to this difference. Here univariate and multivariate range tests, as described previously, are employed.

Analysis

Table 2 indicates the distribution of observations among the various levels of the six independent variables. Table 3 gives the mean response to each factor for each class of each independent variable. The object of the following analysis is to determine if there are any statistical differences among these means.

First, which, if any, of the six indepen-

TABLE 3. Mean Responses to Twenty Factors by Levels of Independent Variables.

Decision Factor	Overall Mean	Soil Zone			Farm Type			Farm Size				Value of Machinery Investment	
		I	II	III	I	II	III	I	II	III	IV	I	II
1	3.256	3.262	3.226	3.275	3.242	3.277	3.278	3.176	3.222	3.391	3.293	3.274	3.240
2	3.204	3.093	3.211	3.267	3.233	3.169	3.056	3.056	3.195	3.292	3.358	3.059	3.177
3	2.873	2.722	2.910	2.938	2.879	2.860	2.944	2.690	2.781	3.094	3.130	2.671	2.858
4	1.830	1.865	1.896	1.763	1.858	1.791	1.778	1.759	1.869	1.771	1.935	1.721	1.897
5	2.335	2.228	2.348	2.391	2.341	2.331	2.222	2.398	2.350	2.281	2.260	2.338	2.349
6	2.512	2.540	2.513	2.499	2.467	2.591	2.389	2.458	2.529	2.589	2.447	2.502	2.528
7	3.036	3.097	3.043	2.995	3.006	3.089	2.944	2.954	3.053	3.089	3.049	2.936	3.057
8	3.316	3.401	3.287	3.285	3.291	3.340	3.611	3.255	3.307	3.344	3.407	3.324	3.316
9	2.684	2.629	2.746	2.674	2.717	2.649	2.389	2.519	2.706	2.760	2.788	2.498	2.717
10	2.695	2.713	2.767	2.632	2.689	2.714	2.500	2.588	2.701	2.797	2.707	2.507	2.719
11	2.879	2.873	2.860	2.987	2.847	2.920	3.056	3.060	2.920	2.729	2.675	3.023	2.881
12	2.726	2.717	2.738	2.722	2.659	2.834	2.611	2.731	2.703	2.714	2.805	2.749	2.735
13	1.715	1.722	1.760	1.679	1.670	1.783	1.722	1.750	1.717	1.714	1.650	1.749	1.723
14	3.193	3.131	3.211	3.219	3.123	3.291	3.389	3.296	3.184	3.219	3.000	3.342	3.168
15	3.121	3.097	3.204	3.077	3.110	3.129	3.333	3.056	3.072	3.240	3.203	3.073	3.067
16	2.653	2.540	2.677	2.704	2.620	2.711	2.500	2.644	2.620	2.677	2.732	2.635	2.649
17	2.897	2.945	2.889	2.874	2.898	2.889	3.056	2.912	2.848	2.906	3.008	2.918	2.869
18	3.072	3.122	3.093	3.026	3.039	3.131	2.889	3.046	3.056	3.109	3.106	3.068	3.057
19	1.843	1.835	1.817	1.866	1.797	1.897	2.167	1.931	1.770	1.922	1.789	1.836	1.860
20	1.462	1.460	1.498	1.440	1.473	1.443	1.556	1.542	1.471	1.438	1.341	1.571	1.468

dent variables lead to a significant difference in responses? Table 4 reports the results of a six-way MANOVA that measures the differences in response due to farm and operator characteristics. All but farm size and farm type have a significant influence on responses at the 95 percent level or better. It is important to recall that this result does not imply that farm type and farm size do not influence which machines are purchased or the amount of machines purchased. Rather, it suggests that the factors which decision makers take into consideration are the same for small and large farms and for grain, mixed, and livestock farms. This finding vividly distinguishes the neoclassical decision model (which would consider only farm type, farm size, and machinery inventory), from a farm management process model.

Soil zone, value of machinery inventory, the operator's age and education all tend to influence the factors considered by farmers. The next issue is which soil zones, which age groups, etc., lead to different responses. The results of the various one-way MANOVAs and the multiple comparisons are reported in Tables 5 and 6. Table 5 indicates the F statistic related to each pair of levels within an independent variable. The numbers in brackets are the probability that the two groups come from the same population. Table 6 summarizes this information for three levels of significance.

These tables indicate that the responses of farmers in the brown soil zone differ from those in the black zone, but that those of the dark brown zone are intermediate and thus indiscernible from either. At the 95 percent significance level those operators with less than $50,000 of machinery (category 1) and those with more than $350,000 of machinery (category 5) gave distinct responses. Categories 2 and 3 can be distinguished but category 4 is inter-

TABLE 3. Extended.

Value of Machinery Investment			Operator Age				Operator Education				
III	IV	V	I	II	III	IV	I	II	III	IV	V
3.304	3.207	3.083	3.353	3.384	3.166	3.115	3.533	3.154	3.276	3.333	3.291
3.443	3.276	3.667	2.941	3.241	3.205	3.038	3.400	3.242	3.213	3.102	3.151
3.139	3.172	2.917	2.676	2.949	2.832	2.885	2.933	2.829	2.864	2.861	3.047
1.810	1.793	1.500	2.088	1.855	1.813	1.500	1.400	1.788	1.833	1.861	1.977
2.253	2.414	2.583	2.088	2.207	2.438	2.423	2.400	2.617	2.296	2.185	1.903
2.462	2.690	2.417	2.529	2.403	2.604	2.269	2.200	2.663	2.509	2.556	2.128
3.095	3.241	2.750	2.971	3.037	3.037	3.115	3.400	3.038	3.061	2.944	2.953
3.266	3.414	3.583	3.618	3.330	3.292	3.192	3.000	3.329	3.303	3.370	3.337
2.810	2.931	2.500	2.794	2.668	2.690	2.654	2.533	2.817	2.662	2.611	2.547
2.791	3.069	3.000	2.941	2.580	2.777	2.385	2.800	2.821	2.700	2.639	2.372
2.665	2.966	2.833	2.824	2.798	2.939	2.923	3.267	3.033	2.866	2.769	2.593
2.595	3.276	2.333	3.147	2.733	2.704	2.500	2.333	2.850	2.754	2.574	2.488
1.614	1.759	2.000	2.000	1.682	1.728	1.538	1.467	1.804	1.732	1.630	1.523
3.051	3.414	2.833	3.118	3.148	3.219	3.423	3.667	3.417	3.163	3.019	3.012
3.310	3.379	3.167	3.000	3.037	3.183	3.269	3.267	3.229	3.116	3.102	3.849
2.646	3.034	2.333	2.706	2.696	2.617	2.692	2.867	2.796	2.629	2.565	2.453
2.842	3.345	3.333	3.088	2.980	3.826	2.846	2.667	2.900	2.895	2.917	2.919
3.057	3.276	3.417	3.294	3.000	3.101	3.192	3.200	3.121	3.105	2.954	2.884
1.753	2.138	1.750	1.853	1.741	1.913	1.885	1.667	2.029	1.811	1.741	1.651
1.335	1.310	1.333	1.647	1.477	1.436	1.538	1.533	1.533	1.439	1.389	1.477

mediate and not distinguishable from either. With respect to age, farmers under 25 years (category 1) are significantly different from all others at the 95 percent confidence level. Those 25 to 40 are distinguishable from those 41 to 65, but farmers over 65 are not distinguishable from either the 25 to 40 or the 41 to 65 age group. Finally, with respect to education level, each group is significantly different from all others except those with a technical diploma (category 4), which is an intermediate between those below and above.

Thus there is a considerable amount of regularity in the responses due to relationships between the responses and characteristics of the farm and farm operator. While it is difficult to impute any ordinal relationships when a multivariate technique is employed, the analysis seems to indicate a linear gradation of responses as soil zone and education change, and a curvilinear (U shaped) change as age and value of machinery change.

Next, multivariate confidence intervals are calculated for individual decision-making factors to determine which factors, if any, play a particularly important role in the observed multivariate relationships. Table 7 compares 95 percent confidence intervals with the mean responses

TABLE 4. F-Values and Prob-Values from Six-Way MANOVA.

Independent Variable Treatment	F-Value	Probability of Type I Error
Soil Zone	1.42	0.0449*
Farm Type	1.27	0.1211
Farm Size	1.22	0.1212
Value of Machinery Inventory	1.79	0.0001**
Operator Age	1.81	0.0002**
Operator Education	1.75	0.0001**

* Significant at the 95 percent confidence level.
** Significant at the 99 percent confidence level.

TABLE 5. F-Values from Pairwise Simultaneous Multivariate Multiple Comparisons, for Independent Variables (Soil Zone, Machinery Inventory, Age, and Education).

Independent Variable	Class	Class 2	Class 3	Class 4	Class 5
Soil Zone	1	1.10 (.3397)	2.16** (.0023)		
	2		1.06 (.3923)		
Value of Machinery Inventory	1	2.29** (.0011)	5.33** (.0001)	2.00** (.0057)	1.80** (.0170)
	2		2.82** (.0001)	1.38 (.1248)	1.63* (.0390)
	3			1.45 (.0899)	1.44 (.0947)
	4				1.63* (.0389)
Operator Age	1	1.64* (.0376)	2.05** (.0043)	2.14** (.0026)	
	2		4.01** (.0001)	1.30 (.1710)	
	3			1.04 (.4137)	
Operator Education	1	1.67* (.0336)	1.80* (.0167)	2.18** (.0020)	2.27** (.0012)
	2		2.47** (.0004)	2.63** (.0001)	4.68** (.0001)
	3			0.83 (.6765)	2.40** (.0006)
	4				1.25 (.2044)

* Significant at the 95 percent confidence level.
** Significant at the 99 percent confidence level.
(The numbers in parentheses are the probability of a Type I Error, i.e., the Prob-Value.)

to selected factors.[1] It is clear that none of these factors generate significantly different means on an individual basis. Thus it appears that the influence of the four independent variables, while significant, is operative in an overall, multivariate sense only.

Table 7 indicates those factors which are relatively (if not absolutely) significant. Consider, for example, those factors with class mean differences (column 4) that are at least 40 percent of the multivariate confidence interval (column 5).[2] Soil zone differences made their biggest

[1] In order to reduce the calculations, the total set of factors was reduced to this smaller set by selecting only those factors with significantly different means on the basis of the Duncan's Multiple Range Test—a univariate test. Since the multivariate test is less discerning, those differences which are insignificant in the univariate test cannot be significant in the multivariate case.

[2] Since none of the criteria in Table 7 are significant in multivariate tests and all are significant in the univariate test, the dangers inherent in the simpler test are indicated. On the other hand, the more demanding multivariate test tends to overlook certain weak but, perhaps, meaningful differences. The list in Table 7 indicates which criteria merit further research. The 40 percent factor was chosen arbitrarily in order to identify the most significant from this group.

TABLE 6. Distinct Groupings on the Basis of Simultaneous Multivariate Multiple Comparisons.

Independent Variable	Class	Confidence Level 99%	95%	90%
Soil Zone	1	A	A	A
	2	AB	AB	AB
	3	B	B	B
Value of Machinery Inventory	1	A	A	A
	2	B	C	C
	3	C	B D	D
	4	BC	CD	C
	5	BC	B	B
Operator Age	1	A	A	A
	2	AB	B	B
	3	C	C	C
	4	BC	BC	BC
Operator Education	1	AB	A	A
	2	A	B	B
	3	BC	C	C
	4	CD	CD	CD
	5	D	D	D

Note: Levels, within an independent variable, with the same letter cannot be distinguished at the associated level of confidence. Those with two or more letters cannot be distinguished from two or more other levels. For example, at the 90 percent confidence level, Operator Age, class 1(A) is discernible from all others, but class 2(B) is not discernible from class 4 and class 4(C) is not discernible from class 3. Classes 2 and 3 are discernible, suggesting that class 4 falls between classes 2 and 3.

impact on responses related to (2) time available due to weather, and (3) time available due to labor supply. The current value of machinery most affected the responses to (10) income tax deductions, and (11) cash availability. Age appears to be most influential in its effect on (19) family persuasion. Finally, the operator's education has its largest impact on (5) soil texture, (6) topography, and (10) income tax deductions. It is important to note that the discussion above is not intended to imply that farmers consider the above factors more important than others. Rather it indicates that the importance ratings varied more than usual in response to changes in the independent variables. For example, family persuasion is rated quite low by all groups, but those farm managers between

TABLE 7. Multivariate Confidence Intervals Associated with Class Means for Independent Variables.*

Decision-Making Criterion	Highest	Lowest	Difference	Multivariate Confidence Interval (95%)
Soil Zone Class Mean				
2	3.267	3.093	0.174	0.421
3	2.938	2.722	0.216	0.521
16	2.704	2.540	0.164	0.477
Value of Machinery Inventory Class Mean				
2	3.667	3.059	0.608	1.655
3	3.172	2.671	0.501	1.370
4	2.583	2.253	0.330	1.737
9	2.931	2.498	0.433	1.221
10	3.069	2.507	0.562	1.335
11	3.023	2.665	0.358	0.714
12	3.276	2.333	0.943	2.440
16	3.034	2.333	0.701	2.193
17	3.345	2.842	0.503	1.287
20	2.292	1.966	0.326	0.996
Operator Age Class Mean				
1	3.384	3.115	0.269	1.066
4	2.088	1.500	0.588	1.483
5	2.438	2.088	0.350	1.177
6	2.604	2.269	0.335	1.314
8	3.618	3.192	0.426	1.344
12	3.147	2.500	0.647	1.780
19	1.647	1.436	0.211	0.418
Operator Education Class Mean				
1	3.533	3.154	0.379	1.466
4	1.977	1.400	0.577	1.664
5	2.617	1.930	0.687	0.861
6	2.663	2.128	0.535	0.853
9	2.817	2.533	0.284	1.651
10	2.821	2.372	0.449	0.850
11	3.267	2.593	0.674	1.910
12	2.850	2.488	0.362	1.894
13	1.804	1.467	0.337	1.635
14	3.667	3.012	0.655	1.719
19	1.633	1.333	0.300	0.783

* The confidence intervals are reported only for those decision-making factors which showed significant class differences at the 95 percent univariate confidence level.

the ages of 25 and 40 tended to rate it lower than all other age groups.

The final stage of the analysis involves the testing for correspondence between the responses of farmers, agricultural repre-

TABLE 8. Ranked Mean Importance Rating by Respondent Occupation*

Decision-Making Factor	Farmers		Machinery Dealers		Ext. Agents		
	Mean	Rank	Mean	Rank	Mean	Rank	Overall Mean
8	3.319	1	3.018	7	2.920	7	3.278
1	3.261	2	3.442	1	3.320	1	3.281
2	3.201	3	3.239	4	3.080	4	3.203
14	3.190	4	2.965	8	2.240	15	3.144
15	3.119	5	3.044	6	2.720	9	3.102
18	3.070	6	2.841	10	2.040	18	3.022
7	3.038	7	2.770	12	3.000	6	3.009
17	2.892	8	2.823	11	1.960	19	2.863
3	2.873	9	3.257	3	3.240	3	2.921
11	2.872	10	2.416	16	2.360	12	2.812
12	2.725	11	2.920	9	3.000	5	2.752
10	2.692	12	3.381	2	3.280	2	2.778
9	2.684	13	3.044	5	2.800	8	2.724
16	2.651	14	2.673	14	2.640	10	2.653
13	2.613	15	2.300	18	1.800	20	2.551
6	2.516	16	2.327	17	2.320	13	2.492
5	2.343	17	2.159	19	2.080	17	2.317
19	1.841	18	2.717	13	2.280	14	1.943
4	1.830	19	2.027	20	2.200	16	1.859
20	1.461	20	2.540	15	2.560	11	1.599

* Overall mean may not equal the sum of the weighted means due to rounding error.

sentatives, and machine dealers. Table 8 presents the mean responses of the three groups to the 20 factors, ordered according to the farmer's ranking. Thus factor 8, size of other machinery, was ranked highest by farmers but seventh highest by machinery dealers and agricultural representatives.

A one-way MANOVA performed on these data indicates extremely significant differences among the three groups (greater than 99.8 percent confidence for all comparisons). Furthermore, calculation of 95 percent multivariate confidence intervals around individual factors (see Table 9) indicates that three variables were particularly important in differentiating the groups. These were (10) more income tax deductions, (19) family persuasion, and (20) persuasion by friends and neighbors. In all three cases, farmers rated the factors lower than did machinery dealers and agricultural extension agents.

Thus it would appear that farm machinery dealers and agricultural representatives—two groups who are vitally concerned with decisions made by farmers—could learn much from a study such as this.

Conclusions

The analysis above indicates the complexity of the farm management decision process. While few, if any, individual decision factors stand out as being related to the decision-makers circumstances (age, education, etc.), it is equally clear that these factors taken together are strongly influenced by the circumstances under which they are made. Thus the value of multivariate analysis is also illustrated.

Based on this study we are unable to reject the null hypotheses that farm type and farm size have no bearing on the importance attributed to the factors considered when buying a tractor or a combine. It is not suggested that these variables have no effect on the decisions themselves. On the contrary, microeconomic theory pre-

TABLE 9. Multivariate Confidence Intervals Associated with Class Means for Respondent Occupation.*

Decision-Making Criterion	Class Mean Highest	Lowest	Difference	Multivariate Confidence Interval (95%)
1	3.442	3.320	0.122	0.487
3	3.257	2.873	0.384	0.607
4	2.200	1.830	0.370	1.081
7	3.038	2.770	0.268	0.509
8	3.319	2.920	0.399	0.994
9	3.044	2.684	0.360	0.550
10	3.381	2.692	0.689	0.591**
11	2.872	2.360	0.512	1.233
14	3.190	2.240	0.950	1.133
15	3.119	2.720	0.399	0.978
17	2.892	1.960	0.932	1.157
18	3.070	2.040	1.030	1.156
19	2.717	1.841	0.876	0.556**
20	2.560	1.461	1.099	0.934**

* This analysis involves 1,081 observations. The confidence intervals are reported for only those decision-making factors which showed significant class difference at the 95 percent univariate confidence level.

** Significant difference between class with the highest mean and classes with the lowest mean.

dicts that these variables will be very important in machinery purchase decisions. As pointed out above, the fact that these variables are not significant elements in the farm management process underscores the difference (and the complementarity) between the neoclassical and farm management process models of behavior. The two models address different aspects in the overall management process. Production theory relates to the optimal mix and size of the machinery inventory. The process model indicates how the decisions are made.

The analysis allows us to reject the null hypotheses that soil zone, value of machinery inventory, the operator's age and education do not affect the importance of the various factors. Each of these, in fact, leads to patterns of responses which differ according to the levels of the variables. Farmers in the brown and black zone, perhaps because of differential growing seasons, place different emphases on the timing-related factors. Farmers in the black soil zone rate them higher and those in the brown soil zone rate them lower. Farmers with more education place less importance than others on soil texture, topography, and income tax deductions.

The value of machinery inventory and operator age do not generate such straightforward patterns of response. The importance of income tax deductions increases as the value of machinery inventory increases except for the largest category, those over $350,000, where it decreases slightly. The importance of having enough money to pay cash becomes less important as the value of machinery inventory increases to the $249,000 range, then increases in importance for the $250,000 to $350,000 category, and decreases for the over $350,000 category. Farmers in the 25-to-40 age bracket place less importance on family persuasion than do farmers in other age brackets. This is the age when parental influence has waned and before the influence of children is heeded.

While the above insights are important, of even greater significance is the conclusion that these four variables affect the responses since it suggests that farm manager decisions are influenced by variables which are treated only indirectly in neoclassical theory. The existence of a management process which allows for the inclusion of noneconomic factors or criteria in decision making appears to be validated. While a more rigorous statement of the model and a broader search for signifcant independent variables is needed, this study indicates that farm managers consider at least these four factors.

In addition, we are able to reject the null hypotheses that agricultural representatives and farm machinery dealers perceive the management process accurately. These groups, in fact, underestimate the importance of machinery wearing out, and overestimate the importance of improved features on new models, and income tax considerations. These findings may suggest the need for these groups to learn more about their clientele's decision-making process.

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