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A Micro-Simulation Approach to the Estimation of Returns to Learning and Information in Corn and Soybean Production*

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Introduction

The analysis presented in this paper represents an empirical attempt to measure the benefits of research information and learning (feedback) to managers of corn and soybean farms. A management game incorporating key decisions in corn and soybean production was developed. Participants in an experiment, a group of undergraduate farm management students, were asked to play the game by making a series of decisions. Some of the participants in the experiment were denied access to research information and/or feedback from the previous decision. Total profits was the measure used to assess the benefits of the information and feedback. Results of the experiment indicated a consistently significant positive return to both learning (feedback) and to research information. In particular, the return to information was much larger than was expected on an *a priori* basis.

Conceptual Framework

It has long been recognized that the entrepreneurial ability of a manager can be at least as important a determinant of firm profits as the amount of other resources (land, labor and capital) that are available. Despite this fact, little is known of how the availability of information useful in making management decisions influences the profits of a firm.[1/]

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Consider a profit function:

(1) $\Pi = f\ (L, N, K, M;\ P_1 . . . P_n)$

where:

Π = profits for the firm

L = land
N = labor
K = capital
M = managerial ability

$P_1 . . . P_n$ = a vector of prices on inputs and outputs

further:

(2) $M = g\ (i, h;\ Z_1^* . . . Z_m^*)$

where:

i = information from research that is useful in making a managerial decision

h = learning which takes the results of feedback from decisions made in a previous time period

$Z_1^* . . . Z_m^*$ = a vector of characteristics of the manager that act to influence the manager's ability to use information in a decision making context. These characteristics are assumed constant for each manager.

Hence, for the individual manager:

(3) $\Pi = f\ (L, N, K, g(i, h);\ P_1 . . . P_n)$

It is hypothesized that firm profits are related to the amount of research information available to the entrepreneur. It is further hypothesized that learning due to feedback from decisions made in previous time periods influence profit levels. A 2-way analysis of variance experiment with a management game is used to test these hypotheses.

The Research Tool

The tool used to assess the returns to learning (feedback from the previous decision) and information was the Purdue University Corn-Soybean Production Simulator (game). The game was designed to simulate the operation of an Indiana grain farm over a five year period and incorporated a number of management decisions basic to corn and soybean production. These decisions are listed in Table 1. All decisions relevant to corn and soybean production were not included in the game. Each decision included in the model was chosen because research or extension information (from Purdue and elsewhere) useful in making the decision was available.[2/]

The game was constructed such that the management decisions had an impact on gross returns, costs of production, or both. Much of the data used in the construction of the game were obtained from published and unpublished reports by the Purdue Agronomy Department, and through conversations with Purdue Agronomists. Data on costs of production and labor requirements were largely taken from previous extension models in operation at Purdue. In certain cases, appropriate statistical tools were used to derive coefficients not readily available directly from the research data. For example, coefficients representing corn and soybean response to fertilizer incorporated in the game were estimated from Purdue Agronomy Farm data using a Cobb-Douglas production function.

The Experimental Design

Figure 1 illustrates the design used to conduct the analysis of variance experiment with the management game. Participants in the experiment consisted of a group of students in a senior level course in farm management. The vast majority of the 60 participants in the experiment were quite familiar with corn and soybean production practices. Most were reared on corn belt grain farms.

Table 1. Decisions Incorporated in the Purdue University Corn-Soybean Production Simulator

1.	Combination of corn and soybeans to be planted on 600 acres
2.	Soybean variety selection
3.	Row width for soybeans and corn
4.	P_2O_5 and K_2O applied to soybeans
5.	N, P_2O_5 and K_2O applied to corn
6.	Date to begin planting soybeans
7.	Date to begin planting corn
8.	Date to begin harvesting soybeans
9.	Date to begin harvesting corn
10.	Moisture level to which soybeans are to be artifically dried
11.	Moisture level to which corn is to be artificially dried

Some 73 percent of the students were farming alone or in partnership. Additional characteristics of participants are summarized in Table 2.

No Research Information	Research Information	
Group 1	Group 2	No feedback from the previous decision
Group 3	Group 4	Feedback from the previous decision

Figure 1. The Experimental Design

Each participant in the experiment was required to work with the same set of resources -- a 600 acre farm assumed to be located in Tippecanoe County, Indiana, and assumed to be suitable for corn and soybean production. (All participants were asked to complete decisions for each of the 5 decision periods with access to no information other than the characteristics of the farm (i.e., acreage, soil tests, owned machinery) and early spring corn and soybean prices. Participants were then arrayed on the basis of the total profits generated for the 5 years. The array was divided into groups of 4 individuals. Each individual in the groups was randomly assigned to one of the treatments as shown in Figure 1. The experimental design thus insured that managerial ability as measured by the initial decisions was distributed to each treatment group. This made possible meaningful comparisons of cell means.

Feedback consisted of the results from the decisions of the previous year (period). The feedback approximated a detailed set of farm records. Included in the feedback was information on yields per acre, prices received, harvest moisture, hired labor, machinery, fertilizer, herbicide, and other variable costs, taxes on land and interest on borrowed capital.

Table 2. Characteristics of Participants in the Experiment

1.	Average Semesters of College Work Completed	7.3
2.	Average Grade Point (6.00=A)	4.78
3.	Percent Who Were Reared on a Farm	94.2
4.	Percent Not Currently Farming	26.9
5.	Percent Farming Alone	5.8
6.	Percent Farming With Father	57.7
7.	Percent Farming With a Relative Other Than Father	1.9
8.	Percent Farming With a Non Relative	7.7
9.	Percent Who Intend to Return to Farm After Graduation From College	76.9
10.	Percent Who Had Never Grown Corn or Soybeans	9.6
11.	Percent Who Had Grown Corn But Not Soybeans	15.4
12.	Percent Who Had Grown Soybeans But Not Corn	1.9
13.	Percent Who Had Grown Both Corn and Soybeans	73.1

Information consisted of research data largely obtained from the Purdue Agronomy Farm. As part of the research project, an information retrieval system was developed. Some 20 tables of research data useful in making management decisions for the game were stored on a magnetic disc unit. Participants in the experiment in groups having access to information were allowed to retrieve the tables of information as required by using a system of key words through a remote computer terminal (teletype).

It is also important to note that the information did not tell the participant which decision to make. In fact, a substantial amount of interpretation was required. The information provided to the groups consisted of data that is readily available from an experiment station of a land grant college.

Statistical Results

Mean profits generated per year for each of the four treatments over the 5 years of operation of the game are presented in Table 3. Fluctuations in mean profit levels over the 5 years were due primarily to variation in prices and weather factors incorporated into the game. An analysis of variance of the data is presented in Table 4.

Results of the analysis clearly show a consistently significant positive return to both feedback and information. The group with access to information and feedback was able to generate average profit levels nearly twice as great as the group with access to neither feedback or information. Mean profit levels (Table 2) were entirely consistent with expected results for every decision period. Analysis of variance results (Table 3) were also consistent with *a priori* expectations.

For decision 1, there was no feedback from the previous decision and accordingly the F ratio for feedback was nonsignificant. Remaining F ratios testing for the effects of feedback and information were significant at levels ranging

Table 3. Mean Profits Generated Per Year for Each of Four Treatments, Five Years of Operation

Decision Period (year)	Treatment I No Information No Feedback	II Information No Feedback	III No Information Feedback	IV Information Feedback
1	-3,314	-1,316	-2,292	-504
2	11,978	16,554	14,094	19,316
3	13,814	19,553	17,787	25,267
4	343	5,021	4,099	7,177
5	20,475	24,235	25,990	28,073
Average of 5 years	8,659	12,810	11,935	15,866

Table 4. Analysis of Variance of Profits

Decision	Condition	F Ratio	Significance
1	Feedback-No Feedback	.33	nonsignificant
1	Information-No Information	1.42	.25
1	Interaction-Feedback and Information	.00	nonsignificant
2	Feedback-No Feedback	2.82	.100
2	Information-No Information	11.21	.005
2	Interaction-Feedback and Information	.05	nonsignificant
3	Feedback-No Feedback	9.39	.005
3	Information-No Information	17.13	.005
3	Interaction-Feedback and Information	.30	nonsignificant
4	Feedback-No Feedback	7.04	.025
4	Information-No Information	12.46	.005
4	Interaction-Feedback and Information	.53	nonsignificant
5	Feedback-No Feedback	8.83	.005
5	Information-No Information	3.53	.100
5	Interaction-Feedback and Information	.29	nonsignificant

from .25 to .005. F ratios testing for multiplicative interactions between feedback and information were nonsignificant in every decision period. Hence, it is apparent from the analysis that both feedback and information exert a positive influence on total profits, and that feedback and information together have a greater impact on profits than either alone.

Concluding Remarks

1. It is possible to show positive returns to both learning (feedback) and information in a simulated environment. Empirical results provided solid statistical evidence to support the initial hypotheses that both learning (feedback) and information are major determinants of profit levels for "managers" of simulated corn and soybean farms.
2. In the simulated environment, information appeared to perhaps have a more important impact on profits than did feedback. In many cases, individuals confronted with the feedback-no information condition appeared to be groping for an optimal decision. A trial and error approach for the group was very evident. For example, even after several decisions had been made, many members of the group with feedback but without information were applying fertilizer to crops at rates that were far from optimal. Individuals in both groups with access to information "zeroed in" on fertilization levels that were nearly optimal very early in the experiment.
3. As might be expected, an examination of the data revealed that the greatest marginal returns to feedback and information occurred for the "managers" that generated very low profits under the no feedback-no information condition. These "managers" were able to make a substantial improvement when confronted with either feedback or information. There was little evidence of a return to feedback for those who had generated large profits without feedback or information. However, even those "managers" who generated

large profits without information were able to generate greater profits when given the research information. One implication that might be drawn from the results of the analysis is that aids should be directed toward low-income farmers for it is here that the greatest marginal returns are possible.

4. If farm managers in the real world behave similarly to participants in the experiment, the potential benefits to improved information delivery systems may be substantial. A number of participants in the experiment commented on the usefulness of having information on all phases of corn and soybean production readily available in one place. A remote computer terminal may prove to be a more effective means than traditional research and extension bulletins for making large amounts of research information readily available for use by farm managers.

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Footnotes

1/ Leslie (6) used a management game to study the impact on profits of information for managers of fluid milk plants. Haseley (4) analyzed the relationship between information feedback and firm performance for food processing and marketing firms. Jones (5) followed an experimental design similar to that presented in this analysis for analyzing the effects of competitive environments on decisions by supermarket managers. Bohl (1) estimated a learning curve (return to feedback) for farm input supply firm managers using a management game. A number of efforts to estimate the effect on profits of agricultural research on a more aggregated basis habe been conducted. See, for example, (2 and 3).

2/ If the objective of the experiment is to attempt to measure the benefits of research information, there is no point in the inclusion of management decisions in the game which require research information that does not now exist.