Institute of Agricultural Economics and
The Royal Veterinary and Agricultural University
Denmark

Farmers' Decision Making
- a descriptive approach

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Brian H. Jacobsen, Dorthe E. Pedersen,
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PRODUCTION AND PRICING DECISIONS IN CASH-CROP FARMING EFFECTS OF DECISION TRAITS AND CLIMATE CHANGE EXPECTATIONS

Elke U. Weber, Center for Decision Research,
Graduate School of Business, University of Chicago
Steve Sonka University of Illinois

I. Introduction

Gradual changes in climate over time (e.g., global warming) has been postulated to lead to major global changes in a variety of areas, including agricultural production. However, the nature and time course of such changes are hard to assess. Globa change in agricultural production, for example, will come about as the sum of gradu adjustments made by individuals at the farm-level in the face of perceived gradu local changes in weather and climate conditions. More needs to be know about the wa in which individuals who make such decisions (a) utilize weather, climate, and other information, (b) detect gradual changes against a background of large variability, and (c) adapt to such changes in their local climate patterns. The availability of a realistic set of assumptions about this process that incorporate knowledge about human capabilities and limitations in perception, learning, and information processing will be crucial if future macroeconomic impact models are to provide valid predictions of likely change and of the dynamics of change in the face of global warming.

The long-term objective of this project is to provide information that will lead to the develop a such a set of assumptions. To this effect, we examine how farmers make production and farm management decisions and whether differences in decision making characteristics lead to measurable differences in farm performance. We also look at issues of forecasting, in particular at the role that farmers' attitudes and expectations about climate change play in their memory of past events in in their predictions about uncertain future events). Finally, we examine whether differences in perceptions or attitudes about climate change are associated with differences in current farm practices or projected future farm practices.

The motivation and design of this study draws upon three distinct areas of research: decision making under uncertainty, the use of climate information in decision making, and adaptation to climate change.

Decision Making Under Uncertainty

Decision making under uncertainty has an extensive research history. Axiomatic advances in the 1940's led to a variety of different expected and non-expected utility theory, the latter motivated by empirical work showing that people's decisions in a variety of circumstances violate various axioms. In addition to ever more general variants of utility models, a variety of models have explained behavioral deviations by postulating that dimensions in addition to utility are being considered in risky decisions (e.g., regret (Loomes & Sugden, 1982) or risk (Coombs, 1975; Sarin & M. Weber, 1993; Weber & Milliman, 1994).

Empirical work to evaluate these models has largely been based on people's choices between monetary lotteries. Implicit in this choice of task is the assumption that risky decision situations can be characterized as choices between alternatives whose outcomes are known at best probabilistically, that the risk in the situation consists of the uncertainty about which of the possible known outcomes will occur, and that the objective is to choose that alternative out of the provided choice set that will maximize expected utility (or some multi-attribute variant). This ubiquitous use of choices between monetary lotteries as a research paradigm has not gone without criticism (e.g., Goldstein & Weber, 1994). One class of criticisms (March & Shapira, 1987) evolves around the conceptualization of risky decision making as the passive assumption of immutable risk(s), whereas in applied contexts, e.g., risky business decisions, decision makers frequently perceive their task instead as the active management of risk (e.g., restructuring the decision itself or modifying the choice alternatives to a level of acceptable risk; Edwards & Slovic, 1965). There is also growing realization (March & Shapira, 1990; Weber & Milliman, 1994) that risk perceptions and risk attitudes may depend on the previous history of the decision maker (e.g., whether previous decisions have turned out to be successes or failures, after the fact). Effects of previous outcome history (e.g., as a determinant of aspiration levels or reference points) suggests that memory, learning, and expectations ought to be incorporated into models of risky decision making. However, the issue of experience and task-specific memory has been largely ignored in models of decision making (Weber, Goldstein, & Barlas, 1994).

Another class of criticisms addresses the simplicity of gambling decisions. Real-world

decisions usually are much more complex, thus raising questions about generalizability. The additional complexity of real-world decisions has a variety of sources (the effects of most of which have remained unexplored): (a) the decision may be ill-defined because the decision objective is unknown or controversial, possible decision alternatives are unknown and have to be generated, and/or the consequences of the choice alternatives are unknown and may have to be generated with a causal model of the situation (where causal relationships between variables may have to be learned, or information about the value of causal variables may have to be acquired); (b) the decision involves the processing of a large amount of information, or highly uncertain or ambiguous information, or information of questionable validity; (c) the decision maker operates under time pressure or other performance stress; (d) the decision maker is more experienced and motivated than undergraduates making (hypothetical) decisions about money lotteries; (e) the decision environment is unstable, i.e., changes over time, so that decision makers have to constantly update (relearn) the values of variables or contingencies between variables.

In this study, we address a complex real-life risky decision situation, namely production and pricing decisions made by Illinois cash-crop farmers, that will allow us to study the effects of many of these factors. The decisions are made by experienced decision makers in their area of expertise and with a prior history of such decisions and their outcomes (i.e., opportunity for using information from memory). The decision makers have clear incentives (i.e., decision quality determines farm profitability). The decision maker can and must play an active role (e.g., in the generation of decision alternatives, the prediction of their likely consequences, and in the type and amount of information considered), and choice alternatives are only partially defined (e.g., from past experience), but also subject to change (e.g., in a changing technological, regulatory, or climate environment). Finally, the consequences of choice alternatives are uncertain, ambiguous, and ascertainable only with less than perfect validity, and subject to change (especially in a changing climate environment).

Climate Information and Decision Making

Over the last two decades, several investigations have carefully evaluated the potential value of weather and climate forecasts in improving decisions whose outcomes are affected by climate variables. These studies generally employ decision theory as their underlying paradigm, and have focused either on short-term forecasts (Baquet, et al., 1976; Lave, 1963) or longer-term climate predictions (Winkler, et al., 1983). In general, these analyses have concentrated on determining the accuracy levels necessary for climate predictions to have economic value (Winkler, et al., 1983; Brown, et al., 1986). Changnon, Sonka, and Hofing (1988), for example, investigated the value of climate predictions for the seed corn production sector, by looking at decisions about the allocation of different corn varieties by producers in the Midwestern United States. Actual managers with responsibility for such decisions were provided with (alternative) predictions of summer growing conditions. Their allocation decisions, given either with and without the benefit of climate predictions, were then entered into an economic model that replicated the stochastic nature of summer growing conditions in the region. The analysis documented that predictions with even low accuracy could have potentially large economic value, if available with sufficient lead time. This study illustrates the potential knowledge to be gained from decision experiments that use actual, experienced decision makers.

Adaptation to Climate Change

As concern about greenhouse gases and their effect on the globe's climate grew over the last decade, numerous analyses of the effect of a change in climate upon agricultural production were conducted. In a review of such studies, Sonka (1991) examined the strengths and weaknesses of their methodologies. In general, these studies showed little evidence that climate change poses any severe threat to food security, but the robustness of that conclusion was put into question by some methodological weaknesses. One such weakness was the fact that climate was the only factor that was assumed to differ from current conditions, despite the fact that a changed climate some 20 to 50 years into the future will face a world that is likely to be greatly different from today's conditions. Global population growth and technological change are only two factors, in addition to climate change, that will significantly affect food security. Another methodological weakness was the failure to consider the <u>dynamics</u> associated with a changing climate. The answers provided by these agricultural impact assessments thus may be flawed by the fact that these models have tended to (a) assume an instantaneous change in climate, (b) focus on physical and biological processes, and (c) ignore the adaptation potential that individuals and society can implement as climate changes (Ausubel, 1983; Glantz, Robinson, & Krentz, 1985).

Some studies have tried to rectify these deficiencies, by incorporating the effects of changes in non-climatic factors (Kane, Reilly, & Toby, 1991; Lewandrowski & Brazee, 1991). The ongoing work by Kaiser, et al. (1991a,b) examines the <u>dynamics</u> of a changing climate over time. Simulating individual farm decisions, the effect of climate change is evaluated in a series of annual decisions. Production is affected by climate change through changes in the annual decisions made. The simulation assumes, however, that decision makers have perfect expectations of the altered climate. Absence of a better alternative, i.e., a more valid set of assumptions about decision makers' climate expectations, is a likely explanation for the clearly unrealistic assumption of perfect expectations. Providing the foundation for a theoretical framework and an empirical data base for better assumptions is one of the goals of our project.

II. Experiment

We selected a sample of 48 farms from among the participants in the Illinois Farm Business Farm Management (FBFM) Association, a voluntary record-keeping cooperative. To keep the sample homogeneous on external variables, we imposed the restrictions that the selected farms produced cash-crops and were family operations with one primary and full-time farm owner and decision maker. Use of FBFM participants gave us access to detailed financial and production records from these producers for the last six years and allowed us to link survey responses to actual farm performance. Mean farm size was 740 acres, ranging from 263 to 1608 acres; approximately half of each farm was devoted to corn, the other half to soya bean production. The respondents had an average of 26.5 years of experience as the primary farm decision maker, and less than half had attended college.

We conducted individual structured interviews shortly before spring planting, which lasted between 2 and 2 1/2 hours and involved 154 numerical, multiple-choice and open-ended answers. Farmers provided information about their production and pricing decisions and other farm practices, and in particular about the following set of annual decisions: (A) What varieties of corn to plant?; (B) When to start planting?; (C) What tillage practice to use?; (D) Whether to buy, replace, or rent new equipment?; (E) Whether to purchase crop insurance and how much?; and (F) How to price the crop?. For each of these decisions, farmers told us what and how much information (past and present) they considered, from what sources they receive this information, by what decision rule or process they arrive at their decision, and what factors contributed to perceived decision difficulty. For each decision, farmers were asked to check off as many categories as applied. A frequency count of their answers across farmers (listed in decreasing frequency) is shown in Table 1.

TABLE 1. **Frequency of Responses (frequencies >= 10 are highlighted in boldface).**

TYPES OF INFORMATION CONSIDERED

	A	B	C	Decision D	E	F	Row Total
Technological Information	**30**	2	**29**	**26**	5	5	97
Market and Price Information	6	1	2	**20**	**14**	**39**	82
Short-term Weather Forecast	5	**39**	**13**	1	1	3	62
2-4 week Climate Forecast	4	**20**	5	1	3	3	36
4-6 week Climate Forecast	6	1	0	1	**16**	**15**	39
Other	8	5	3	**10**	**12**	3	41
None	0	0	2	2	4	0	8

SOURCES OF INFORMATION CONSULTED

	A	B	C	Decision D	E	F	Row Total
Farm Magazine	4	3	**32**	**20**	**11**	**22**	92
Own Farm Records	**26**	9	3	**15**	**21**	**10**	84
COOP Extension	**14**	**11**	**17**	9	**11**	7	69
Other Farmers	**20**	8	**16**	**17**	2	4	67
Input Suppliers	**27**	**11**	**10**	8	5	2	63
Agricultural Newspaper	7	2	**14**	9	4	**14**	50
Professional Consultant	9	6	7	5	4	**17**	48
Popular Media	7	**15**	4	3	5	**13**	47
Commercial Newsletter	4	2	5	3	4	**12**	30
Computer Information Base	5	3	1	0	4	8	21
USDA Publication	1	1	4	1	5	9	21
Illinois Farm Bureau	2	0	1	0	2	3	8
None	0	7	0	1	1	0	9

DECISION PROCESSES USED

	A	B	C	Decision D	E	F	Row Total
Objectively Weigh Options	**26**	**13**	**24**	**35**	**24**	**21**	143
Do Same As Last Year	**24**	**21**	**19**	4	**23**	**13**	104
Follow Gut Feeling	3	**10**	3	**12**	**12**	**22**	62
Do What Experts Suggest	**14**	8	4	7	4	**11**	48
Do What Other Farmers Do	6	6	**10**	3	0	0	25
Follow Gov't Regulation	3	1	**14**	5	0	0	23

SOURCES OF DECISION DIFFICULTY

	A	B	C	Decision D	E	F	Row Total
Want Keep Options Open	**14**	8	9	**13**	9	**17**	70
Time Pressure	4	**31**	**15**	3	1	3	57
Conflicting Information	**18**	1	**12**	0	3	**18**	52
None	**10**	3	6	8	**13**	3	43
Afraid to Make Mistake	3	**11**	5	9	5	9	42
Short- and Long-Term Goals Conflict	2	1	5	**18**	6	3	35
Insufficient Information	8	6	3	1	5	7	30
Reason Conflicts With Gut Feeling	2	6	2	5	7	6	28
Other People Have Conflicting Goals	1	0	6	1	2	2	12
No Win Situation	1	0	1	2	5	0	9
Too Much Information	2	1	2	0	0	3	8

Identification of Decision Traits or Characteristics

Farmers' answers to the questions in Table 2 about their decision processes, their responses to other questions about production and pricing practices (i.e., the number of different varieties of corn planted, acres allocated to experimentation, ownership and usage of a personal computer (PC), the keeping of climate records, the purchase of crop and/or hail insurance, the use of forward contracts and/or the futures market, the use of a regular before or after harvest pricing strategy, either of one's own design or provided by an expert, and their age, years of experience as primary farm decision maker, and education level were used as input variables into a principal components factor analysis which identified an underlying structure of seven decision making traits. Each had an eigenvalue greater than 2.0, and accounted from 12% to 5% of the variance. Table 2 lists the variables that characterize each trait, i.e. that influence the trait score with factor loadings that are high in absolute value terms.

TABLE 2. **Seven decision traits, and the variables that characterize them (i.e., variables with factor loading > |.50|; factor loadings are shown in brackets).**

TRAIT 1: Pricing Sophistication

(+.94) Prices production before harvest
(+.94) Uses forward contracts
(+.72) Uses pricing strategy of own design

TRAIT 2: Practical Experience

(-.60) Does not experience short-term vs. long-term goal conflict
(+.79) Is older
(+.82) Has been primary farm decision maker longer
(-.60) Has less education

TRAIT 3: Active Experimentation

(+.57) Plants a larger number of varieties of corn
(+.53) Allocates more acreage to try out varieties not grown before
(+.84) Owns Personal Computer
(+.87) Uses Personal Computer for farm business

TRAIT 4: Passive Belief in Collective Wisdom

(+.90) Uses other farmers as primary source of information
(+.81) Decides by doing what other farmers do

TRAIT 5: Micro-Managing

(+.54) Uses short-term weather forecasts in decisions
(+.77) Finds time pressure to be primary source of decision difficulty
(+.60) Keeps weather and climate records
(-.57) Does not use same after harvest pricing strategy each year

TRAIT 6: Systematic Analysis

(+.81) Uses market and price information in decisions
(+.50) Gets information from university COOP extension
(+.57) Decides by objectively weighing options
(+.50) Finds conflicting information to be primary source of decision difficulty

TRAIT 7: Macro-Managing

(+.88) Uses farm magazines as primary source of information
(-.53) Does not get information from professional consultants
(-.51) Does not keep weather and climate records

Table 3 shows the distribution of the seven decision traits in our sample of farmers. The strength of each trait in each farmer was classified as either "strongly negative" ($t_i <= -1$), "moderately negative" ($-1 < t_i <= 0$), "moderately positive" ($0 < t_i < 1$), or "strongly positive" ($t_i >= 1$). Since the decision traits are the output of a factor analysis, each one had a mean of 0 and a standard deviation of 1 across farmers, as well as a zero correlation with any other trait. Table 3 shows that the distribution of some traits is skewed. While the majority of farmers (74%) has positive scores on pricing sophistication for example, the majority also has negative scores on active experimentation (63%).

TABLE 3. **Distribution of traits in sample of farmers.**

Trait:	% of Farmers With Indicated Trait Strength			
	str-neg	mod-neg	mod-pos	str-pos
Pricing Sophistication	17	9	72	2
Practical Experience	21	21	44	14
Active Experimentation	12	51	21	16
Passive Belief in Collective Wisdom	12	45	27	17
Micro-Managing	13	45	25	17
Systematic Analysis	16	37	21	26
Macro-Managing	10	45	40	5

Decision traits like the ones identified in Table 2 are only useful if they predict managerial decisions or actions and thus, ultimately, the success of the enterprise. Since success of a farming operation is, arguably, multidimensional, we used the following five proxies for it. The first one, i.e., <u>net farm income standardized by the number of crop acres</u>, is a measure of a farm's operational efficiency. The second and third, i.e., <u>average prices</u> received for either corn or soya beans received in a given year ($/bushel), are measures of a farmer's pricing success. The last two, i.e., <u>average crop yields</u> for either corn or soya beans achieved in a given year (bushels/acre), are measures of the a farmer's production success.

In addition to decision traits, a variety of other variables can be expected to contribute to these measures of farm success. The following variables were thus included as co-variates in the analysis (a general linear model with repeated-measures) of decision traits on farm success: total crop acreage, total capital investment, total months of labour, soil quality,and the percentage of acreage in either corn, soya beans, or a government program. The repeated measures were on the five proxies for farm success described above, as well as on six different years for which these success measures were available (1985 to 1991). In this period, 1988 was a draught year, and 1989 a year at which production was at an all time high. Table 4 shows the results of this analysis, either conducted separately for the operational efficiency, pricing success, and production sucess measures, respectively, as well as across all five measures.

TABLE 4. **Significant Predictors of Success of Farm Operation.**

Measures of Farm Success:

(1) Net Farm Income / Total Crop Acres

Significant Predictors	Type of Relationship
Trait 1	+
Crop Acreage	+
Months of Labor	+
Year	
Year x Trait 2	- in '86
Year x Trait 4	+ in '85,'87
Year x Months of Labor	+ in '87, '88
Year x % in Corn	- in '89

(2&3) Average Corn/Soya Bean Price Received

Significant Predictors	
Trait 3	
Measure x Trait 3	
Year x Trait 2	+ in '88
Year x Trait 3	
Year x Trait 6	
Year x Trait 7	
Year * Crop Acreage	
Measure x Year x Trait 3	+ for soya in '88
Measure x Year x Trait 5	- for corn in '88, '90
Measure x Year x Trait 6	+ for soya in '88, - in '89, '90
Measure x Year x Trait 7	+ for soya in '88, - in '89

(4&5) Average Corn / Soya Bean Yield

Significant Predictors	
Trait 5	+
Soil Quality	+
Measure x Soil Quality	
Year x Trait 3	- in '88, + in '89

All Five Success Measures Combined

Significant Predictors	F-value	p-value	d.f.'s
Crop Acreage	12.95	.005	1,21
Months of Labor	21.29	.0001	
Measure x Trait 1	3.85	.01	4,84
Measure x Trait 4	4.01	.01	
Measure x Crop Acreage		24.50	.0001
Measure x Months of Labor		24.87	.0001
Measure x Soil Rating	4.86	.005	
Year x Trait 4		2.74	.05 5,105
Year x Crop Acreage	2.44	.05	
Year x Months of Labor	3.39	.01	
Year x % in Soya Beans	3.00	.05	
Measure x Year	3.80	.0001	20,420
Measure x Year x Trait 2		1.96	.01
Measure x Year x Trait 4		2.29	.005
Measure x Year x Trait 5		1.73	.05
Measure x Year x Crop Acreage	3.67	.0001	
Measure x Year x Months of Labor	5.21	.0001	
Measure x Year x % in Corn	4.18	.0001	
Measure x Year x % in Soya Beans	4.85	.0001	

The most interesting result of Table 4 is the fact that different decision making traits contribute to the different dimensions of farm success. Micromanaging (Trait 5), for example, has a negative effect on prices, but a positive effect on yields. As another example, pricing sophistication (Trait 1) has a positive effect on operational efficiency, but no effect on prices or yields.

In addition to examining the effect of the decision traits on farm success, we also looked at a less indirect measure of impact, namely whether they predicted the behavior of farmers. Table 5 lists those behaviors that were significantly affected by scoring high on each of the seven decision making traits. It is worth noting that a stronger belief in the greenhouse effect is associated with a stronger tendency to micro-manage.

TABLE 5. **Behaviors correlated with different decision making traits (at .05 level of significance)**

Behaviors Correlated with Trait 1: Pricing Sophistication
- Less reliance on intuitive predictions of climate for decisions
- More likely to consider climate forecasts in production and pricing decisions
- More likely to consider South American and world weather in pricing decisions
- More likely to list technological/product issues as important planting decisions
- Relies on professional forecasts of climate for decisions
- More likely to consider irrigation if climate changed
- More likely to remember draughts

Behaviors Correlated with Trait 2: Practical Experience
- Remembers fewer specific weather events
- Less likely to remember draughts
- Less likely to indicate that solution to planting problems have changed
- Main change in solution to production decisions is change in production <u>methods</u>

Behaviors Correlated with Trait 3: Active Experimentation
- Lower confidence in own intuitive climate forecasts
- Supports Ethanol Promotion less strongly
- More likely to change pricing strategy because of changes in cash flow
- Less accurate in remembering 1985-1991 April rainfalls

Behaviors Correlated with Trait 4: Passive Belief in Collective Wisdom
- More likely to see different crops/varieties as response to climate change
- More likely to see more insurance as response to climate change
- More likely to draw in remembered 1985-1992 April rainfall in increasing or decreasing order (rather than by memorability)

Behaviors Correlated with Trait 5: Micro-Managing
- Stronger belief in greenhouse effect
- Expects a greater reduction in average rainfall over next 30 years
- Main change in solution to production decisions is change in <u>equipment</u>
- More likely to list technological/product issues as important planting decisions

Behaviors Correlated with Trait 6: Analytic, Systematic Decision Making
- Main perceived source of change in production decisions are new circumstances
- More likely to expect little or no change in IL climate in next 20-30 years

Behaviors Correlated with Trait 7: Macro-Managing
- More likely to remember a draught and be wrong
- Less likely to consider climate forecasts important
- More likely to change pricing strategy because of change in tax laws
- Gives April rain estimates larger than accurate
- Gives lower next-July temperate estimate than other farmers
- More likely to make July temp. estimate by remembering a long-range weather forecast
- More likely to see nature of planting decisions as changed over last 2-5 years
- Main change in solution to production decisions is change in production <u>methods</u>

TABLE 6. **Relationships between Beliefs about Climate Change and Behavior** (Pearson correlation coefficients, significant at the .05 level, are shown in brackets).

<u>Degree of Belief in</u>:	<u>Correlates with</u>:
Unchanged Climate	
	(-.32) Purchase of less hail insurance
	(-.32) Reduced use of futures market
	(-.44) Smaller percentage of harvest priced by futures
	(+.34)More accurate memory of July rainfalls in 1985-91
Greenhouse Effect or Ozone Depletion	
	(+.30) Regular before-harvest pricing strategy
	(+.33) Greater percentage of harvest priced by futures
	(-.43)More error in memory of April and July rainfalls in 1985-91
Global Warming	
	(+.35) Greater use of medium- and long-term climate forecasts
	(+.30) Forecasts being judged to be more important
	(+.33) Forecasts used more

Weather and Climate Records, Beliefs about Climate Change, and Behavior

When weather and climate records were kept, which was true for 28% of our sample of farmers, farmers were more likely to (a) use forward contracts and the futures market (r = .42), and (b) price crops before harvest (r = .33) and by a regular pricing strategy (r =.47),devised by an outside source (i.e., an expert) (r = .35). Farmers keeping such records were less likely to use their memory to make temperature forecasts (r = -.38), but on the other hand had greater confidence in their intuitive climate predictions (r = .32). There was no relationship between farmers' beliefs about climate change and their keeping of weather records.

However, a variety of other behaviors were affected by beliefs about climate change. Farmers were split in those beliefs, with 55% of them predicting no or very little change in the climate of East-Central Illinois over the next 20-30 years, and the remaining 45% predicting a warmer, drier, and more variable climate. As shown in Table 6, a stronger belief in climate change was associated with insurance and pricing decisions designed to lessen the potentially negative effects of greater weather unpredictability. Interestingly, stronger beliefs in climate change also were associated with weather memories (about April and July rainfalls in each of the years 1985-91) that were less accurate. Finally, a stronger belief in global warming was associated with greater use of medium- and long-term climate forecasts.

Summary and Conclusions

This study demonstrated individual differences in the way Illinois cash-crop farmers made production and pricing decisions, and dealt with the possibility of climate change. Differences in decision making traits were significant predictors of the success of the farm operation and of important farm decisions. Decision making traits (in particular, micro-managing) were found to be associated with belief in climate change, even though the causal direction of the association remains undetermined with correlational data. Belief in climate change, in turn, was associated with differences in hedging decisions and the accuracy of weather memories.

These results show that there may not be a single "way" in which farmers arrive at production and pricing decisions, and that governmental policy designed to educate farmers about climate change and strategic responses may have to take a multi-faceted approach.

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