Decision making under risk

a study of models and measurement procedures
with special reference to the farmer's marketing behaviour

A. Smidts

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Ale Smidts

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ABSTRACT

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Free descriptors: utility/preference theory, marketing, risk attitude, relative risk attitude, strength of preference, subjective probability distribution, marketing behavior of farmers, marketing of ware potatoes, multiple method measurement.

The objectives of the study were: a) to review, discuss and test a number of theories on individual decision making under risk; much attention is specifically given to the definition and empirical testing of the concept of relative risk attitude, b) to investigate in a large scale survey the validity, reliability and practical feasibility of measurement procedures for measuring subjective probability distributions, risk attitude, and strength of preference, and c) to develop and test a model which describes the farmer's decision making process with respect to the choice of a marketing strategy for ware potatoes.

The theoretical and methodological issues in this study are analyzed in the context of a farmer's choice of a marketing strategy. A field study was conducted in which a large number of farmers (250) were interviewed three times in two consecutive years.

The concept of the relative risk attitude concerns the relationship between a utility function assessed by means of lotteries and a strength of preference function assessed by means of riskless techniques. Per respondent the relative risk attitude was assessed. In both years a significant difference was found between the utility and strength of preference function. In this study therefore, the hypothesis of the relative risk attitude is confirmed. Moreover, the relationship between the functions can be described by the hypothesized negative exponential relationship. This means that the farmers exhibit a constant absolute and an increasing proportional relative risk attitude. The implications of the findings concerning the relative risk attitude are given.

An evaluation was given of models originating from utility theory and behavioral decision theory (such as Prospect Theory). It was concluded that the subjective expected utility model is still the most useful model for analyzing decision making under risk. We applied this model to explain the farmer's marketing decision making process. Results show that, in both years, the subjective expected utility model outperformed the subjective expective value model in predictive validity. The farmer's risk attitude therefore significantly influences his prefences for marketing strategies. However, the increment in predictive validity due to taking the risk attitude into account was relatively

small. This finding was attributed to the high percentage of pairwise second degree of stochastic dominant subjective probability functions.

A multiple method procedure was applied in the assessment of both risk attitude (that is, conjoint measurement and a standard lottery method) and strength of preference (that is, the midvalue splitting and the rating technique). The stability and convergent validity of the measurements were assessed. The results showed significant annual test-retest correlations ranging from 0.19 to 0.45. When conceiving risk attitude as a latent variable measured by two indicators the stability correlation is 0.82 (LISREL-estimate); likewise the stability of the latent variable strength of preference is 0.61. Convergent correlations were all statistically significant and ranged from 0.15 to 0.49. Further comparisons between the measurement techniques concerned the sensitivity to response effects, interviewer bias and practical feasibility.

With respect to the measurement of risk perception two methods were compared, the so-called indirect and direct method. In the indirect method a subjective probability distribution is obtained whereas with the direct method the first two moments of the distribution are directly assessed. Both methods yielded valid and plausible results and the correspondence in measurements between both methods was high. Since the direct method is more easy to apply to both the respondent and the interviewer and the predictive validity of models using data from both methods was equally high, the results in this study suggest that the direct method is to be prefered in survey research.

Little empirical research deals with the farmer's marketing behavior under risk. In this study the marketing strategy with respect to ware potatoes, the farmers' most important crop, is analysed. To whom, when and how much to sell per selling-option are the major decisions. Typically, farmers choose a combination of selling-options, e.g. a fixed-price contract combined with selling at the spot market.

The farmer's choice process was modeled by means of two attributes: price and marketing channel. This hypothesized two-attribute model was confirmed in both years of measurement. Furthermore, the farmers in the study can be characterised by a constant absolute and an increasing proportional risk attitude. Only a small percentage of farmers are slightly risk seeking, all others are risk neutral to risk averse. Differences between farmers in degree of risk aversion are substantial. However, few consistent relationships were found between the farmer's risk attitude and personal and situational variables.

Implications of the results of the study and suggestions for further research are given.

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CHAPTER ONE

SCOPE AND FRAMEWORK OF THE STUDY

This study is concerned with decision making under risk. The empirical setting of the study deals with the choice behavior of agricultural producers with respect to the marketing of their produce, in particular, the marketing of their ware potato produce. The main decisions the farmer has to make in this respect are: when, how much, at what type of selling-option and through which marketing channel he should sell. The important characteristics of this empirical setting are the large number of individual economic decision makers who are all confronted with the same risky marketing context and who have to choose between a large number of risky choice alternatives.

At the beginning of the project the analysis of the farmer's marketing behavior was considered the central issue. To this end the theoretical notions on decision making under risk were studied. Very soon it turned out that the farmer's decision problem provided a good setting for the study of a number of scientifically interesting topics of decision making under risk. One of these topics concerns the concept of relative risk attitude which focuses on the distinction between a classical von Neumann-Morgenstern utility function and a strength of preference function. Another topic concerns the methodological aspects of measuring risk perception, risk attitude and strength of preference in survey conditions. The focus in the study therefore shifted toward the theoretical and methodological issues. Consequently, the study consists of three main problem areas: the analysis of a number of theoretical and methodological issues in decision making under risk and the analysis of the farmer's marketing behavior as a decision under risk.

This first chapter presents an introduction to the study by pointing out the important role of risk in agricultural decision making in general, and in marketing ware potatoes in particular. This is followed by a brief review of three scientific approaches to studying risky decision making and by a short review of the empirical research in decision making under risk conducted in the fields of agricultural decision making and marketing. Finally, research objectives are stated and a short description of the data set is presented.

1.1 The role of risk in the farmer's decision making

Risk is a pervasive element in agriculture. Stochastic environmental factors strongly influence the agricultural production processes, thereby creating uncertain financial outcomes. One group of environmental factors, i.e. the climatological and biological (e.g. infectious diseases) factors, cause variability in the physical production. The second source of uncertainty concerns market price variability, composed of variability in prices of inputs and in product prices. The factors mentioned causing the uncertainty are fairly unpredictable and cannot be controlled by farmers.

Farmers have to anticipate and respond to these risky circumstances. There are many possible reactions with respect to the variability in physical production. In the region in which this study took place, the variability in physical production is being taken into account as much as possible by means of e.g. adequate water, pest and fertilizer management. In this study we will concentrate on the farmer's response to the variability in product prices by means of his marketing decisions. Specifically his marketing decisions concerning the variability in market prices for ware potatoes.

As will be elaborated upon in Chapter 2, ware potatoes are a very important crop in the region in which this study took place. Often farmers allocate no less than a fourth to a third of arable land to potatoes (either seed or ware potatoes). The remaining area is allocated to crops like wheat and sugar-beets, both crops with fairly stable financial results. Although the yield (in kg/ha) of the latter crops may fluctuate somewhat, prices for wheat and sugar-beets are fairly stable, although decreasing in recent years due to EC-price arrangements. Variability in the farmer's income is therefore mainly caused by variability in the financial results of ware potatoes.

Variability in gross returns of ware potatoes is mainly due to variability in prices for ware potatoes. Prices for ware potatoes fluctuate heavily, both in respective marketing years, and within a marketing year. By choosing a particular way of selling, hereafter to be defined a marketing strategy (see Chapter 2), farmers may try to reduce this price risk. To illustrate the effect of choosing a particular marketing strategy on price variability, the following examples are presented.

If in marketing year 83/84 a farmer had sold his potatoes at the spot market in *October*, he would have received 35 cts/kg (or Dfl/100kg) whereas, if he had waited until *May* he would have received 76 cts/kg; that is twice the price in seven months time. In the consecutive marketing year 84/85 however, selling in *October* would have resulted in 18 cts/kg whereas in *May* the farmer would have received only 11 cts/kg!

As an alternative to spot market sales, the farmer could have chosen to sell by means of a *fixed-price contract*. In this way, he would have received 25 cts/kg in both years (a fixed-price contract of 25 cts/kg is common for farmers delivering in May/June). Selling by means of a so-called *pooling contract* would probably have resulted in the average market price in both years, that is 55 and 14 cts/kg respectively. The average price over two years on the basis of this pooling contract, unweighted by yield, would have been 34 cts/kg compared to the 25 cts/kg on the basis of the fixed-price contract! That is, when considering only these two marketing years (83/84 and 84/85), choosing a fixed-price contract apparently reduces price risk but also lowers mean price; not every farmer would be willing to accept a lower mean price of this magnitude in exchange for reduced price risk. This is the essence of decision making under risk: the trade-off between the expected value and price risk.

The farmer has to make two important decisions concerning his marketing strategy. Firstly, he has to decide when and how much to sell at the spot market and/or how much to sell by means of a particular type of contract, e.g. a fixed-price or pooling contract. The effects these decisions can have on mean price and price risk were shown in the examples described above.

Secondly, the farmer has to choose a *marketing channel*. This concerns the choice between a cooperative company or one of several private marketing companies. Each company will have pro's and con's and will try to persuade farmers to do business with them. Insights into the motives of farmers for preferring and choosing a particular company and into the way farmers deal with risk are very important to them. Information about the choice behavior of farmers is especially relevant with respect to the development of new services like new types of selling contracts, or information services about the potato market. For example, a segmentation of the market with respect to risk attitude of farmers might give rise to new services tailored to the amount of price risk reduction each segment finds acceptable.

1.2 Approaches to studying decision making under risk

Reviewing the literature on decision making under risk, broadly speaking three orientations in the study of decision making under risk can be distinguished. Firstly, in the *utility theory/decision theory* approach, a strong axiomatically oriented and formal treatment of decision making is given. It is carried out mainly by economists and mathematical psychologists. The second approach concerns the so-called *behavioral decision theory*, a specialization within cognitive psychology. The primary interest of the experimental and cognitive psychologists working in this field is the description of decision making under risk. Thirdly, an application oriented type of research known as *decision analysis* can be distinguished. Decision analysis is typically a field of intersection of economics, psychology, statistics, operations research and computer science. A short characterization of each approach is given below. It should be noted that this overview intends to provide only a sketch of rather different fields of work on decision making under risk. It does not profess to be a complete or exhaustive overview.

The first field of research: *utility theory* directly follows the line of research which started by the seminal work of von Neumann and Morgenstern (1947). They deduced a normative decision rule, called the expected utility rule, from a limited number of compelling axioms. The expected utility rule prescribes how a decision maker or organization should choose between risky alternatives. The *expected utility model* is still the dominant model in the analysis of decision making under risk. Nowadays, much attention is given to the development of new or weakened axioms to account for the discrepancies which are frequently found between the choice behavior predicted by the expected utility model and actual behavior. Consequently, alternative normative models of decision making under risk have been developed e.g. a generalized expected utility model (Machina 1982).

In this approach, the economic behavior of individuals and the market patterns are analyzed from a formal viewpoint. Research topics include e.g. the theoretical analysis of optimum insurance policies, the analysis of time preferences and sequential choices and bargaining. Representatives of this field of inquiry are e.g. Arrow, Allais, Harsanyi, Fishburn and Machina. Recently, conferences on the Foundations and Applications of Utility, Risk and Decision Theory, abbreviated as FUR-conferences, have been organized which bundle researchers working in this field. Conference papers published in Hagen and Wenstöp (1984), Stigum and Wenstöp (1983), Daboni et al. (1986), Munier (1988) and articles published in e.g. the journals 'Theory and Decision' and 'The Journal of Risk and Uncertainty' provide an overview of research topics.

The second field, *behavioral decision theory* is predominantly interested in *how* decision makers decide. Their focus is on describing risky decision making. Much attention is paid to how people form judgments of risky events by processing probabilistic information and to the question of which simplifying rules people apply in arriving at decisions in complex risky situations.

Research shows that experimental psychologists can create stimuli and situations in which predominantly naive and unaided subjects exhibit systematic and persistent deviations from the normative expected utility model. In the experiments the prescriptive rules serve as a bench-mark from which deviations in choices are studied. The way in which the wrong choices are made provides clues for the characteristics of human information processing. These studies give rise to descriptive models of risky decision making as alternatives to the expected utility model. One important model in this respect is Prospect Theory (Kahneman and Tversky 1979).

Applications of behavioral decision theory can be found in such diverse fields as e.g. medical diagnostics, the perception and evaluation of risky technologies and gambling behavior in black jack or poker. Representatives of this field of inquiry are e.g. Tversky, Kahneman, Slovic, Fischhoff and Hogarth. Overviews of topics and findings can be found in e.g. Kahneman and Tversky (1982), Einhorn and Hogarth (1981), Arkes and Hammond (1986). At SPUDM-conferences (Subjective Probability, Utility and Decision Making) presentations are given which provide an overview of recent topics. Reviewed conference papers are published in the journal 'Acta Psychologica'.

The emphasis in the utility theory approach of decision making under risk is clearly on normative models and on theoretical as opposed to empirical research. Contrariwise, in behavioral decision theory emphasis is clearly on the description of risky decision making as opposed to the normative view of the utility theorists.

Consequently, in behavioral decision theory empirical research gets much attention. Predominantly experimental research is conducted.

A further difference between both lines of inquiry mentioned above is that in utility theory the main attention is directed to the utility component of decision making: *risk preferences*, whereas behavioral decision theory concentrates mainly on *risk perceptions*.

Decision analysis tries to reconcile both efforts. Notions of both fields mentioned above are synthesized and used in applications to important and complex risky decisions. Decision analysis consists of a set of techniques and procedures designed to help individuals and organizations make inferences and decisions. It is focused on making better decisions by careful analysis of those decisions. Decision analysis benefits from behavioral decision theory since this theory clarifies when, how and why people make risky decisions which depart from the normative models supplied by utility theory. Since decision problems are often very complex, unstructured and multiattributed, help is needed to decompose the problem into suitable parts and to assess decision makers' preferences for each part. Those parts are then recomposed by means of appropriate techniques to point out the best choice. The use of techniques from operations research may be useful in this assessment, especially in conducting sensitivity analyses. Careful and elaborate decision analysis is justified when the stakes are high and the inference or decision is intellectually difficult or insecure.

Applications of decision analysis are very diverse. In principle each major decision could become a subject of decision analysis, e.g. deciding on the site for a nuclear power station, a new factory or airport, evaluating transport systems, and identifying and structuring corporate objectives. Representatives of this field are e.g. Keeney and Raiffa (1976), Howard (e.g. 1988), and von Winterfeldt and Edwards (1986).

If utility theory is characterized as 'normative, theoretical' and behavioral decision theory as 'descriptive, empirical', then decision analysis can be characterized by 'normative, empirical'. The main goal of decision analysis is a normative one, that is, to point out the best alternative to the decision maker using a normatively correct utility model and given the subjective input of the decision maker. This subjective input concerns the perception of the uncertain consequences of alternatives open to the decision maker (the d.m.'s subjective probability distributions), and the evaluation of the consequences by the decision maker (the d.m.'s risk attitude). As a consequence, much attention and empirical research is devoted in decision analysis to techniques of eliciting subjective probability distributions and in assessing risk attitudes.

In this study, theoretical notions and methodological considerations taken from all three fields will be used in an integrated approach to the choice problem under study.

1.3 Research on decision making under risk in agriculture and marketing

In agriculture, especially ideas and practices derived from decision analysis and the expected utility model are used in analyzing farmers' decisions under risk. Overviews of the application of decision analysis in agriculture are presented by Dillon (1971), Anderson et al. (1977) and Barry (1984). A large body of literature exists in the field of risky decision making in agriculture, both at the theoretical and empirical level. An enumeration of research topics that have been given attention will now follow.

By means of models from operations research, *supply and demand structures* are analyzed (Hanf and Mueller 1979, Hazell 1982)), and *optimum farm cropping plans* are constructed (Hazell 1971, Mapp et al. 1979, El-Nazer and McCarl 1986) or theoretically derived (Collender and Zilberman 1985, Collins and Barry 1986). Also theoretically *optimum hedging ratio's* are either derived (Bond and Thompson 1975, Nelson 1985) or obtained by simulation (Bailey and Richardson 1985, Brandt 1985).

Empirical studies concerning the *attitudes of farmers towards income risk* are Bond and Wonder (1980), Francisco and Anderson (1972), Dillon and Scandizzo (1978) and Binswanger (1980). Studies of Boussard and Petit (1967), Lin, Dean and Moore (1974), Brink and McCarl (1978) and Scott and Baker (1972) concerned empirical studies of the *choice of farm cropping plans* as a decision under risk.

Decisions concerning the *optimum level of pesticides* are analyzed in e.g. Carlson (1970), Webster (1977) and Thornton (1985). The *use of fertilizer* is analyzed in Moscardi and de Janvry (1977) and the *amount of futter reserve* in Officer and Halter (1968). Adoption and utilization of modern-seed technology in the Philippines is studied in Huijsman (1986) who analyzes the hypothesis that slow *adoption of new technologies* by poor farmers is caused by farmers' risk aversion. Specific attention to risky decision making of small, subsistence farmers in underdeveloped countries is presented in Roumasset et al. (1979).

Two aspects are striking in this literature. Firstly, literature on decision making under risk of farmers is predominantly devoted either to total farm planning, especially crop production planning, or to specific production decisions like fertilizer input decisions and pest management. Surprisingly little literature exists about farmers' market related decisions under risk. When marketing decisions are studied, then they are mostly concerned with the futures market. One such study to be mentioned here is Martin and Hope (1984). It is not very surprising that attention is directed to the futures market when studying farmers' marketing behavior since the futures market is developed for reducing price risks (an analysis of the role of the ware potato futures market in price risk reduction can be found in Wierenga and Meulenberg 1984). In this study we will not pay attention to the futures market in an explicit sense. The role of the potato futures market for the individual farmer in the Netherlands is limited. Only a very small percentage of potato growers actually buy and sell on the futures market; it is typically used by wholesale companies and the potato processing industry. In this study therefore, our attention is directed to the choice of marketing strategies as a decision under risk, irrespective of the use of the futures market.

A second observation concerns the fairly small number of field or experimental studies of farmers' risky decision making. In the studies that do exist, the number of farmers researched is typically limited to some dozens, often selected subjectively. It is therefore very difficult to generalize findings from these studies (Robison 1982). Robison further notes that many empirical studies suffer from methodological weaknesses. Binswanger (1980) is a notable exception in these respects since he studied a fairly large sample of farmers (about 200). Binswanger's research is furthermore very interesting because he measured risk attitudes using real-money-bets while nearly all the other studies apply bets with hypothetical outcomes.

To conclude, field research devoted to modeling the farmer's decision making process with respect to the choice of marketing strategies as a decision under risk is sparse. Also, much of the research done is hampered by methodological and sampling problems which make it hard to generalize findings.

Since the decision problem in this study concerns a marketing decision, also the body of literature on decision making under risk in marketing should be given attention to. In marketing, the decision making process of both the marketing decision maker and the consumer is interesting when studying the effects of risk.

With respect to the way the marketing decision maker deals with risk it is concluded that this topic is scarcely researched empirically. Of course, each handbook on managerial decision making or on marketing research includes a chapter in which attention is given to the expected value and the expected utility model and in which the essentials of Bayesian decision theory are discussed. However, these models and techniques are not applied extensively in actual marketing decision making (see e.g. Green et al. 1988). Green et al. state that reasons for the reluctant acceptance of these methods may reflect a lack of either understanding, capability, or need for more sophisticated techniques. In general, it is appropriate to state that systematic research into how marketing decision makers actually decide and particularly how they deal with risk, is lacking (Lee, Acito and Day 1987 and Perkins and Rao 1990).

Literature on the modeling of consumer behavior under risk might be interesting for this study especially with respect to methodological issues, since our empirical setting concerns a large number of individual decision makers who will be interviewed in a survey. In consumer behavior, especially in the sixties and seventies, attention is given to the empirical study of decision making under risk. Starting with Bauer (1960) and shown in the volume of Cox (1967) considerable research in this field was conducted with respect to the effects of *perceived risk* on decision making. Usually, in multiattribute decision models, perceived risk is incorporated by means of extra attributes. For example, Cunningham (1967) modeled perceived risk by two attributes: a) the uncertainty about the outcome of the decision, and b) the extent of negative outcomes that are possible after the purchase of a product. See also the models of e.g. Bettman (1973) and Pras and Summers (1978).

In this type of research into perceived risk, hardly any reference is made to utility theory, the expected utility model or subjective probability distributions. Nor is much attention given to techniques and procedures in measuring risk attitudes of consumers or to eliciting subjective probability distributions. One might characterize this research by a naive modeling of risk. Recently however, utility theory and measurement techniques have been given more attention to in consumer decision making under risk. For example Hauser and Urban (1979) and Eliashberg (1980) successfully modeled consumer preferences by means of expected utility theory and predicted preferences reasonably well with the model. Also Currim and Sarin (1983) applied expected utility theory in modeling consumer preferences under uncertainty by means of a multiattribute model. According to Corstjens and Gautschi (1983), the theoretical model of expected utility is particularly relevant for e.g. concept testing and new product development.

Notwithstanding these efforts, the bulk of consumer research does not deal explicitly with risk. Multiattribute models under certainty are assumed to provide a sufficient approximation of the consumer's preferences and choices. One very important reason for this limited attention is, according to Eliashberg and Hauser (1985), the difficult question formats and elaborate measurements that are needed in an explicit modeling of risk. Typically, in marketing research, interviews are subject to time limits. Moreover, it is not yet clear whether the predictive validity of the models will increase significantly if perceived risk and risk attitude are incorporated in accordance with the expected utility model.

To conclude, more research is needed to evaluate the effects on predictive validity of the explicit modeling of decision making under risk and to develop respondent-friendly and easy-to-handle measurement techniques. The recent work by e.g. Eliashberg and Hauser (1985) and Currim and Sarin (1989) is stimulating this kind of research. Since methodological problems in this study resemble those in consumer research, insights gained in this study will be beneficial for consumer research, too.

1.4 Research objectives

From the review of the body of literature on decision making under risk the following conclusions can be drawn.

Firstly, utility theory and behavioral decision theory provide a number of theoretical notions on decision making under risk. In both fields, a number of models are proposed to explain preferences and choices of decision makers. Typically, the models are confronted with one another in experimental research and these experiments are often conducted with students as decision makers and with hypothetical decision contexts. It is interesting therefore to compare those models theoretically and empirically in a field study with decision makers familiar to the, non-hypothetical, decision problem.

Secondly, in decision analysis and utility theory recently the concept of the relative risk attitude has been introduced (see e.g. Dyer and Sarin 1982). This concept seems attractive from both a theoretical and methodological point of view. However, empirical research into the concept is scarce and inconclusive.

Thirdly, the methodology to be used in modeling decision making under risk stems mainly from decision analysis. However, in decision analysis assessments are conducted with a very small number of decision makers, in ideal conditions with respect to the time available in interviews, the motivation of the decision maker, the opportunity of using the computer in assessments and so forth. In a survey the conditions are much less ideal and the question arises whether the techniques from decision analysis are applicable and practically feasible in these conditions.

Fourthly, in field studies that do exist, especially in studies with agricultural producers as respondents, typically a fairly small number of respondents is involved. Furthermore, often only one measurement technique is used to elicit subjective probability distributions or to assess risk attitudes. Moreover, these measurements usually take place only once with each respondent. Consequently, in field studies there is very scarce evidence with respect to the validity and the reliability of the measurement procedures.

In order to gain insight into the issues mentioned above, the purpose of this study is threefold.

Firstly, theoretical notions from utility theory and behavioral decision theory on risky decision making will be reviewed and tested with respect to the explanation of individual decision making under risk. Specifically, the subjective expected utility model will be compared to competing models (the subjective expected value model and a so-called pragmatic model) in the explanation and prediction of preferences. Another main topic concerns the definition and empirical testing of the concept of relative risk attitude.

Secondly, in this study special attention will be given to the methodological problems of measuring the risk perceptions and risk attitudes of a large sample of decision makers in survey conditions. Insight will be gained into the stability of measurements and into convergent and discriminant validity of risk perception and risk attitude measurements by means of applying a *multitude* of measurement techniques *twice* for each respondent. The use of multiple techniques deserves much more attention than has been given until now (von Winterfeldt and Edwards 1986).

Thirdly, an analysis is given of the farmer's decision making process with respect to the choice of a marketing strategy for ware potatoes. The choice of a marketing strategy is an important and risky decision to be made by the farmer each year. Consequently, it is expected that an analysis that incorporates risk will perform better than an analysis without explicit attention paid to risk. This decision problem is thus suitable to test the theory and methodology. Insights into the farmer's decision making process can be useful for suppliers of marketing services. For example, the analysis will provide wholesale companies with information about market segmentation, positioning, the development of new services or adjustment of present services. Findings from the study might also be useful in the design and development of decision support or expert systems meant to support and possibly improve decisions of individual farmers.

From these three objectives specific research questions will be derived and presented (in Section 3.6), following the presentation of the structuring of the decision problem in Chapter 2 and a review and evaluation of models for decision making under risk in Chapter 3.

1.5 The empirical study

With a sample of 250 farmers, randomly selected from the population of farmers in an important region for ware potato production in the Netherlands, face-to-face interviews were held in 1984 and 1985. In 1984 each farmer was interviewed twice for about one to one and a half hours each. In 1985 each farmer was interviewed again in order to enable test-retest analyses.

A preference formation model has been developed in which the main elements concern the way in which a farmer perceives the price risk associated with a marketing strategy (the risk perception) and the farmer's risk attitude. Multiple measurements of both risk perceptions and risk attitude were obtained. Techniques used for measuring risk perceptions include an interval technique to elicit subjective probability distributions and magnitude scaling. Risk attitude is assessed by means of lotteries, conjoint measurement and a direct rating technique. Also, preference measurements for a number of marketing strategies and choice behavior of farmers were recorded. Furthermore, motives for choosing a marketing channel and a number of background characteristics of the farmer and his farm were collected. A detailed description of the operationalizations made, the data collection and the sampling procedures will be given in Chapter 4.

The study differs from other studies in the field of decision making under risk in the following respects. This study analyzes and models decision making under risk for a fairly large sample of decision makers and the data used is collected in survey conditions. These circumstances led to the approach of multiple indicators in the measurement of important variables in the model. Risk perception, risk attitude as well as strength of preference are all operationalized in several ways, thus providing the opportunity to study whether the measurements of each concept correspond with one another. By repeating the measurements in two

consecutive years this correspondence can be analyzed twice and it is possible to get more insight into the stability of the respective measurements.
In particular, the combination of the features of the large sample, the use of multiple measurements procedures per concept and the use of test-retest measurements distinguishes this study from most of the other empirical studies.

1.6 Outline of the book

In Chapter 2, an elaborate delineation will be presented of the decision problem the farmer is confronted with. A description of the risks associated with the ware potato market, the structuring of the decision problem and the definition of the choice alternative in this study, namely the marketing strategy, will receive attention in this chapter. The chapter finishes with a conceptual model of the farmer's decision making process.

In Chapter 3, theories which are commonly used in decision making under risk are reviewed and evaluated. Much attention will be devoted to the subjective expected utility model and the concept of relative risk attitude, the latter being associated with the value/utility distinction. Some criticism of the descriptive inaccuracy of the subjective expected utility model is presented and alternative descriptive models like Prospect Theory are discussed.

Chapter 4 contains a description of the design of the empirical study. Operationalizations of variables are given, followed by a description of data collection and sampling procedures.

Chapters 5, 6 and 7 each contain one of the main elements of the conceptual decision model: risk perception, risk attitude and the combination of both into preference formation.

Chapter 5 deals with the methods of measuring risk perceptions and a subsequent extensive discussion of measurement results. Stability and convergent validity of the perception measurement are analyzed by comparing the results obtained by means of the elicitation of subjective probability distributions with those obtained by means of more simple and easy-to-handle direct measurement techniques.

In Chapter 6, methods and procedures for assessing risk attitudes are presented. Risk attitude is assessed with both riskless and risky procedures. The results of assessing the degree of risk aversion of farmers are presented, the concept of relative risk attitude is tested and stability and convergent validity of the multiple measurements of risk attitude are discussed. Furthermore, the relationship between a farmer's risk attitude and background characteristics is determined.

In Chapter 7, the preference for marketing strategies is analyzed. A test of the conceptual model of preference formation will be given. Specifically, the predictive validity of the subjective expected utility model is compared with the subjective expected value model. Furthermore, a comparison is made between the expected utility model and a pragmatic model of preference formation. Finally, the preference of farmers for a marketing strategy is linked to background variables.

Chapter 8 then contains a summary and synthesis of the major findings and conclusions, as well as suggestions for further research.

CHAPTER TWO

STRUCTURING THE FARMER'S DECISION PROBLEM

In this chapter the farmer's decision problem at the time of the research will be delineated. First, a description is given of the crops grown in the region and their respective yields, as well as the prices and gross margins over the years. Special attention is given to the price variations of ware potatoes, within and between marketing years.

When confronted with the problem of marketing their ware potato produce, farmers have a number of selling-options and have to decide upon the moment of delivering their potatoes and through which marketing channel they wish to use. The choices open to farmers will be described and a definition of a marketing strategy, as it is conceived in this study, will be given. This marketing strategy is the choice alternative in this study. When analyzing the attributes which might be important in choosing between marketing strategies, it will turn out that a two-attribute model of preference formation suffices. Those two attributes are the *price* which can be obtained by a marketing strategy and the *marketing channel* chosen. The chapter concludes with a description of the conceptual model of the decision making process.

2.1 A characterization of the decision context

In the region in which this study took place, the IJsselmeerpolders, two polders located in the heart of the Netherlands, a typical farmer grows three crops: potatoes (ware or seed potatoes), sugar-beets and cereals (mainly wheat). If a fourth crop is grown farmers might choose, among other things, onions, pulses, French beans, sprouts or cabbage.

Legally the area allocated to potatoes is limited to a maximum of a third of the arable land. Two common crop rotation plans exist in the region. First, a plan in which the area is allocated equally to three crops (potatoes, sugar-beets and cereals). In a second common plan the area is allocated equally to four crops (potatoes, sugar beets, cereals and some fourth crop). Nearly always farms grow either ware potatoes or seed potatoes, seldom both.

The high intensity of potato production in the plan with only three crops poses cultivation problems, especially with respect to potato sickness. This high intensity makes it necessary to take special production measures, like desinfecting the soil. Another way of preventing soil sickness is to choose a lower potato cultivation intensity, e.g. a fourth or a fifth of the arable land.

In Table 2.1 some statistics are presented concerning the average yield in kgs, price and gross margin[1] for the most important crops over a number of years. This table clearly shows that the average gross margin of potatoes is by far the largest, at Dfl 8572,= for ware potatoes and Dfl 10.905,= for seed potatoes. The average yield for ware potatoes was 47148 kg/ha at an average price of 23.73 cts/kg (or, equivalently, Dfl/100 kg), (see also Figure I.1, Appendix I).

Table 2.1 Mean yield (in kg/ha.), prices (in cts/kg) and gross margin (in Dfl/ha.) for a number of crops in the Central Clay area (73/74 to 86/87)

YEAR	WARE POTATOES		SEED POTATOES		WARE POTATOES	SEED POTATOES	WHEAT	SUGAR BEETS	OTHER CROPS
	kg/ha	cts/kg	kg/ha	cts/kg	DFL/ha	DFL/ha	DFL/ha	DFL/ha	DFL/ha
73/74	46197	15.87	31931	36.11	5981	9053	2332	4088	4366
74/75	44869	14.61	28851	38.57	5021	8431	2791	4801	2885
75/76	36022	35.09	24641	64.92	10942	12976	2408	5336	4630
76/77	45869	44.45	30701	98.97	18501	26174	3071	5466	5774
77/78	39614	13.01	21363	61.82	1940	6836	2234	4460	3249
78/79	45036	17.76	27980	42.64	5501	7220	3156	4721	3743
79/80	45399	19.37	27299	40.99	6566	7515	2956	4961	5090
80/81	48755	21.28	29661	39.03	8365	8443	2990	6155	5636
81/82	52005	27.21	32107	40.67	11955	9589	3391	6068	5438
82/83	51340	19.32	33673	45.65	7442	11652	3923	5885	4812
83/84	41958	51.11	24531	78.12	18568	15379	3750	5835	6950
84/85	54633	17.36	35203	47.54	5812	11676	3688	6070	4882
85/86	52481	15.97	36182	35.54	5090	7709	2675	5938	3307
86/87	55987	19.76	38953	40.04	8330	10010	3415	6773	5907
Mean	47148	23.73	30220	50.76	8572	10905	3056	5468	4762
Median	46033	19.35	30181	41.85	7004	9321	3031	5651	4847
St. dev.	5734	11.69	4906	18.69	4910	5028	536	766	1164
Coef. var.	0.12	0.49	0.16	0.37	0.57	0.46	0.18	0.14	0.24

Source: BUL 73/74-86/87, LEI, The Hague.

The large difference in the amount of variation in gross margin between crops is striking (compare the coefficients of variation in Table 2.1). Whereas the gross margins for potatoes show a very large standard deviation in guilders per ha. and are skewed to the right (the mean is larger than the median), the results for sugar-beets and wheat are fairly stable. Gross margins for ware potatoes range from Dfl 1940,= to Dfl 18.568,= per ha. which is almost a tenfold difference. Moreover, these numbers are averages; for individual farms variations might be larger.

[1] Gross margin is defined as gross returns minus total allocated costs per ha. The allocated costs consist of costs of seeds and seed potatoes, fertilizers, plant protection products, contract work and other costs (incl. interest).

Variation in gross margin of potatoes is mainly caused by variation in prices. Prices for cereals and sugar-beets are more or less stable since they are EC-regulated, whereas potatoes are a free market crop and thus prices are a result of varying supply and demand levels.

On the aggregate level, yield and prices for ware potatoes are not significantly correlated over the years.[2] The main reason for this finding is probably the fact that market prices for ware potatoes in the Netherlands are influenced by the potato yield in countries importing Dutch potatoes. Since yield in the Netherlands appears to be practically independent of yield in those countries and almost two-third of potato produce is exported, prices are influenced strongly by export demand (see also Figure I.2, Appendix I).

Table 2.2 *Mean monthly prices of ware potatoes of the Dronten and Emmeloord exchanges, 73/74-86/87, field crop delivery (0 mm. upwards), in cts/kg*

Year	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	Mean	St.dev.
73/74	13.37	17.20	15.79	14.09	14.07	10.60	10.05	8.96	9.66	12.64	2.93
74/75	7.71	11.18	17.41	15.44	10.76	9.88	10.75	14.53	15.81	12.61	3.27
75/76	23.66	31.25	37.94	42.00	64.75	68.75	78.50	108.44	117.17	63.61	33.35
76/77	55.50	50.38	48.81	49.75	55.91	41.25	35.31	35.56	33.50	45.11	8.84
77/78	7.60	8.74	7.64	7.81	7.63	7.00	7.47	13.02	17.94	9.43	3.67
78/79	10.00	11.47	14.64	16.29	18.46	16.94	17.74	22.29	21.96	16.64	4.18
79/80	16.13	17.67	19.34	19.15	19.89	17.11	13.21	12.38	9.35	16.03	3.63
80/81	11.79	16.05	22.00	21.17	20.78	18.94	19.03	18.48	27.16	19.49	4.22
81/82	18.27	18.82	18.78	20.37	24.32	28.27	38.97	49.25	53.08	30.01	13.69
82/83	14.21	15.52	16.92	16.24	13.63	13.71	13.67	11.84	15.74	14.61	1.60
83/84	35.50	35.44	41.65	44.41	48.35	67.08	75.19	70.72	76.40	54.97	17.16
84/85	15.41	17.53	13.51	11.71	13.09	12.89	12.41	12.63	11.52	13.41	1.92
85/86	11.56	8.60	9.06	9.96	9.54	8.09	8.50	12.23	12.35	9.99	1.65
86/87	18.00	16.90	15.75	16.40	20.48	18.10	18.44	15.84	9.63	16.62	3.01
Mean	18.48	19.77	21.37	21.77	24.40	24.19	25.66	29.01	30.81	23.94	4.10
St.dev.	12.85	11.64	12.39	13.41	18.22	20.53	23.60	28.85	31.40		
Coef. var.	.69	.59	.58	.62	.75	.85	.92	.99	1.02		

To further illustrate the large price variation of ware potatoes, Table 2.2 presents the mean monthly prices of potatoes. Not only are there large price variations between marketing years but prices also fluctuate heavily within a year. Fluctuations were especially large in 75/76, 81/82 and 83/84. Averaged over the years, prices increase within the marketing year as a result of storage costs. However, in some years prices increase strongly within a year (e.g. 75/76 or 81/82) but increases can also be minor (82/83). Even a decrease within a year may occur

2 Pearson $r = -.33$, $p < .12$, one-tailed; Spearman is -05).

(e.g. 76/77 and 84/85). Table 2.2 furthermore shows that the coefficient of variation increases within a marketing year. This means that, in general, price risk increases within the year. The farmer has to deal with these price fluctuations within each marketing year by means of his selling strategy. The next section describes the marketing strategies which are optional to the farmer.

2.2 Analysis of the farmer's marketing decision problem

Potato harvest takes place in September or the first part of October, depending upon the weather conditions. Since almost all the farmers in the IJsselmeerpolders have their own storage facilities, a very large part of the total harvest in the region will be stored by the farmers themselves. Depending upon the quality of the storage facilities (e.g. insulation against high and low temperatures, air-conditioning etc.), potatoes can be stored from September until the end of July the following year. During the storage period ware potatoes decrease in weight and the quality somewhat deteriorates. Through storage management the farmer can influence the degree of weight reduction and quality loss to some degree. The farmer has to be especially alert for disease and rot which, when not acted upon immediately, could lead to the deterioration of his total stocks.

While storage facilities are provided by farmers, grading is performed by the wholesaler. Farmers will therefore deliver their potatoes in bulk. Delivery nearly takes place at one moment in time.

As stated above, the farmer has the opportunity to market his ware potatoes as long as his storage facilities allow him to. To market his potatoes, a farmer has to decide upon three important issues.

a) Choice of a marketing channel: *"To whom should I sell?"*
b) Choice of how to allocate his potato harvest in kgs to a number of selling-options and the timing of selling: *"When and how much should I sell at each selling-option?"*
c) Choice of a moment of delivery: *"When should I deliver?"*

As we will see in Section 2.3 the specific choice a farmer makes with respect to these three elements is what we define as the *marketing strategy* he chooses. Before presenting a definition of the marketing strategy, the three choices will be elaborated upon.

2.2.1 Choice of a marketing channel

In the IJsselmeerpolders almost all ware potatoes are sold to wholesale companies. The amount directly sold by the farmer to the potato processing industry or retailer is negligible (De Graaf 1981). We therefore focus on the wholesaler as the farmer's main marketing channel. Within the group of wholesalers the farmer has to choose between selling to a *cooperative* company or to a *privately-owned* company.[3] [4]

In the region in which this study took place, there is only one cooperative company, which markets approximately a third of the potatoes grown in the area (De Graaf 1981, Smidts 1985). Farmers have to be members of the organization in order to be able to deliver their crop. Membership at first is compulsory for two years and has to be renewed annually. A very important aspect of choosing to join the cooperative as wholesale company is the duty of delivery: a member's whole potato harvest has to be sold through and delivered to the cooperative; selling and delivering to another wholesale company is not allowed. Several private companies trade in the region. Farmers have freedom of choice with respect to how many and to which private companies they sell their potatoes to. In Section 2.4 more specific differences between both types of wholesale companies are discussed.

2.2.2 Choice of allocating harvest to selling-options and timing of selling

After having chosen a marketing channel, a number of selling-options are open to farmers. The options are: a fixed-price contract, a pooling contract, a bottom-price contract and selling on the spot market. As Table 2.3 points out, cooperative and private wholesale companies differ with respect to the options available to farmers. The cooperative does not offer fixed-price or bottom-price contracts.

The allocation of potato harvest to the two remaining options at the cooperative is fixed: either 100% pooling or 50% pooling. Contrariwise, the allocation over options is left open to farmers dealing with private companies. For example, a farmer can sell 50% at a fixed-price contract, 25% by means of pooling and 25% at spot market prices. The options offered by the cooperative company will be described first, then a description of the selling-options of private companies will follow.

[3] Because farmers are members of a cooperative company, in principle one cannot speak about "selling" to a cooperative company in the same sense as one speaks about selling to a private company. For reasons of comparibility in this study delivering to a cooperative company is denoted as selling.

[4] Henceforth, a privately-owned wholesale company is referred to as a private wholesale company.

Table 2.3 Selling-options open to the farmer and market share of each option in 1983 (calculated on kgs)

		Market share, 1983[b]	
Cooperative company			*36.1%*
1)	100% POOLING[a]	20.7%	
2)	50% POOLING 50% selling on the SPOT MARKET (at one or more selling moments)	15.4%	
Private companies			*63.9%*
1)	FIXED-PRICE CONTRACT	15.5%	
2)	BOTTOM-PRICE CONTRACT	5.4%	
3)	POOLING CONTRACT	8.1%	
4)	Selling on the SPOT MARKET (at one or more selling moments)	34.9%	

a 100% refers to the total harvest of a farmer
b Source: Smidts (1985)

Selling-options at the cooperative company

Each year, before June, a farmer who sells to the cooperative company has to choose between:

a) selling his total potato harvest (100%) by means of a pooling contract (henceforth referred to as 100% pooling) or
b) selling 50% of his harvest by means of a pooling contract and 50% at spot market prices (referred to as 50% pooling, 50% spot market).

a) 100% POOLING

In this form of contract, all potatoes brought in by all farmers choosing this contract are sold by representatives of the cooperative. The total gross returns of these sales, minus costs, is distributed among farmers in proportion to the amount of potatoes delivered. The price a farmer receives will be close to the average market price, since the cooperative is spreading its sales over the marketing year. At the moment of delivery, farmers receive a preliminary payment based on the expected pooling price. The final payments will be made in June or July.

In principle each farmer receives the same price. However, price differentiation takes place by means of a premium and discount system. Firstly, differences in storage costs are taken into account. Farmers delivering early in the season (say October or November) have lower storage costs than farmers delivering at the end of the season (say July). The calculation of storage costs is based on the costs of average storage facilities. Secondly, premiums or discounts are given depending upon the waste percentage, size distribution and quality of the delivered potatoes. Quality is measured by means of a standardized and objective method. This quality premium system stimulates farmers to improve their ware potato quality.

A very important characteristic of the 100% pooling system is that the farmer does not take active involvement in the market itself, i.e. in deciding how much and when to sell. These decisions are taken over by the representatives of the cooperative. Farmers are only engaged in the production and storage of potatoes.

b) 50% POOLING, 50% SPOT MARKET

In this form of contract, a farmer has to sell 25 tons/ha (net) potatoes by means of pooling. Since return is approximately 50 tons/ha net, this means that around 50% of total harvest is sold via pooling. The remaining potatoes are sold to the cooperative at their spot market prices. The farmer is free to choose when and how much to sell at spot market prices. E.g. he can either sell this 50% at one moment in time or in portions at several moments (at probably different spot market prices). Selling at spot market prices implies that the farmer has to acquire as much information and insight into price movements as possible. He therefore has to keep track of the potato market actively.

In comparison with the 100% pooling contract this form of contract should, in principle, result in a higher average price and a larger price risk. The reason for this is that the amount sold on the spot market by an individual farmer is fairly small which leaves less opportunity to the farmer to spread his sales over time than it does to the cooperative company selling a large amount. His price risk will therefore be larger and this larger price risk should be offset by a higher average price. The higher average price despite the larger price risk may be the main reason why a farmer prefers the 50% pooling form of contract to the 100% pooling contract. Another reason might be the active involvement in the market which does not reduce a farmer to a mere grower of potatoes.

The same premium and discount system with respect to moment of delivery, waste percentage, size distribution and quality, as described for the 100% pooling contract is applicable here.

Selling-options offered by private companies

As Table 2.3 shows, a farmer can choose pooling, fixed-price, bottom-price contracts or selling at spot market prices.

In contrast with the cooperative, the amount sold through each selling-option is to be decided by the farmer. He can therefore distribute his amount of potatoes among the options as he wishes. Contracts are settled at a fixed amount of potatoes, usually 100, 150 or 200 tons net. Usually, contracts are signed before planting and well before harvest time. Most contracts are only for one year. Premiums and discounts are given according to the specifications in the contracts depending upon the moment of delivery, size distribution, waste percentage and quality of potatoes.

a) POOLING CONTRACT

This contract resembles the cooperative pooling system. A number of farmers bring in a certain amount of potatoes. A pooling committee, consisting of representatives of the wholesale company and a representation of farmers, decides when to sell and how much. The committee can decide to spread sales evenly over the marketing year in order to arrive at an average market price. The strategy employed depends on the price risk the committee is willing to take. Also, a very risky selling strategy might be employed e.g. by selling at only a few moments in time.

The price farmers receive is based on the gross return minus a payment to the wholesale company as compensation for using the representatives' market information and sales system. This compensation amounts to approximately 10% of the wholesaling price.

b) BOTTOM-PRICE CONTRACTS

A second selling-option consists of the bottom-price contract. According to this contract, the farmer always receives a specified bottom-price. The wholesale company guarantees payment of this bottom-price irrespective of the market situation. Of course, this payment will not be made when the wholesale company goes bankrupt.

The price farmers receive is calculated as follows. A weekly regional market price is set at the regional potato exchange. On the basis of this price, an average market price is calculated for the marketing year. In case this average market price is higher than the average bottom-price, 75% of the positive difference is paid to the farmer, on top of the bottom-price. The remaining 25% of the difference is received by the wholesale company. In case the average market price falls below the bottom-price, the farmer receives only the bottom-price.

The price risk is limited in this form of contract because of the bottom-price and because the final price is calculated on the basis of the average market price. The level of bottom-prices varies somewhat between wholesale companies and respective years.

c) FIXED-PRICE CONTRACT

A third option consists of selling a net amount of potatoes at a fixed contract price. A characteristic of this contract is the transfer of total price risk from the farmer to the wholesale company. Furthermore, the farmer knows the final price he will receive with certainty well before the marketing year. The farmer's income from potatoes will, of course, still be uncertain because of yield risk.

d) SELLING ON THE SPOT MARKET

A final option consists of selling an amount of potatoes at one or more moments in time at spot market prices. Prices are settled by taking into account the moment of delivery, which may be several months later than the actual selling moment.

The timing of the moment of selling is, of course, very important, especially when market prices fluctuate heavily. The farmer should therefore be informed about the potato market and the expected price changes as well as possible. Of course, a farmer might reduce his price risk by spreading his sales over the marketing year. Selling the total amount at one moment in time would be most risky.

2.2.3 Choice of a moment of delivery

A third choice to be made by the farmer is the moment of delivery. As stated above ware potatoes can be stored until the end of July, which is, however, only possible with very good storage facilities. The quality of the storage facilities is therefore a limiting factor on the moment of delivery.

There are four natural moments of delivery depending upon the storage facilities. Firstly, if no facilities are available at all, delivery takes place during the harvest in September or October. Secondly, if insulation against low temperatures is limited, delivery will take place around the end of December. Thirdly, if insulation against high temperatures is limited and/or no measures are taken against sprouting of potatoes by using chemicals, delivery typically takes place at the end of March. The fourth group of storage facilities and storage measures allows storage towards June or July. In our operationalisation of the marketing strategies, described in Section 2.3, these four natural moments of delivery will be taken into account.

2.3 Defining the choice alternative: the marketing strategy

From the description above, it is clear that a farmer has to make many decisions and that these decisions are spread over a long period of time. Contracts with private companies are mostly decided upon around February and March, even before the potatoes have been planted, whereas spot market sales may start in September and could well last until April or June of the following year, even after the new potato crop has already been planted.

Since we do not intend to describe this whole on-going decision making process, some limitation is needed. In our view a useful focus of research would be the choice situation in June. By then, the marketing channel and delivery period will usually have been decided upon. Also, more importantly, at this moment the cooperative farmers will have decided upon their choice between 100% pooling and 50% pooling and the farmers selling to private companies will have chosen the type of contracts and the amount per contract. Furthermore, the amount to be sold at spot market prices will be reasonably clear by subtracting the amount contracted from the expected yield.

The sole issue that will not yet be settled in June is the exact timing of spot market sales. However, farmers will probably have certain intentions concerning both the number of times they plan to sell (often this is a rather small number) and the approximate selling moments. The latter are described in terms of "towards the moment of delivery", "before winter" or "in early spring". From the viewpoint of studying the risk taking behavior of farmers, we are more interested in knowing whether someone intends to sell, say 40% in March or April, than in knowing that he actually sells, say 32% on April 14. Not knowing the exact timing and amount of spot market sales therefore poses no problem in studying the influence of risk perceptions and risk attitudes on the overall strategy chosen.

The *marketing strategy* that a farmer chooses is thus defined as a farmer's choice of a marketing channel (in terms of the type of wholesale company), and given this channel choice, his choice of allocating the harvest to selling-options and the timing of selling at the spot market, and the choice of a moment of delivery.

To further characterize the marketing strategy we might view the farmer as one who allocates his 'potato capital' to selling-options to construct a portfolio analogous to a portfolio of stocks. He chooses types of contracts and amounts per contract in such a manner that he will arrive at a trade-off between the expected price and the price risk he finds acceptable. The trade-off the decision maker finds acceptable is seen as being dependent upon his risk attitude.

To illustrate the concept, some examples of marketing strategies are described below:

1. Sell to a cooperative company
   100% POOLING
   Delivery: April

2. Sell to a cooperative company
   50% POOLING
   50% SPOT MARKET: sell 25% in December/January and the remaining 25% in April/May
   Delivery: June/July

3. Sell to a private company
   100% BOTTOM-PRICE: with bottom-price at 16 cts/kg
   Delivery: December/January

4. Sell to a private company
   100% SPOT MARKET: sell 10% in October, 50% in January and 40% in March
   Delivery: March

5. Sell to a private company
   25% POOLING
   50% FIXED-PRICE of 25 cts/kg
   25% SPOT MARKET: sell in April/May
   Delivery: May

In this study data will be collected concerning perceptions and preferences of marketing strategies which are similar to the examples above. The marketing strategies used will be described in Chapter 4.

2.4 Choice of a marketing strategy as a two-attribute decision problem

The marketing strategy as defined above and further illustrated in the examples, is the object of choice in this study. The focus is on explaining the preference for a marketing strategy: why do farmers differ in their preferences for marketing strategies? The first part of this section concerns a brief presentation of modeling multiattribute decision making in general. In the second section the farmer's decision making process will be modeled by means of two attributes.

2.4.1 Analysis of multiattribute decision processes

The decision making process for choosing one alternative from a set of alternatives is often divided into a number of distinct stages. Usually the following stages are distinguished: a) problem definition, b) the search for information about alternatives, c) evaluation of the alternatives, d) choice of one alternative and e) evaluation of the results or outcomes of the final choice (Keeney and Raiffa 1976, Engel et al. 1986, Boehlje and Eidman 1984). Here we will focus on the evaluation of the alternatives stage.

Usually, in models of both risky and riskless decision making, preference or attitude formation at the stage of evaluation of alternatives is conceived as consisting of at least three important elements:

a) perception of each alternative in respect of one or more relevant attributes
b) the evaluation of each possible outcome for each attribute
c) some rule combining perception and evaluation.

Since these three elements also form the essence of the theories of decision making under risk which will be described and discussed in detail in Chapter 3, only a very short description of each element is presented here.

a) Perception of alternatives in respect of attributes

Important here is how many and which attributes are relevant in forming the perception of a choice alternative. If only one attribute captures the essence of an alternative a one attribute decision problem results. However, more than one attribute is mostly needed to fully describe alternatives. These multiattribute decision models are common in e.g. modeling consumer behavior (Engel et al. 1986).

A second important aspect concerns the distinction between certainty and risk. Are the outcomes certain when choosing an alternative or are they merely probable? If outcomes are merely probably the perception is usually captured by a subjective probability distribution of outcomes. If outcomes are certain the perception of each alternative can be represented by one score on an attribute, for example measured on a Likert scale.

In essence, outcomes are never certain to the decision maker. For example: what will a meal ordered in a restaurant taste like or what will be the fuel usage of a car one has bought? All decision making is therefore essentially decision making under risk. However, in studying decision making, modeling the decision process as if it were a decision under certainty, often may be accurate enough in explaining choice behavior. Especially consumer behavior is usually modeled as a decision under certainty as is shown by e.g. the Fishbein and Ajzen model of reasoned action (Ajzen and Fishbein 1980), fairly popular in the study of consumer behavior. Not modeling risk explicitly may be less appropriate for important consumer decisions with fairly large risks (Hauser and Urban 1979). In these cases multiattribute decision models under risk are more appropriate. These models are discussed extensively in Keeney and Raiffa (1976).

An important reason for modeling under certainty is its simplicity in respect of measurement procedures and analysis compared with modeling under risk. In general, modeling decisions under risk should predict preferences and behavior better to justify the additional effort.

b) Evaluation of outcomes for each attribute

This element in the evaluation of alternatives concerns a statement of a decision maker about the attractiveness of each possible outcome for each attribute. In case of certainty (only one possible outcome), the evaluation is one score e.g. measured on a semantic differential scale. In case of risk, the evaluation of possible outcomes can be represented by a function that links each outcome to its attractiveness to the decision maker. In the expected utility model, to be discussed in Chapter 3, the shape of this function indicates the risk attitude of the decision maker.

The manner in which the evaluation function should be assessed and the interpretation that should be given to each type of assessment, is subject to discussion. Two different views exist in this respect. According to one view the assessment should be performed by registrating decision makers' responses to lotteries. In this way, a so-called utility function can be constructed which indicates the risk attitude. According to another view responses should be assessed with respect to differences in outcomes which are certain. The resulting function is called a value function which indicates a decision maker's strength of preference and not his risk attitude. This value/utility debate concerning the theoretical and empirical relationship between the two types of functions constructed will be discussed extensively in Chapter 3.

After assessing single-attribute evaluation functions, the trade-off between attributes should also be assessed for multiattribute models. Descriptions of these procedures can be found in Keeney and Raiffa (1976) and von Winterfeldt and Edwards (1986).

c) Combining perception and evaluation

In most preference formation models under certainty the perception and evaluation scores are combined multiplicatively by attribute. These multiplied components are then added over attributes to arrive at a summated rating of favorableness (expectancy-value models). In case of risk and a one-attribute model, this implies that the probability of an outcome is multiplied by the evaluation of this outcome. Summing these components over all possible outcomes results in a preference score for each alternative. The validity of the combination rules of multiplication and addition are studied explicitly in information integration theory (Anderson 1981, Anderson and Shanteau 1970).

In case of multiattribute decision models, several combination functions are proposed for combining the separate utility components of single attributes. The most simple model is an additive one in which utility components are simply summed over attributes. This special case results if mutual utility or value independence exists between attributes (see Keeney and Raiffa 1976 for a definition of mutual utility independence). Another model is the multilinear model which incorporates interaction effects between the utility components.

This general discussion of modeling the stage of evaluation of alternatives is now followed by a specific analysis of this stage in the farmer's decision problem under study.

2.4.2 Attributes for evaluating marketing strategies

Each year the farmer has to choose a marketing channel and a combination of selling-options. Important in both decisions is: what are the relevant attributes for evaluating both choices? An overview of attributes will be given here. Some criteria emerge when studying the differences between marketing strategies, other criteria have been suggested by farmers during a number of depth interviews.

Attributes for choosing a marketing channel

The focus here is on the choice of the type of wholesale company: a cooperative and a private company. Many differences exist between them. The most important motives which probably play a significant role in choice behavior are briefly discussed here.[5]

First, *risk of bad debt* will probably be assumed to differ between a cooperative and a private company. In this context, the risk of bad debt is defined as the risk of receiving payment too slowly, not fully or not at all. Although the chance of receiving no payment at all is actually fairly small because of the small number of bankruptcies, this event occasionally happens. In fact, in 1986 a private company in the region in which this study took place did go bankrupt. Nevertheless, most farmers received most of their credits.

Apart from the possibility of not paying at all, firms will probably differ with respect to speed of payment. A slow payment will probably be experienced by farmers as much more annoying than the chances of receiving no payment at all. A difference in this respect between cooperative and private companies especially came up in depth interviews with the farmers. No notable payment problems were reported with the cooperative, whereas accounts were given of instances of irregularities with private companies. Of course, private companies will differ in this respect.

A second attribute concerns *contracting risk*, which is defined here as the risk that a wholesale company does not stick to the arrangements made in the contract. One example is the risk of being urged to deliver later than agreed which causes extra storage costs or storage problems with respect to potato quality. Another, even worse example is that the wholesale company does not want to

[5] In this study's questionnaire a number of open-ended questions was included in order to list these motives. The findings are reported in Smidts (1985).

receive the inventory at all. Other contracting risks are incorrect quality, size and/or waste determination. In the interviews, the above mentioned risks were seen as very small or negligible when dealing with a cooperative but potentially problematic with private companies. It should be noted, however, that although potentially problematic, contracting risk was not seen as a severe risk with private companies either.

Quality determination and a quality premium and discount system may be a third attribute. In this system the quality of ware potatoes is assessed by means of an objective and standardized method; premiums and discounts are given in accordance with the quality ratings. The cooperative company already started with such a standardized system in the early seventies. Recently, the larger private companies are also applying a standardized quality premium system in connection with their contracts, especially pooling. However, most spot market sales at private companies are still carried out without such a system. With those companies, quality is usually assessed by eye-balling and is implicitly accounted for in the price. At this moment, the quality payment system still constitutes a relevant difference between private and cooperative companies but differences are decreasing, particularly between the larger private companies and the cooperative company.

Still other differences exist between cooperative and private companies. To mention but a few: the obligation to deliver the total harvest to the cooperative, the limited number (i.e. two) of selling-options available at the cooperative compared to the larger number at private companies, the specification of the payment bill, friendliness and expertise of the company's representatives and service and advice about e.g. technical aspects during the potato production process and at delivery.

All aspects mentioned above will to some extent influence the preference and choice of a marketing channel. The choice of the marketing channel can be viewed as a two-stage process. Firstly, the farmer chooses between the cooperative and a private company (in the region in which this study took place, there is only one cooperative wholesale company). Secondly, when he has decided not to deal with the cooperative, he has to choose one or more specific companies from the group of private companies. Most of the attributes mentioned above are linked to the first choice between the cooperative and private company; some are relevant in the second stage. The focus in this study is on the first stage. We will concentrate on modeling whether a farmer chooses either a cooperative or a private company. Therefore all differences between the two types of wholesale companies can be represented by only one attribute which is a dichotomy: either a farmer favors a cooperative or he favors a private company. Preferences for a specific private company within the group of private companies will not be studied here.

Price as an attribute for choosing a combination of selling-options

Earning money is the primary objective of selling potatoes. Before planting, one might therefore view gross margin as the farmer's appropriate attribute for evaluating selling-options. After planting gross return would be considered most appropriate. In this study however, price is taken as an attribute. There are three arguments for this choice. Firstly, since price and yield are often negatively related in agriculture, striving for a small price risk could result in high return risk. As stated above, however, the correlation between yield and price of ware potatoes is not significantly different from zero on the aggregate level. Because of the lack of correlation between yield and price and the small variability of yield (see Table 2.1) the variability in gross return stems mainly from the variability in prices.

Secondly, a further argument for choosing price instead of return as attribute, is the moment of chosing a marketing strategy, namely June. In June, the farmer can already make a fairly good prediction of the yield. That is, yield is not very uncertain anymore at that moment, but has a more or less fixed value. Farmers will therefore choose between marketing strategies conditional on this information about expected yield.

A third, but perhaps most important, argument for choosing price came up at individual depth interviews with sixteen farmers. Those farmers stated price and not gross return or gross margin as the criterion of choice between marketing strategies.

When choosing between marketing strategies, the price to be obtained with each strategy is not known beforehand, and uncertain. An impression of the prices which might result and the chances of occurrence is therefore needed. This impression can be formally described by a probability distribution. Since each farmer could perceive the market situation differently, these probability distributions are subjective (or personal) probability distributions. They indicate a farmer's degree of belief about the chance of occurrence of an outcome. Heterogeneity in perception is therefore handled by means of these subjective probability distributions.

Conclusion

It follows from our definition of the choice alternative, the marketing strategy, and from the review of attributes, that two attributes are most important in modeling preference and choice. These attributes are price and marketing channel. Price is an attribute for which outcomes are uncertain whereas the marketing channel can be described by a dichotomy: a cooperative versus a private wholesale company.

Note that the moment of delivery is a limitation which is handled by means of the description of the marketing strategy, that is, farmers who cannot deliver later than, say, December will have to state their preferences for a set of marketing strategies delivering in December (see Chapter 4).

2.5 A model of the decision making process

A schematic overview of the model for choosing a marketing strategy in a specific marketing year is presented in Figure 2.1. Three decision stages are distinguished in this model: the evaluation of alternatives, the choice of one alternative and the outcomes of choice.

The evaluation of alternatives is modeled by means of two attributes: price and marketing channel. Important elements in the formation of the preferences are the perception of the marketing strategy in respect of price and the risk attitude of the decision maker in respect of price. The motives linked to the choice of a marketing channel are combined into a single choice between a cooperative and a private wholesale company.

The evaluation of alternatives results in a preference ordering of marketing strategies. In the model it is assumed that a high preference for a marketing strategy will result in a high intention to choose the marketing strategy. However, the relationship between preference and choice is influenced by the storage facilities of the farmer which acts as a short term limitation on choice with respect to the moment of delivery.

At the end of the marketing year, the post-decision outcomes will be apparent. They concern the ware potato price the farmer has received and the farmer's (dis)satisfaction with this price, bad or good experiences with respect to the marketing channel, etc. It is expected that the post-decision outcomes will influence decision making in the ensuing year by means of a feed back loop. Examples in this respect are that a farmer switches from the cooperative company to a private company or changes his perception of a particular selling-option. Another example is that a high price of ware potatoes in a particular year may raise the farmer's wealth. This might induce him to become less risk averse in the following year (this effect can be represented by a utility function for wealth with decreasing absolute risk aversion (see Chapter 3)).

The essential elements of the stage of evaluation of alternatives with respect to price are the price perception of marketing strategies, the farmer's risk attitude and the way in which these two elements are combined into a preference index.

The first element concerns the price perception (in June) of marketing strategy j. It is assumed that a farmer does have an idea about what prices to expect and the degree of belief of occurrence of these prices with each marketing strategy. That is, farmers should form an impression of the price risk for each marketing strategy. These opinions can be encoded into a coherent probability distribution by means of suitable elicitation techniques.

In the study it is thus assumed that the farmer forms an impression of the probability of each price associated with each marketing strategy. However, the process of *how* a farmer forms this perception is not studied here. Most probably, the farmer will combine knowledge of previous prices per strategy with recent information about the market stemming from e.g. futures market prices, forecasts of yield in the Netherlands and abroad and a forecast of mean market price by a macro model of the Agricultural Economic Research Institute-LEI. Furthermore, this perception will probably be influenced by the farmer's characteristics like the number of years he has already been marketing ware potatoes (in turn this experience will be strongly related to the age of the farmer). How farmers combine all these sources of information, for example whether they combine these in a normatively correct manner (e.g. the Bayes rule) or whether psychological biases are present (Kahneman and Tversky 1982), is beyond the scope of this study.

The second element in the evaluation stage is the risk attitude in respect of price. In general, this is the inclination to forebear risks to a greater or lesser extent. In Chapter 3 more specific information about the theoretical content and measurement of this attitude will be given. For example, in the expected utility model this attitude is represented by a utility function measured by means of lotteries.

In the model a relationship is conceived between risk attitude and background characteristics of the farmer. Since in the literature few consistent relationships have been reported between the risk attitude and characteristics of a person this is largely an exploratory research subject. Variables that are potentially relevant in this respect are specified. The most important variables are a farmer's age and level of education (younger and more educated farmers are supposed to be less risk averse), his experience with marketing potatoes (more experienced farmers are probably less risk averse), and farm characteristics like arable land and solvency (farmers of larger farms and/or more solvent farms are less risk averse). Characteristics of the farmer will possibly also be related to the motives for choosing a marketing channel. This will largely be an exploratory research subject.

Up until now, the elements which seem important in choosing between marketing strategies have been delineated. Yet, no analysis is given about how to combine perceptions and risk attitude into a preference index or how to combine the two attributes of price and marketing channel into one overall evaluation. Also, the concepts of risk attitude and risk perception are still largely undefined and no procedures about how to measure these elements are presented. These subjects will be dealt with in Chapter 3. In that chapter theories about how one should select an alternative with uncertain outcomes from a set of alternatives and about how people actually make these choices, is extensively discussed and evaluated. In

Chapter 4 then, an operationalization of the conceptual model presented here will be given.

Summary

In this chapter the farmer's decision making process was structured. It was pointed out that in the region where this study took place the gross margin of ware potatoes is most variable and consequently influences the farmer's income most.

The variability in gross margin of ware potatoes is mainly due to variability in market prices for potatoes. By means of the marketing strategy the farmer can respond to this variability in prices. A farmer may choose a risky marketing strategy supposedly leading to a high mean price over marketing years but also to a high variability in price. Contrariwise, he might choose a strategy with low risk, e.g. a fixed-price contract. An elaborate discussion was presented of the selling-options open to the farmers.

A second important choice with respect to the marketing strategy is the choice of a marketing channel. This channel is differentiated into a cooperative and a private company.

The analysis of the decision context resulted in the conception of a two-attribute decision making model with price and marketing channel as attributes. The main elements in this model are the risk perception and risk attitude in respect of price.

CHAPTER THREE

MODELING DECISION MAKING UNDER RISK

The farmer's decision problem was delineated in the previous chapter. It was concluded that a farmer has to choose between marketing strategies on the basis of essentially two attributes: price and marketing channel. Since price is a random variable, choosing between marketing strategies concerns decision making under risk. How to choose between alternatives with uncertain outcomes constitutes the subject of this chapter.

Since the farmer's decision making is seen as an example of decision making under risk, in this chapter an up-to-date review of the major theoretical issues into the general problem of decision making under risk will be presented. The most important models proposed to prescribe and describe choice behavior under risk will be discussed.

Most attention will be devoted to the subjective expected utility model since this is the dominant model to study risky decision making. The basic ideas in this expected utility model originate from Bernoulli in 1738 (see Section 3.1). Von Neumann and Morgenstern (1947) succeeded in providing the fundamental foundation of the model (Section 3.2). An interesting recent development with respect to the expected utility model is the hypothesis of relative risk attitude. This concept is linked to the discussion about the theoretical and empirical relationship between a strength of preference and a utility function. In Section 3.3 the concept of relative risk attitude will be defined and evaluated. It will be made clear that one can view this concept as providing the proper link between the Bernoulli and the von Neumann-Morgenstern model.

The expected utility model is essentially normative. It prescribes how a decision maker should choose. As a descriptive model of decision making it has received a lot of criticism (Section 3.4). Alternative descriptive models proposed, like Prospect Theory (Kahneman and Tversky 1979), will also be discussed.

Following the review of theoretical issues, the chapter finishes with applying the theory of decision making under risk to the problem of selecting marketing strategies (Section 3.5) and with formulating research topics and questions for empirical study (Section 3.6).

3.1 Decision making under risk: the basic ideas

In essence, choosing between alternatives with uncertain outcomes implies choosing between probability distributions of outcomes X. A first possibility to choose between the probability distributions is by rank ordering them according to the centre of gravity of the distribution: the *expected value*, denoted as $E(\underline{x})$, and by then choosing the alternative with the highest expected value (henceforth, a random variable will be denoted by $\underline{x}$). A consequence of this decision rule is that a decision maker should be *indifferent* between two distributions with the same expected value, irrespective of the higher moments of the probability distribution. In general, however, most people will prefer one distribution to the other; they are not indifferent to the distribution of outcomes around the expected value.

For example, in case a choice has to be made between two alternatives with normally distributed outcomes with the same expected value but with different variances, the choice criterion of expected value implies that people do not prefer one distribution to the other. However, it is usually contended that most people would prefer the distribution with the smaller variance. The latter type of preference is called risk aversion.

To account for risk averse preferences Bernoulli suggested already in 1738 that by taking the expected value of the probability distribution measured in subjective psychological values, a better criterion for rank ordering distributions would be obtained. (For the English translation of the original Latin text see Bernoulli 1954). This choice criterion is denoted as the expected utility criterium $E[v(\underline{x})]$, where $v(x)$ is the transformation function of outcomes X into subjective values or utilities. It would be rational to then choose the probability distribution with the *highest* expected utility. To be more specific, the transformation function $v(x)$ which Bernoulli proposed was a logarithmic function implying diminishing marginal utility. This function was clearly meant to indicate the intensity of satisfaction (strength of preference) for an outcome. In this study the function $v(x)$ will be called a value or strength of preference function.[1]

The concavity of the function $v(x)$ has a significant implication for the evaluation of risk: a decision maker is risk averse if and only if his evaluation function is concave (Keeney and Raiffa 1976). Firstly, however, let us define risk aversion more precisely. Consider a decision maker facing a lottery L_1 yielding either outcome x_H or a less preferable outcome x_L with equal probability ($p = 0.5$). Evidently, the expected value $E(\underline{x})$ of this lottery is $(x_L + x_H)/2$. Now suppose the decision maker is asked to state his preference for either receiving $E(\underline{x})$ with certainty or the lottery L_1. If the decision maker prefers the certain outcome $E(\underline{x})$ to the lottery L_1 with the same expected value, then the decision maker states that he prefers to avoid the risks associated with the lottery. This preference is defined as risk aversion. Apparently a 50% chance of losing an amount x does not counterbalance a 50% chance of winning an amount x.

Risk aversion is implied in a concave evaluation function (see Figure 3.1). For a concave curve, the expected utility of the probability distribution ($E[v(\underline{x})]$) is smaller than the utility of the expected value of the probability distribution ($v[E(\underline{x})]$), that is, $E[v(\underline{x})] < v[E(\underline{x})]$. For example, a decision maker with $v(x) = \ln$

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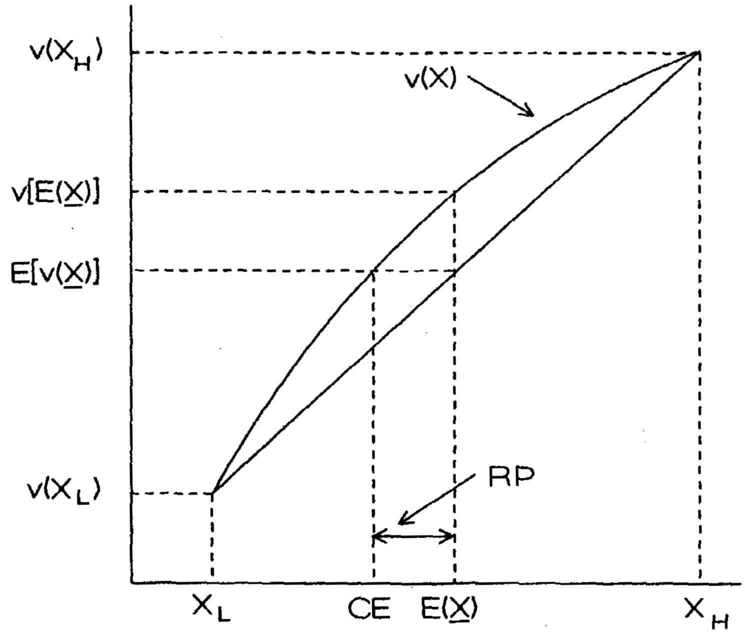
1 In the usual notation the Bernoulli function is denoted by $u(x)$ instead of $v(x)$ and is called a utility function. In this study, however, we want to differentiate between a value function $v(x)$ and a von Neumann-Morgenstern utility function $u(x)$ (see Section 3.2). The function Bernoulli proposed is clearly a value function. In Section 3.3 the relationship between $v(x)$ and $u(x)$ will be discussed.

x and facing a 50/50 lottery with as outcomes \$ 100 and \$ 200 will prefer the amount \$ 150 for certain to the lottery, because $v[E(\underline{x})] = \ln 150 = 5.01$ is larger than $E[v(\underline{x})] = (\ln 100 + \ln 200)/2 = 4.95$. Stated otherwise, a decision maker with a concave function v(x) should be willing to exchange a distribution of outcomes for a non-random outcome of the size of the expected value of the distribution.



v(x):	value function of a risk averse decision maker
$E(\underline{X})$:	expected value of lottery L yielding x_L with probability p (= 0.5) and x_H with 1-p (=0.5)
CE:	the decision maker's certainty equivalent for lottery L
RP:	risk premium of lottery L
$E[v(\underline{X})]$:	expected utility of lottery L
$v[E(\underline{X})]$:	utility of expected value of lottery L

Figure 3.1 Graphical illustration of important concepts in decision making under risk

In Figure 3.1 also the concepts of certainty equivalent and risk premium are presented graphically. These concepts are defined as follows.

The lowest non-random outcome the decision maker is willing to accept in exchange for a probability distribution is called the *certainty equivalent*. This certainty equivalent, denoted as CE, is defined by:

$$v(CE) = E[v(\underline{x})] \tag{3.1}$$

that is, the utility of the certainty equivalent equals the expected value of the distribution of subjective values.

The difference then between the expected value of the distribution of outcomes and the certainty equivalent is called the *risk premium* of the lottery:

$$RP = E(\underline{x}) - CE \qquad (3.2)$$

The risk premium RP thus is the amount of the attribute the decision maker is willing to 'give up' from the average (i.e. the expected value) to avoid the risks associated with the particular lottery (Keeney and Raiffa 1976). The risk premium is a suitable indicator to express the degree of risk aversion. Confronted with the same lottery, the more risk averse decision maker is willing to give up more for having the dispersion completely eliminated, which means that his risk premium is larger.

In contrast to a risk averse decision maker, a decision maker with a convex value function, that is, a function with increasing marginal utility, would opt for the distribution instead of a non-random outcome of the same size as the expected value of the distribution (a negative risk premium). A decision maker with such a preference is defined as risk seeking.

Only in case of a linear function v(x), a decision maker would be indifferent between the expected value of the distribution and the non-random outcome of the same size. This risk neutral case implies the use of the decision rule of expected value: the expected value rule is a special case of the expected utility model when assuming a risk neutral decision maker.

To summarize the ideas so far:

FUNCTION		RISK PREMIUM			RISK ATTITUDE	
concave	<=>	risk premium	> 0	<=>	risk averse	
linear	<=>	risk premium	= 0	<=>	risk neutral	(3.3)
convex	<=>	risk premium	< 0	<=>	risk seeking	

However, Bernoulli's approach of proposing a diminishing marginal utility function for evaluating probability distributions showed some difficulties (Sinn 1983). Firstly, no explanation for risk seeking behavior was presented, since this would imply a convex, that is, an increasing marginal value function. Such a function is not very plausible. Secondly, many questioned the interval or cardinal character of the proposed value function. According to them, only ordinal utility existed. Thirdly, even if there is an interval value function for non-random outcomes, there is no obvious reason for risk to be evaluated by using this function. Why should a value function describing preferences under certainty have anything to say about preferences under risk? Allais (1953) pointed out that two people with the same value function may well differ with regard to their preferences in risky choices. Especially this third point will be discussed later when presenting the theory of Allais and discussing the value/utility distinction.

The element that remained of Bernoulli's model was the idea of maximizing the expectation of subjective values of outcomes. Not until the work of von Neumann and Morgenstern (1947), however, the reason for taking the expectation of subjective values as the appropriate rule for rank ordering probability distributions was made clear. Their theory of expected utility will be presented in the next section.

3.2 The expected utility model

The dominant model for studying risky decision making undoubtedly is the von Neumann-Morgenstern (1947) model (abbreviated as NM-model). Like Bernoulli, NM also developed an expected utility rule. That is, probability distributions should be rank ordered with respect to expected utility. However, their theory differs from Bernoulli's theory in important respects. Firstly, while Bernoulli directly states that people should maximize expected utility, NM make a set of assumptions (axioms) about preference orderings and they prove that, if one abides by those assumptions, one always prefers the alternative with the highest expected utility (after the original formulation by von Neumann-Morgenstern many alternative systems of axioms have been formulated; important examples are Savage (1954) and Luce and Raiffa (1957)). Secondly, the nature of their evaluation function, hereafter called the utility function, has nothing to do with strength of preference, according to NM.

The expected utility theory has been derived and explained in many sources. A selection of these sources now follows. Very formal and axiomatic descriptions and explanations of expected utility theory are presented in Savage (1954), Luce and Raiffa (1957) and Fishburn (1970, 1982, 1988). A less formal approach can be found in Dillon (1971), Levy and Sarnat (1972), Vlek and Wagenaar (1979), Schoemaker (1980), Sinn (1983) and von Winterfeldt and Edwards (1986).

The following, fairly informal presentation of axioms draws heavily on Sinn (1983) and von Winterfeldt and Edwards (1986).

The following sets are defined:

1) A set of choice alternatives $A = (A_i;\ i = 1, 2, \ldots, I)$
2) A set of outcomes $X = (x_j\ ;\ j = 1, 2, \ldots, J)$
3) A set of probabilities $P = (p_i(x_j)\ ;\ i = 1, 2, \ldots, I;\ j = 1, 2, \ldots, J)$, in which $p_i(x_j)$ is the probability of outcome x_j with alternative A_i.

These sets are *known* and *certain*.[2] The (only) way that uncertainty enters into the choice problem is when the choice must be made before it is known which out-

[2] This is one of the main points of criticism of Simon (1986) against the expected utility model as a descriptive model of decision making. For example, he states that one of the main issues in problem solving concerns the search for good alternatives (see Section 3.4.1).

come will prevail. Each alternative A_i is thus represented by a probability distribution. The existence of a function U(.) which orders probability distributions in an ordinal way follows from the following axioms.

Axiom of ordering

The decision maker has a complete weak ordering of all attainable probability distributions of outcomes.

The weak ordering of course implies *connectivity* and *transitivity*. By connectivity is meant the ability of a decision maker to indeed make judgments of preference or indifference when faced with any two lotteries in A. That is, for any two lotteries L_1 and L_2, he prefers either L_1 to L_2 or L_2 to L_1 or else he is indifferent. Connectivity would be violated if the respondent said: "I really can't make up my mind". Violations of that kind may occur if the lotteries are very similar in expected utility or are very complex (von Winterfeldt and Edwards (1986).

Transitivity implies that if L_1 is preferred to L_2 and L_2 to a lottery L_3, then L_1 must also be preferred to L_3. If a decision maker would not be transitive he could be used as a money pump. This implication can be shown by the following example. If a decision maker owns L_3, then given a choice between L_3 and L_2, he would be prepared to pay to exchange L_3 for L_2. Then given L_2, he would pay something more to exchange it for the preferred L_1. Finally, as a result of his intransitivity, he would again be prepared to pay when given a choice between L_1 and L_3 in order to end up with L_3 etc.! Thus, he begins and ends at the same lottery, but becomes poorer in the process (Fishburn 1988).[3] Like connectivity, transitivity may be violated if lotteries are very complex or similar in expected utility. The so-called preference reversals (Grether and Plott 1979) are an example of intransitivity.

Axiom of independence

Suppose a decision maker prefers probability distribution L_1 to L_2; it thus follows that distributions built up by combining L_1 and L_2 with another distribution L_3, satisfy

$$\begin{pmatrix} p & 1-p \\ L_1 & L_3 \end{pmatrix} \succ \begin{pmatrix} p & 1-p \\ L_2 & L_3 \end{pmatrix}$$

if $0 < p \leq 1$.

[3] It is doubtful that any subject would agree to be used as a money pump. This implication illustrates the necessity of providing a subject with a cycle of choices instead of a number of single choices in experiments which investigate the transitivity in choice behavior.

This axiom means that, given a choice between two lotteries, both providing the same prize with probability (1-p), but different prizes with probability p, the ordering of the two lotteries should be the same as that of the two different prizes.

This axiom is very important since it implies that the utility of an outcome is independent of the probability of receiving that outcome and that the evaluation of an alternative is independent of other alternatives in the choice set. A violation of this axiom would mean that no single evaluation function exists; only evaluation functions conditional on probabilities would exist. The famous Allais-paradox is an example of the violation of the independence axiom (Allais 1953, 1979). This effect is referred to by Kahneman and Tversky (1979) as the certainty effect: people overweight outcomes that are considered certain, relative to outcomes which are merely probable.

The formulation of the independence axiom presented above stems from Samuelson (1952). Other versions of the principle in this axiom are the sure-thing axiom of Savage (1954) and the substitution axiom (Allais 1953).

Archimedes axiom

If outcome X_1 is preferred to X_2 and X_2 to X_3 then there is one and only one probability p ($0 < p < 1$), so that the decision maker is indifferent between the certain amount X_2 and a lottery offering X_1 or X_3 with probabilities p and 1-p respectively.

This axiom, also called the continuity axiom, states that some indifference probability can always be found. It would be violated if any one alternative or outcome is so attractive or unattractive that even very small probabilities cannot reduce their utility or disutility (e.g. a nuclear energy accident with catastrophic consequences).

Axiom of non-saturation

If X_1 is larger than X_2 then X_1 is preferred to X_2. This implies a monotonically increasing evaluation function.

The above axioms are sufficient to prove that a utility index u(x) exists, unique up to positive linear transformations, so that computing expected utilities will yield a preference ordering U(.) among probability distributions in accordance with the axioms.[4] U(.) takes the following form:

[4] The formal proof will not be given here since excellent references exist in this respect e.g. Luce and Raiffa (1957) or Fishburn (1970). More important, however, is the interpretation of expected utility. This will be presented in the next section.

$$U(A_i) = \sum_{j=1}^{J} p_i(x_j)\, u(x_j) \tag{3.4}$$

in case of discrete probabilities, and:

$$U(A_i) = \int f_i(x)\, u(x)\, dx \tag{3.5}$$

in case of continuous probabilities,

with:

$U(A_i)$	=	expected utility of alternative A_i
$p_i(x_j)$	=	probability of outcome x_j with alternative A_i
$f_i(x)$	=	probability density of alternative A_i
$u(x)$	=	utility function

The preference function U(.) appears to be the expected value of the utility of outcomes with probabilities taken as weights. The function u(x) is defined up to positive linear transformations which means that the function $g(x) = a + b\,u(x)$ with $b > 0$ results in the same ordering of probability distributions. Thus, u(x) is an interval scale.

The interpretation of expected utility and the utility function

In Sinn (1983) a very readable derivation of the expected utility rule from the axioms can be found. Here, however, we confine ourselves to a demonstration of the application of the axioms in a specific example in order to clarify the interpretation of expected utility. Specifically, attention will be given to the interpretation of the utility function u(x).

Suppose a farmer has to choose between the marketing strategies A_1 and A_2, described by the probability distributions shown in Figure 3.2A. In this figure the outcomes concern the prices for ware potatoes in cts/kg. Notice that the expected value of A_2 (24.0 cts/kg) is larger than A_1 (21.5 cts/kg) but that the standard deviation is also larger (the standard deviation of A_2 is 15.3 cts/kg and 7.8 cts/kg for A_1). Confronted with these distributions, how should he choose between them? Does the higher expected value of A_2 compensate the larger risk? In accordance with the expected utility model, the expected utility of each alternatives should be computed and compared. Hereto, the farmer's utility function u(x) must be known.

Suppose Figure 3.2B describes the utility function of two farmers. Both these functions are concave, which implies risk averse farmers. The functions are scaled between 0 and 1, for the relevant range of potato prices (10 to 70 cts/kg).

Of course, a higher price is preferred to a lower price so 70 cts/kg is scaled as 1 and 10 cts/kg is scaled as 0. Later on, a description will be given of the questioning procedures to assess such a function u(x). In these procedures use is made of the Archimedes axiom.

Since u(x) is an interval function other values than 0 and 1 could have been taken equally well. For convenience and clarity the utilities are scaled between 0 and 1 since this makes it possible to read the indifference probabilities directly from the graph. For example, according to the graph for Farmer 1 the utility of 25 cts/kg equals 0.40. Since u(10)=0 and u(70)=1 we can derive the indifference probability between the certain outcome 25 cts/kg and a lottery yielding 70 cts/kg with probability p and 10 cts/kg with probability 1-p as follows. Applying the expected utility rule:

$$u(25) = p\ u(70) + (1-p)\ u(10)$$

thus:

$$0.40 = p\ 1 + (1-p)\ 0 = p$$

Therefore the indifference probability of 25 cts/kg is p = 0.40 (Archimedes axiom). Stated otherwise, Farmer 1 facing the lottery [70, 0.40; 10, 0.60] would have specified 25 cts/kg as his certainty equivalent. (Note that the expected value of this lottery is 34 cts/kg; since the farmer's certainty equivalent is 25 cts/kg, it follows that the risk premium is 9 cts/kg).

In the same manner, Farmer 1 is indifferent between 40 cts/kg and the lottery [70, 0.68; 10, 0.32] and for him 15 cts/kg is equivalent to the lottery [70, 0.15; 10, 0.85] (see the function u(x) in Figure 3.2B).

The next step is to substitute the outcome of 25 cts/kg in alternative A_1 (Figure 3.2A) by the lottery [70, 0.40; 10, 0.60] by applying the independence axiom. In the same manner each possible outcome of alternatives A_1 and A_2 can be substituted by binary lotteries with 10 and 70 cts/kg as outcomes and with probabilities derived from the function u(x). In Figure 3.2C the substitution of all possible outcomes by these binary lotteries is shown for both alternatives and for Farmer 1.

By applying standard probability calculus to both alternatives, Figure 3.2D results from Figure 3.2C. Now, each alternative is expressed as a binary lottery with possible outcomes 10 and 70 cts/kg and their respective probabilities. Confronted with these two lotteries in Figure 3.2D, it is clear that Farmer 1 chooses the alternative for which the probability of receiving 70 cts/kg is largest (implied in the axiom of non-saturation); in this case he chooses alternative A_2 (a probability of 0.322 on 70 cts/kg compared to a probability of 0.303 on 70 cts/kg for alternative A_1).

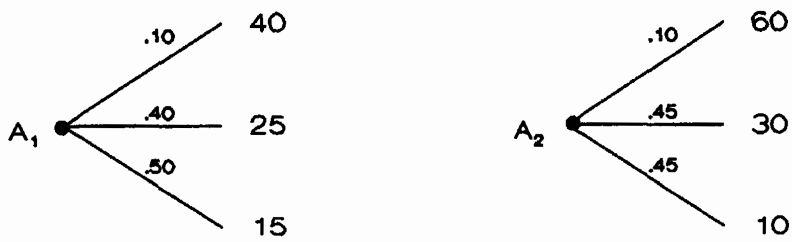


Figure 3.2A *Two probability distributions to be evaluated*

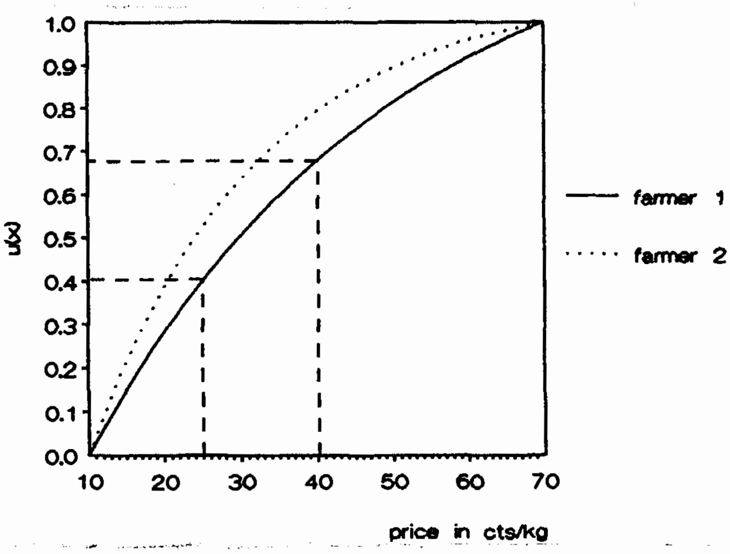


Figure 3.2B *The utility function u(x) of two farmers*

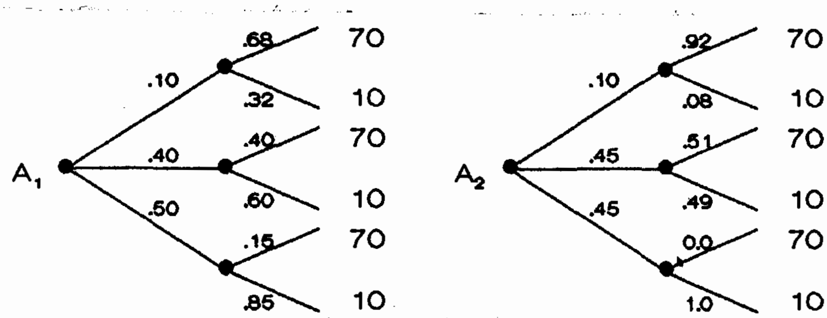


Figure 3.2C *Substitution of outcomes by binary [70, p ; 10, 1-p] lotteries, with p in accordance with u(x) of Farmer 1*

Figure 3.2D *Reduction of distributions A_1 and A_2 into equivalent binary [70, p ; 10, 1-p] lotteries, for Farmer 1*

The same procedure can be followed for the more risk averse Farmer 2 (see the u(x) function in Figure 3.2B). In contrast to Farmer 1, this farmer will prefer alternative A_1 to alternative A_2 since A_1 is equivalent to the binary lottery [70, 0.398; 10, 0.602] and alternative A_2 is equivalent to [70, 0.384; 10, 0.616].

The axioms of expected utility theory thus imply that when u(x) is known, *all probability distributions can be transformed into equivalent binary distributions.* Maximizing expected utility then means: *choosing the alternative (binary distribution) with the largest chance of receiving the most attractive outcome.*

This result is very elegant. No reference whatsoever needs to be made to a strength of preference function for outcomes. The evaluation function u(x) should therefore better be called a *probability indifference function* instead of a utility function to point out the exact nature of the function. In measurement procedures only indifference probabilities have to be obtained without reference to intensity of psychological satisfaction for an outcome.

In essence, the function u(x) has nothing to do with the type of function Bernoulli proposed. Marginal utility for u(x) here refers to marginal substitution between the probability of receiving X_H in a standard lottery [X_H, p ; X_L, 1-p] and X (Baumol 1972). A convex function is therefore no problem since no increasing marginal utility has to be assumed. Furthermore, it should be noted that the cardinal or interval nature of u(x) only has an operational meaning, since the NM model starts from an ordinal ordering of alternatives (axiom of ordering). The NM-model thus meets the criticism on the Bernoulli model.

To remain in accordance with literature, the von Neumann-Morgenstern evaluation function will be called the *utility function* (denoted by u(x)) and a Bernoulli type evaluation function will be called a *value function* or *strength of preference* function (denoted by v(x)). Later, the diverging views with respect to the nature of the utility function and its relation to the value function will be discussed (see Section 3.3).

Characterising the risk attitude of a decision maker by means of the Pratt-Arrow coefficients of risk aversion

A measure is needed to capture the concavity of the utility function in order to classify decision makers with respect to risk attitude. Since the function u(x) is unique up to positive linear transformations a measure is needed which is independent of the particular transformation parameters. Pratt (1964) and Arrow (1965) independently defined such measures as the *absolute* and *proportional risk aversion coefficients*, which are defined as follows:

Pratt-Arrow coefficient of *absolute* risk aversion

$$r(x) \equiv -\frac{u''(x)}{u'(x)} \tag{3.6}$$

with:

$$u'(x) = \frac{d}{dx} u(x)$$

and

$$u''(x) = \frac{d^2}{dx^2} u(x)$$

Pratt-Arrow coefficient of *proportional* risk aversion

$$s(x) \equiv -x \frac{u''(x)}{u'(x)} = x\, r(x) \tag{3.7}$$

The sign of the second derivative of the function provides information about the form of the increasing function. If this second derivative is negative for all x, then u(x) must be concave, and the decision maker therefore risk averse (in this case r(x) > 0 and s(x) > 0). If the second derivative is positive for all x, then u(x) is convex implying that the decision maker is risk seeking (r(x) < 0 and s(x) < 0). Since the magnitude of the second derivative depends upon the scaling of the interval scale u(x), this scaling effect is removed by dividing the second derivative by the first derivative (the first derivative is positive for increasing functions).

The coefficients of risk aversion have the following behavioral implications. The coefficient of absolute risk aversion indicates the risk preferences associated with lotteries with absolute changes in outcomes, that is, e.g. a 50/50 binary lottery with outcomes $ 100 above or below the status quo. If the degree of risk aversion, that is, the magnitude of the risk premium of the lottery, does *not* depend on the *level* of the status quo, then such a decision maker is said to be *constantly absolute risk averse* (r(x) is constant). If the risk premium of the lottery decreases as the level of the status quo increases, then such a decision maker is said to be *decreasingly absolute* risk averse (r(x) is decreasing in x).

To illustrate these definitions, consider the reaction of a person to losing $ 100 when he is poor and the reaction to losing the same amount when he is wealthy. If in both cases losing this amount is considered equally undesirable, then this person is said to be constantly absolute risk averse. On the other hand, when losing $ 100 is considered less a problem when he is wealthy than when he is poor, the person is said to be decreasingly absolute risk averse. The latter phenomenon makes sense, especially for wealth, since we expect rich people to be less concerned by losing a particular absolute amount than poor people (see also Chapter 6).

Proportional risk aversion pertains to the reaction to lotteries with outcomes e.g. 10% above or below the status quo. Again, if the risk premium of any specific lottery does not depend on the level of the status quo, then such a decision maker is said to be *constantly proportional* risk averse. In the above example this means that losing 10% of one's wealth is evaluated equally undesirable independent of the level of wealth.

If a decision maker is constantly absolute risk averse/seeking, then his u(x) must be a negative exponential function. In case the decision maker is constantly proportional risk averse/seeking, his u(x) must be a logarithmic or power function (Keeney and Raiffa (1976). (See also Chapter 6 for specifications of these functions).

Measurement of the utility function u(x)

In the standard expected utility model, u(x) is assessed by means of lotteries. Although many different questioning procedures exist which will be described in Chapter 6, their common feature is that indifference judgments between pairs of lotteries are obtained. In the simplest case, two binary lotteries are compared. These binary lotteries are characterized by four elements: the outcomes of both lotteries and the respective probabilities. By fixing three elements, the decision maker has to specify the fourth element such that he becomes indifferent between both lotteries. By varying the specification of the three elements in a systematic way, a number of indifference judgments are obtained from which the function u(x) can be constructed.

One example of a measurement procedure is the *certainty equivalence* procedure. By means of this technique the decision maker has to state his certainty equivalent with respect to a lottery with two outcomes. By varying the probability in the lottery, a number of certainty equivalents are specified by the decision maker. Alternatively, the certain outcome could be varied and the decision maker would then have to specify the probability in the lottery for each certain outcome (*probability equivalence* procedure). For all values on an interval, the indifference probabilities can thus be obtained resulting in the required function u(x).

It follows from the independence axiom that it should not matter which probability is used in the questioning procedure. One should get the same utility function irrespective of the probability used in the lottery, and abstracting from random response error. Also the certainty equivalence procedure should result in the same function as the probability equivalence procedure. However, if decision makers do not, willingly or unwillingly, accept the axioms, such procedures do not necessarily result in the same utility function.

Many empirical studies show that, generally speaking, the utility functions assessed are not completely independent of the *probability* used in the lotteries, *response mode* (e.g. probability equivalence methods compared to certainty equivalence methods) or *context* of lotteries (e.g. framing the choice as a gamble or as an insurance decision). Examples of such studies are, amongst others, van Dam (1973), McCord and de Neufville (1983), Hershey et al. (1982), Schoemaker (1980) and Tversky and Kahneman (1986, 1988).

Some people attribute these differences in assessment mainly to random error or response effects, resulting in unintended and unwilling inconsistencies. By confronting the subject with these inconsistencies they can be resolved into one consistent utility function (von Winterfeldt and Edwards 1986). Differences in assessment are thus conceived as a psychometric measurement problem. Other people view the inconsistencies as indications of a violation of the expected utility rule and thus as a reason for refutation of the theory (e.g. Allais 1953, 1979), or they propose alternative (expected utility) models which can account for the deviations in a logical manner (e.g. Machina 1982, Kahneman and Tversky 1979). These alternative models will be discussed in Section 3.4. More will be said about this issue in the following sections.

The subjective expected utility model

In the expected utility model as presented so far, it was taken for granted that the probability distributions are objective. That is, probabilities were seen as relative frequencies of events in a repeating process like throwing dice. Often, however, relative frequencies do not exist since a process does not repeat itself a large number of times in an identical way. For these situations the concept of *subjective* or *personal* probabilities is defined, in accordance with the work of Savage (1954). A subjective probability indicates the "degree of belief" or plausibility of an event. It is assumed that these degrees of belief can be elicited into coherent probability distributions which abide by the rules of probability calculus.

In essence, the measurement procedure for subjective probabilities is as follows. Suppose a decision maker has to choose between the following two lotteries:

A) win \$ x if event E happens
    lose \$ y if event E does not happen

B) win \$ x with probability p
    lose \$ y with probability 1-p

Depending upon the decision maker's preference for either A or B his subjective probability of E is smaller than or larger than p. The subjective probability of event E is obtained by varying p until the decision maker becomes indifferent between A and B.

If subjective probabilities are assumed in the expected utility model, this model is called the subjective expected utility model (abbreviated as SEU-model). Much more can be said about the theoretical and empirical aspects of subjective probabilities. An extensive discussion of the idea and measurement procedures for subjective probabilities will be presented in Chapter 5.

3.3 Relationship between a value and a utility function

In the expected utility model of Bernoulli, a strength of preference function was assumed. To Bernoulli, the decreasing marginal value for outcomes explained why decision makers are risk averse. A risk averse decision maker prefers e.g $ 150 for certain to the 50/50 lottery yielding $ 100 or $ 200 because going from $ 100 to $ 150 is worth more than going from $ 150 to $ 200. However, are the concepts of decreasing marginal value and risk attitude really equivalent?

In the expected utility model of von Neumann-Morgenstern no reference needs to be made to strength of preference in order to prove that it is rational to rank order probability distributions with respect to expected utility. Their utility function is a probability indifference curve without referring to intensity of satisfaction. People need only be capable of providing indifference probabilities in standard lottery questions. However, the theory does not explain why or how decision makers arrive at these probabilities. That is, the theory provides no explanation for risk aversion.

The question now is whether a relationship exists between a value function and a utility function. Are they one and the same function or is the utility function a transformation of the value function? This issue will be dealt with in this section. In Section 3.3.1 the concept of relative risk aversion will be introduced and defined. This is followed by an evaluation of the concept in Section 3.3.2. A conclusion in 3.3.3 ends this section.

3.3.1 The concept of relative risk aversion

Fairly recently, the characterization of the risk attitude of a decision maker by means of the utility function obtained by lotteries was questioned. Bell and Raiffa (1982), Dyer and Sarin (1982), Sinn (1983), Currim and Sarin (1983) and Krzystofowicz (1983) articulate ideas already presented by Krelle (1968). These ideas give rise to the so-called value/utility debate.

According to the above mentioned authors the coefficients of risk aversion based on the utility function u(x) are an entangled measure of two aspects:

a) the evaluation of outcomes under certainty, and
b) the risk attitude.

This idea can be articulated as follows. The outcomes in a lottery are transformed into subjective values under *certainty* by the value function v(x). Then, the subjective values are taken as the consequences in the lottery which are evaluated under *risk* resulting in the utility function u(x) by means of a transformation of v(x), that is: u(x) = g(v(x)). Differences between the utility and the value function are attributed to the influence of risk on preferences. The latter difference is therefore called the "true risk attitude" of a decision maker.

Dyer and Sarin (1982) label this attitude the *relative risk attitude*, since it is defined relatively to the value function.[5] Bell and Raiffa (1982) label this concept the *intrinsic risk attitude* since they see it as an intrinsic characteristic of the decision maker, irrespective of the attribute that is evaluated (e.g. money, time) and the decision context. They even go as far as to call it (p. 341): " ... a basic (personality) trait of the individual". In this study we will follow the terminology of Dyer and Sarin (1982). The concept of relative risk attitude will now be elaborated.

The evaluation function of outcomes under certainty is called a strength of preference function or value function v(x). Axiomatic foundations and the properties of value functions can be found in e.g. Krantz et al. (1971) or Dyer and Sarin (1979) (see also Chapter 6). The strength of preference function describes the *intensity of preference* a decision maker has for an outcome (like Bernoulli's function). This means that a decision maker should be capable of making preference judgments between *differences* in outcomes. In effect in this study a farmer should be able to state that e.g. getting 20 cts/kg instead of 10 cts/kg is more attractive than receiving 30 cts/kg instead of 20 cts/kg. By decreasing the amount of 20 cts/kg it is possible to find such a price, say 16 cts/kg, that the farmer becomes indifferent between both intervals. That is, the farmer states that an increase from 10 cts/kg to 16 cts/kg is similar in attractiveness/value to an increase from 16 to 30 cts/kg. (Such a preference would imply a concave value function (decreasing marginal value)).

However, can we conclude that if an increase from 10 to 16 cts/kg equals in value an increase from 16 to 30 cts/kg then this farmer will be indifferent between receiving 16 cts/kg for certain and the 50/50 lottery yielding 10 or 30 cts/kg? Bernoulli would probably answer in the affirmative; Bell and Raiffa (1982) clearly reply in the negative and suggest the concept of relative/intrinsic risk attitude.

Bell and Raiffa "explain" the relative risk attitude by pointing out that, apart from strength of preference governing choice, the farmer in the example above would be "nervous" about the risk in the lottery. This risk introduced in the lottery might lead to another certainty equivalent than 16 cts/kg. Sinn (1983) states that the relative risk attitude indicates an aversion to or preference for dispersions in utility analogous to the traditional concept of risk attitude which concerns an aversion to or preference for dispersions in outcomes.

[5] Note the difference between the relative risk attitude as defined here and the Pratt-Arrow coefficient of proportional risk aversion, which is sometimes called the coefficient of relative risk aversion.

Before digressing further on the concept of relative risk attitude, a number of definitions are presented here first, following the terminology of Dyer and Sarin (1982).

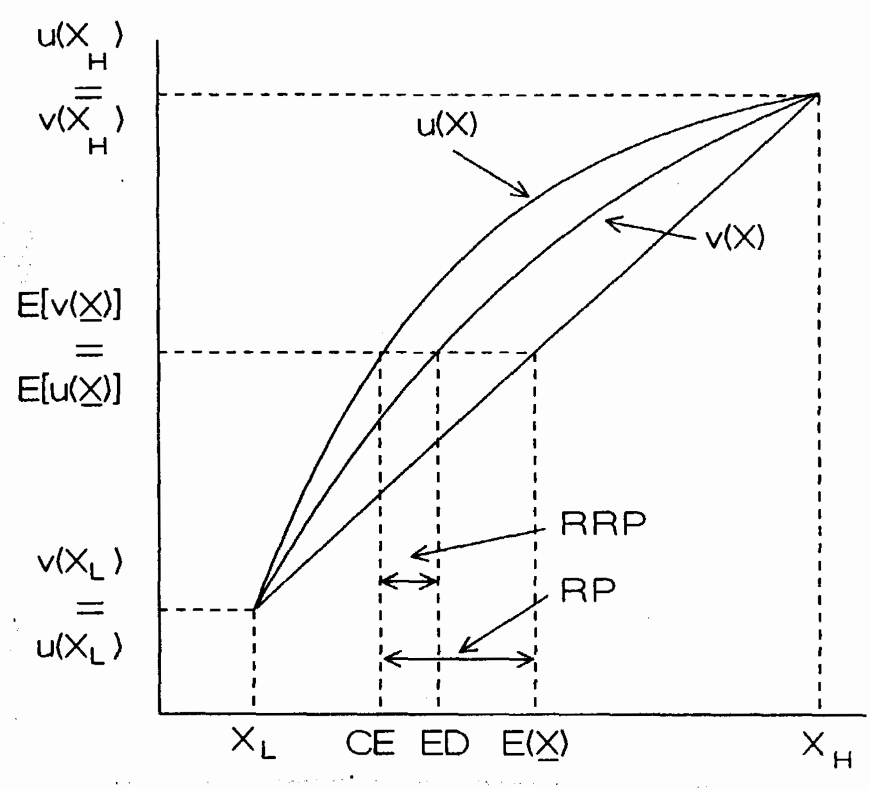
Analogous to the certainty equivalent of u(x) for v(x) an *equal-difference* point is defined. On the interval (X_L, X_H) the equal-difference point ED is the point for which holds:

$$v(X_L) - v(ED) = v(ED) - v(X_H). \tag{3.8}$$

The *relative risk premium* RRP can now be defined as the difference between the equal-difference point (ED) and the certainty equivalent (CE):

$$RRP = ED - CE \tag{3.9}$$

Figure 3.3 illustrates these concepts further.



where:

CE = certainty equivalent for 50/50 lottery [10, 70]
ED = equal-difference point for interval (10, 70)
u(x) = a decision maker's utility function (measured under risk)
v(x) = a decision maker's value function (measured under certainty)
RP = risk premium of the lottery
RRP = relative risk premium

Figure 3.3 Graphical illustration of the concept of relative risk attitude

Furthermore, coefficients can be defined for v(x) which are analogous to the Pratt-Arrow coefficients for u(x). Analogous to r(x), Dyer and Sarin define the *coefficient of absolute value satiation* m(x):

$$m(x) \equiv -\frac{v''(x)}{v'(x)} \tag{3.10}$$

By comparing m(x) and r(x) the following definition of relative risk attitude is obtained; a decision maker is said to be:

relatively risk averse iff. $m(x) < r(x)$ (RRP > 0),
relatively risk neutral iff. $m(x) = r(x)$ (RRP = 0) and
relatively risk seeking iff. $m(x) > r(x)$ (RRP < 0).

Graphically, this means that if the function u(x) is at the left of v(x) this characterizes a relatively risk averse decision maker (his certainty equivalent is smaller than his equal-difference point, RRP > 0), if u(x) is at the right of v(x) then the decision maker is relatively risk seeking (RRP < 0). If u(x) and v(x) coincide, the decision maker is said to be relatively risk neutral.

According to the ideas of the authors mentioned above, it is possible that a decision maker has a concave v(x) function and a less concave u(x) function. In the traditional sense, such a decision maker would be classified as risk averse since u(x) is concave. According to the new interpretation such a decision maker is classified as relatively risk seeking since v(x) is at the left of u(x).

Of course, u(x) and v(x) might be related by linear function ($u(x) = a + b\ v(x)$; $b > 0$) implying no difference. In such a case a decision maker is said to be relatively risk neutral: introducing risk does not affect his decisions! His choices between probability distributions can be completely explained by his value function, that is, *diminishing marginal value completely explains his preferences under risk.*

Disentangling strength of preference and utility, of course, is possible only if a decision maker's value function can be assessed. Are people capable of making judgments on similarity of differences? In general the answer to this question is positive (see e.g. Baird and Noma 1978, Stevens 1975, Lodge 1981, von Winterfeldt and Edwards 1986, and Sinn 1983). In psychophysics the subjective magnitude of stimuli is studied. Routine judgments of loudness, pitch, brightness and the like are collected. Since strength of preference for an outcome is a subjective magnitude, why would it not be possible to measure such a magnitude by applying measurement techniques used in psychophysics? Psychophysics suggests that respondents are even capable of judging differences between stimuli on a ratio scale. Measurement procedures which can be used to assess strength of preference will be presented and evaluated in Chapter 6.

The hypothesis of a constant absolute relative risk attitude

An interesting question concerns the specific relationship between v(x) and u(x), that is, the form of the function g in u(x) = g(v(x)). When examining the logical relationships between value and utility functions several authors conclude that either a *negative exponential* function or a *linear* function is most plausible (Keeney and Raiffa 1976, p. 330-2, Bell 1981, Bell and Raiffa 1982, Sinn 1983, 1985, Barron et al. 1984).[6]

A negative exponential function implies a *constant* absolute relative risk attitude on the subjective continuum v(x)):

$$u(x) = a + b e^{-c\,v(x)} \tag{3.11}$$

where c is the Pratt-Arrow coefficient of absolute risk aversion defined on v(x). If $c > 0$ the decision maker is relatively risk averse, if $c < 0$ the decision maker is relatively risk seeking.

Keeney and Raiffa (1976) and Bell and Raiffa (1982) arrive at the conclusion of either a negative exponential or a linear function by analyzing the relationship between a multiattribute value and utility function. Assuming an additive value function and utility independent attributes, only a negative exponential relationship leads to a multiplicative utility function. A linear transformation of the value function leads to an additive utility function. In plain words, they reason that if each outcome in a lottery is increased in such a way that the same quantity *measured in value* is added to each outcome, the certainty equivalent should also increase by this same quantity of added value. This is only possible if a negative exponential or a linear function describes the relationship between the value and utility function.

Sinn (1983, 1985) arrives at the conclusion of a negative exponential/linear function between v(x) and u(x) from psychophysics. He argues that v(x) is most likely a logarithmic function: v(x) = ln x. Furthermore, he contends that u(x) is a logarithmic or a power function: $u(x) = x^c$ or u(x) = ln x. Hence, only a linear or a negative exponential function (see Equation 3.11) can describe the relationship between v(x) and u(x).

Therefore the conclusion is, that if the relative risk attitude is a viable concept, it should be a constant absolute relative risk attitude.

Advantages of the concept of relative risk attitude

It should be noted that in the view presented so far, u(x) is still used for rank ordering probability distributions, since only this function incorporates the deci-

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6 As shown above, the specific possibility of a linear relationship between u(x) and v(x) implies a relatively risk neutral decision maker. Such a linear function would imply the refutation of the concept of relative risk attitude. In the next Section (3.3.2) further arguments and stronger conditions are presented explaining why both functions should be equivalent.

sion maker's reaction to risk. From the viewpoint of predicting preferences for choice alternatives therefore, the concept of relative risk attitude is not required. The question therefore is: what might be gained by separating the effect of risk attitude from the effect of strength of preference?

The main advantage is, of course, that the relative risk attitude is thought to be a better definition and description of risk attitude. It is a more accurate characterization of the psychological reaction of a decision maker towards risk. If two decision makers choose differently between lotteries, this difference is attributed to and interpreted as a difference in risk attitude, according to the classical expected utility model. However, it may well be that they have the same relative risk attitude whilst they differ in value function (this difference in value function might be caused by e.g. a difference in wealth between the two decision makers). Since the effect of the value function is corrected for, it is suggested that a description of a decision maker has been found which is less dependent upon the decision context or the attribute of the decision. For example, the same relative risk attitude may operate for such diverse attributes as money and time (Bell and Raiffa 1982) or for e.g. insurance behavior with respect to financial loss or health risks (Schoemaker 1980).

Furthermore, since a measure for the true risk attitude of a decision maker is obtained which is less or not at all dependent upon the attribute or decision context, one might expect to find larger correlations between characteristics of the person on the one hand and the relative risk attitude on the other hand.

The concept of relative risk attitude might also be beneficial for modeling multiattribute (consumer) decision making under risk. It has been shown (Keeney and Raiffa 1976, Bell and Raiffa 1982) that in the multiattribute case the same relative risk attitude, that is the same parameter in the negative exponential function operates for all attributes. This implies that a multiattribute additive value function, describing decision making under certainty, can easily be transformed into an additive or multiplicative utility function describing decision making under risk. In principle, only one lottery for one attribute would suffice (Currim and Sarin 1983). We conclude that this opens up many opportunities for analyzing consumer decision making under risk. Since in consumer research much experience exists in assessing multiattribute value functions, e.g. by means of conjoint measurement, these models can be transformed into models describing consumer decision making under risk. Only a few extra assessments are needed. Of course, an even greater advantage for modeling decision making would arise if it turned out theoretically and empirically that u(x) is linearly related to v(x), since the usual models under certainty could then be applied directly in decision making under risk!

Other advantages of defining the concept of relative risk aversion, especially with respect to group decision making, are described in Dyer and Sarin (1982) and Currim and Sarin (1983).

3.3.2 Criticism on the concept of relative risk attitude

Assuming it is possible to measure a value function, the important point here is that the measurement techniques applied do not depend on lotteries. That is, no risk is introduced in the assessment of a value function. The question is, will a function measured by means of such techniques result in the same function as one measured by means of lotteries? If it does, the hypothesis of relative risk aversion can be refuted. Before presenting some empirical evidence about the relationship between v(x) and u(x), some theoretical notions are reviewed.

In the original formulation of expected utility theory no relationship was conceived at all between utility and value functions. For example, Baumol (1958, p. 665) argues against: " ... the mistaken view that the von Neumann-Morgenstern utility index is, or is intended to be, just another device for measuring neoclassical introspective utility, ... ".

Another firm example of this view is given in Keeney and Raiffa (1976) who vigourously point to the difference between a value and a utility function. According to Keeney and Raiffa the value function has nothing to say about preferences for risky options (p. 150): "No probabilistic notions are introduced, and any expected utility calculated from such a *utility function* (i.e. v(x): AS) has no particular interpretation as it does in the case of von Neumann-Morgenstern utility functions. .... The concept of 'expected utiles' has *no* meaning". They conclude (p. 150): "The (von Neumann-Morgenstern) utility functions are completely different from the economist's utility function. Knowing one implies very little about the other. One function can easily be convex and the other concave for the same attribute".[7]

Also e.g. Fishburn (1970, p. 82) has argued that a utility function does not measure preference differences between outcomes since it is only based on simple lottery comparisons and therefore he sees no reason why lottery comparisons should coincide with or be related to preference difference comparisons.

Especially Allais (1953, 1979, 1984) fiercely objects to the idea of a relative risk attitude. However, for another reason than the authors mentioned above. In 1952, Allais was already skeptical of the idea that one could construct a utility function by means of lotteries. To prove his ideas he conducted an experiment which showed that even people well acquainted with expected utility theory did not choose according to the independence axiom. This experiment has become well known as the Allais-paradox. The essence and outcome of the experiment was often replicated (see e.g. Kahneman and Tversky 1979). Essentially, Allais states that a utility function u(x) cannot not be measured, and therefore does not exist, because the function depends on the probabilities used in the elicitation. This standpoint implies a refutation of the von Neumann-Morgenstern expected utility model.

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[7] To some extent, their statement is surprising since it is not consistent with their theorem concerning a negative exponential/linear relationship between a multiattribute value and utility function (Keeney and Raiffa 1976, p. 330-332 and Section 3.3.2).

Instead of a function assessed by lotteries, Allais proposed to assess a value function for evaluating probability distributions. (In particular, Allais states that v(x) is a loglinear function (Allais 1988)). Moreover, according to Allais, if a utility function u(x) does exist it should be *linearly* related to a value function v(x). By introducing his fairly restricted "axiom of cardinal isovariation" he proved this equivalence of a value and utility function (Allais 1979).

By assuming equivalence of the value and utility function however, an old problem is re-introduced: why should a function which describes values attached to outcomes under certainty imply anything about choices under risk? To account for risk in decision making Allais therefore introduced the idea of taking into account the *whole distribution of subjective values* and not solely the expected value of this distribution as proposed in the expected utility model. To Allais (1953, p 55): " ... the dispersion of psychological values ... is the specific characteristic of the psychology of risk". Hagen (1979) specifies such a model with the variance and skewness of the probability distribution of v(x) as extra elements in addition to the expected value $E[v(\underline{x})]$. The parameters attached to the variance and skewness, can be interpreted as the risk attitude of the decision maker. In Hagen's model a risk neutral decision maker takes only the expected value $E[v(\underline{x})]$ into account.

Allais' standpoint shows that a possible difference between u(x) and v(x) should not merely be conceived as a psychometric problem as e.g. von Winterfeldt and Edwards (1986) do (see below); he essentially disagrees with the conclusion of NM: the expected utility principle.

Sarin (1982) and, in a similar vein, Bouyssou and Vasnick (1988), also introduced a number of conditions on the basis of which it can be proved that u(x) and v(x) should be linearly related.[8] Sarin (1982) defined the so-called 'Sure-Thing Theorem for Exchanges', a strong version of the independence axiom. This theorem defines strength of preference *both* on *lotteries* and on *outcomes*. This implies that it would be possible for a decision maker to state the strength of preference of one lottery over another lottery, whereas the expected utility model only assumes a preference rank order of lotteries (axiom of ordering). Of course, empirical examination would be necessary to assess whether subjects are capable of expressing strength of preference on lotteries.

So far, authors have been presented who formally deduce a linear relationship between v(x) and u(x) by introducing extra conditions or axioms. Von Winterfeldt and Edwards (1986) come to the same conclusion in a different manner. They clearly state that the distinction between value and utility is spurious. As decision analysts they have a practical view on the matter. An equivalence of v(x) and u(x) would be very advantageous since it would ease the measurement procedures in decision analysis very much, especially in case of multiattribute decisions

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8 It is interesting to note that at the very same time that Sarin (1982) deduced conditions for the equivalence of v(x) and u(x), the concept of relative risk aversion was introduced (Dyer and Sarin 1982).

(which are most common in decision analysis). Multiattribute value functions are more easily assessed than multiattribute utility functions. Apart from referring to Sarin (1982), they present four arguments in favor of the spuriousness of the distinction (von Winterfeldt and Edwards (1986, p. 213).

Their first argument is: "There are no sure things, and therefore values that are attached to presumably 'riskless' outcomes are in fact attached to gambles". This argument states that an outcome is merely one event in an endless temporal chain of events. Therefore the value of e.g. an amount of money actually represents the value of future events made possible by the current one and one cannot know for sure what those events will be.

In a second argument they state that risk aversion can frequently be explained by marginally decreasing value functions and/or by introducing extra attributes representing e.g regret. From a practical standpoint then it is not necessary to bother about the utility function.

Their third argument is that: "... repetitive choices tend to eliminate risk aversion, and an argument can be made that all choices in life are repetitive" (p. 213). In our opinion this argument is rather weak, since if it were true, why assume non-linear value functions (as they clearly do in their book). When repetitive choices are concerned, one should choose according to the expected value of outcomes implying linear utility or linear value functions.

Their fourth argument is of an empirical nature. They state that (p. 213): "... error and method variance within value and utility measurement procedures overshadow to a great extent the subtle distinctions that one may extract from the theoretical differences". In short, if utility functions measured by means of different techniques differ as much from one another as they do from value functions it is hard to tell whether a true difference (or some smooth relationship) between the functions exist. This argument somewhat resembles the argumentation of Allais concerning the non-existence of u(x) because different probabilities yield different u(x) functions. However, von Winterfeldt and Edwards point out that value functions are also constructed with, possibly systematic, error. Allais never admitted this since it would refute his axiom of cardinal isovariation.

Von Winterfeldt and Edwards (1986) further recommend (p. 256-7): " ... we promote the use of multiple convergent procedures for eliciting utility as we do for construction of value functions. In particular, we argue analysts to use both riskless and risky procedures simultaneously when assessing a utility function. ... We speculate that formally justified utility elicitation methods deviate at least as much from one another as the utility methods do from the value scaling methods. Indeed, this is what we imply in our argument that both do or should measure the same thing. This is, of course, an experimental question".

Empirical research into the concept

Some empirical studies are available. Empirical research with respect to the relationship between value and utility functions has been performed by Fischer (1976, 1977), McCord and de Neufville (1983), Barron et al. (1984), Krzystofowicz (1983a, 1983b) and Van de Stadt et al. (1984).

Fischer (1976) in an experiment concerning multiattribute descriptions of cars, found a high convergent correlation between a subject's strength of preference and his utility for a car (correlations were taken over cars, within-subjects; median correlations fell between 0.84 and 0.95).

McCord and de Neufville (1983) compared the measurement of a value function with utility functions assessed for 23 subjects by applying different assessment methods. In the within-subject analysis, it turned out that differences between the utility functions were of the same magnitude as differences between the value function and the utility function assessed by means of the most commonly used assessment method (certainty equivalent method with 50/50 probabilities). Although questions can be raised about the internal and external validity of the experiment, their results hint that method variance may be so large as to prevent detection of true differences between functions.[9]

Barron et al. (1984) found, when analysing multiattribute decisions, that in most cases a linear relationship between utility and value function provided a good fit and that an exponential transformation improved very little on the linear relationship. Such curvilinearities were considered negligible, especially with a view to the random error in the data.

Krzystofowicz (1983a,b, 1984), on the other hand, did find significant differences between value and utility functions after analysing data of 34 respondents. Moreover, the hypothesis of a negative exponential relationship between u(x) and v(x) could not be rejected.

Van de Stadt et al. (1984) also found an empirical confirmation of the relative risk attitude. Their results can be interpreted as indicating relative risk aversion on the part of their respondents.

Clearly, until now, empirical research into the concept of relative risk attitude is limited and inconclusive. Further empirical work needs to be done on this issue. An important point which comes up when empirically studying the concept of relative risk attitude is the method variance of assessing value and utility functions. This variance might obscure possibly true differences between both functions. A large body of literature on this subject, to be reviewed in Chapter 6, is devoted to the effects of response modes and context in assessing utility functions. Less is known about the variability in assessing value functions, although von Winterfeldt and Edwards (1986, p. 211) state that: " ... (we) conclude that judgments based on strength of preference are not inferior in either reliability or

[9] The internal and external validity are doubtful, because half of the subjects were classified as risk seeking which is an implausible high percentage if serious decision making is concerned. Furthermore, the number and type of subjects (MIT-students and faculty staff) are limited.

validity to judgments based on preference itself; if anything it is the other way around".

Of course, since von Winterfeldt and Edwards reject the idea of relative risk attitude, they suggest a measurement procedure which is aimed towards minimizing differences between risky and riskless techniques. They promote to start an assessment with techniques measuring value functions. Then a number of responses are elicited by means of lotteries to provide consistency checks. When the answers do not coincide the respondent is confronted with his inconsistency and reasons for these differences are sought. According to the authors, this process mostly results in one consistent function. Differences are seen as resulting from random error and unintended inconsistency and they are therefore seen more as an asset which stimulates harder thought than as an indication of relative risk aversion.

3.3.3 Conclusion

In Section 3.3.1. arguments were put forward which suggest that by comparing a value function and a utility function, of which the former is measured with riskless techniques and the latter with lotteries, a more adequate indicator of the risk attitude of a decision maker is obtained. This attitude is called the relative risk attitude. To be more specific, the relationship between both functions should be a negative exponential one, implying a constant absolute relative risk attitude. In contrast, in Section 3.3.2. arguments were presented which suggest an equivalence of value and utility functions: they should be linearly related. If this is the case, the idea of relative risk attitude is spurious. Empirical research into the issue is inconclusive.

However, irrespective of whether the relationship between u(x) and v(x) eventually turns out to be a negative exponential or a linear function, in both cases the concept of relative risk attitude is of great value. Firstly, it enhances our understanding of risk aversion by providing a proper link between the Bernoulli model and the von Neumann-Morgenstern model. Secondly, the practical implication of finding a negative exponential or a linear relationship irrespective of attribute under consideration, will be that it simplifies decision analysis and the analysis of e.g. consumer decision making under risk very much since riskless techniques are more easily applied than techniques using lotteries. By means of a consistent transformation function, the model under certainty can easily be transformed into a model under risk.

At this moment in time, we think that the theoretical arguments and empirical research concerning the concept of relative risk attitude do not warrant a definite conclusion to be made about the type of transformation function, and consequently, the relevance of the concept. The main conclusion that one can draw from the issue is that, in basic research, and if feasible also in applied research, one should not rely on only one measurement procedure for assessing risk attitude. Firstly, in order to analyze the method variance and reliability of the measurement of risk attitude, multiple procedures should be applied. Secondly, the hypothesis of relative risk attitude clearly requires the use of both riskless and risky techniques in measuring risk attitude.

In this study, we will follow the main conclusion and therefore apply the recommended multiple indicator approach. Both risk attitude and strength of preference will be measured with several techniques. In this manner the convergent validity of the techniques in measuring each concept can be analyzed, followed by an analysis of the relationship between both concepts (a test of the concept of relative risk attitude). By repeating the measurements for the same respondents, insight into the stability of the measurements can be gained (see Chapter 4 for the design of the study and Chapter 6 for elaborate presentations of specific operationalizations made).

In a number of respects the research in this study concerning the issue of relative risk attitude distinguishes itself from the empirical research that has been conducted so far.

Firstly, in this study, decision makers are confronted with their own and real economic decision problem. It is thought that these 'real' subjects will yield more serious responses and will spend more thought than e.g. students would, when confronted with more or less hypothetical decision contexts.

Secondly, the scale of this study is much larger than usual. Elaborate measurements will be obtained twice for 200 to 250 decision makers. By questioning such a large number of respondents more statistical analyses can be applied. For example, the multiple indicator approach, in combination with the large number of respondents, makes it possible to conceive the concepts of risk attitude and strength of preference as latent variables. The relationship between these concepts and their stability can then be analyzed by means of causal modeling techniques (Jöreskog and Sorböm 1976, 1977).

Thirdly, the stability of the concepts of risk attitude, strength of preference and relative risk attitude will be assessed. In general, little attention has been given in the literature to reliability issues in assessing utility and value functions. Furthermore, to our best knowledge, the stability of the relative risk attitude has never been assessed.

Fourthly, until now, no attention has been given to the analysis of the relationship between the relative risk attitude and characteristics of the decision maker like age and level of education. In this study, it will be studied whether such relationships exist.

Finally, experience will be obtained concerning the practical problems of assessing value and utility functions in survey conditions for a large number of respondents. This information will be useful especially from the viewpoint of modeling decision making under risk in small-businesses or of consumers.

3.4 Evaluation of the subjective expected utility model in describing choice behavior

3.4.1 Violations of the expected utility rule

The (subjective) expected utility model (SEU-model) can be seen as both a normative and as a descriptive model. As a normative model it states that if the decision maker agrees with the axioms, he will prefer the alternative with the highest expected utility most. By delineating his preferences, that is, his utility function u(x), it is possible to prescribe how and which risky decisions ought to be made (given the objective or subjective probability distributions). Stated otherwise, if the intuitive decisions tend to conflict with SEU prescribed decisions, it follows that decision making will become improved if in the future acts are chosen that have the highest subjective expected utility (Wright 1984). Of course, this implies the possibility to measure this utility function in a valid and reliable way.

As a normative model, the SEU-decision rule is hardly questioned (Howard 1988). Of course, if a decision maker does not agree with the axioms, his choices would consciously depart from the expected utility model. Such is the case with e.g. Allais (1979).

As a descriptive model the expected utility model states that decision makers choose between alternatives with uncertain outcomes as if they were maximizing expected utility. Although the information processing capacity of decision makers is limited and imperfect, it is thought that economic decision makers strive to behave in accordance with the axioms when confronted with serious economic decisions. The expected utility model should therefore at least give an approximation of behavior (Sinn 1983). By means of the model insight is gained into *how* risky decisions are made. The usefulness of the subjective expected utility model to describe choice behavior is tested by establishing the capability to *predict* these choices. The degree of departure of actual decisions from the prescribed decisions can be studied.

As a descriptive model the subjective expected utility model has received a lot of criticism. At this moment in time, the dominant opinion is that the SEU-model is a failure as a descriptive model. The predictive validity of the model is low. The SEU-model does not describe the choice between gambles accurately, not even in relatively simple decision problems and thus is not adequate for describing risky decision making in the more complex real-world, either.

Reviews of the descriptive strengths and weaknesses of the SEU-model are given by Schoemaker (1982), Fischhoff et al. (1983), Einhorn and Hogarth (1981) and Pitz and Sachs (1984). Recent reviews of applications of the SEU-model in agriculture are presented by Young (1979) and Robison (1982). The main arguments and conclusions from these reviews will be given here.

As stated in Section 3.2, it is very important to recognize that the expected utility model is limited to the final comparison of alternatives: the computational phase. That is, the set of choice alternatives and (subjective) probability distributions are already given and certain. According to many authors, e.g. Simon (1986) and von Winterfeldt and Edwards (1986), the structuring phase, however, is by far the most important phase in actual decision making. Most difficulties in choosing under risk appear with the identification and recognition of the alternatives open to choose, determination of relevant attributes, the processing of available information about alternatives, time pressure etc. The computational phase is only of minor importance: half of the problem is solved by defining it. Since the expected utility model is limited to the computational phase, the expected utility model has very little to offer in describing risky choices.

Especially Simon (1986) is very critical of the SEU-model in this respect. He states that, in typical real-world situations, decision makers simply cannot apply the SEU-model no matter how hard they try. According to Simon, human beings have neither the facts nor the consistent structure of values nor the reasoning power at their disposal that would be required to apply SEU-principles. Even in laboratory experiments with choices concerning problems much simpler than real-world problems, choices widely depart from prescriptions by the SEU-rule. With respect to decision analysis, Simon remarks that the real-world problem is often carved and bounded in a simplified approximation so that (p. 102): " ... the correctness of decisions it will produce depends much more on the adequacy of the approximating assumptions and the data supporting them than it does on the computation of maximizing value according to the prescribed SEU-decision rule".

Taking the above criticism into account, the question is: do decision makers then at least choose according to the expected utility model if the decision problem is structured and in accordance with the model? Numerous, mostly experimental, studies are conducted to evaluate the SEU-model in this respect. Actual preferences and decisions are compared with predictions resulting from the SEU-model. Most authors come to the conclusion that even in these structured problems, SEU fails to describe and predict the choices accurately. To quote von Winterfeldt and Edwards (1986, p. 369): "An inordinately long history of discrepancies between the predictions of the model and experiments on choices among bets makes it clear that it does not predict the details of those choices well".

Violations of the SEU-rule are concerned with violations of the independence axiom like the Allais-paradox (called the *certainty effect* by Kahneman and Tversky (1979): people overweight outcomes that are considered certain relative to outcomes that are merely probable). The *isolation effect* concerns the tendency of people to often disregard mutual components of alternatives in order to simplify the choice between alternatives, and to focus on the components that distinguish them (Kahneman and Tversky 1979). Violations of transitivity are the *preference reversals* (Slovic and Lichtenstein 1971, Grether and Plott 1979). A preference reversal means that a subject prefers lottery A to B if he directly compares them, but that the certainty equivalent of lottery A is smaller than that of lottery B, implying that he should prefer B to A in a direct comparison. This phenomenon, of course, leads to the conclusion that the subject could be used as a money pump (see above 3.2). Other violations of the axioms are the Ellsberg paradox (Ellsberg 1961) and the ideal-risk preferences (Coombs 1975, Coombs and Huang 1976).

Further violations of the SEU-rule stem from the context of the decision problem. For example, the wording of a problem may induce decision makers to change their choice between options. In this regard Schoemaker (1980) showed the effect of *insurance formulations* (pay an insurance premium of $ x) compared to *gamble formulations* (a sure loss of $ x). While formally equivalent, the insurance formulations evoked greater risk aversion than did the gamble formulation. Tversky and Kahneman (1981) introduced the terminology of *framing* to refer to the effects of different descriptions on choice (see also Kahneman and Tversky 1984, Tversky and Kahneman 1988).

The reviews of applications of the SEU-model in studies with agricultural producers as subjects are critical of the model too, but the criticism is less profound. According to Young (1979), it is hard to generalize about results from the empirical studies because of the small number of farmers that is analysed per study and the non-representativeness of samples. Also, most studies show one or more methodological problems. The SEU-hypothesis is explicitly tested against other decision criteria in only a limited number of studies. Two studies in this respect are those of Lin et al. (1974) and Officer and Halter (1968). In both studies some support was found for the model but the predictive validity was fairly low.

Robison (1982) also concludes that it is not convincingly proven that farmers make use of the expected utility decision rule. However, the inadequate test designs of many studies make hard conclusions difficult. The SEU-model seems a useful but far from perfect predictor of choice behavior. Nevertheless, Robison views the SEU-model as the most suitable and useful decision model available.

A lot of research thus indicates systematic violations of the SEU-model, even in relatively simple choice problems. These deviations from the normative model, of course, are the key to generating explanations for these deviations.

Schoemaker (1982) concludes that the failure of the SEU-model (p. 548): "... stems from an inadequate recognition of various psychological principles of judgment and choice. Underlying most of these is a general human tendency to seek cognitive simplification". An important principle in this respect is that decision makers do not structure decision problems as holistically as the SEU-model assumes. For example, subjects focus on either probabilities or outcomes and seldomly focus on both simultaneously. Another principle is that probabilities are not processed in accordance with probability theory.

Vlek (1987) also notes the limited information processing capabilities of decision makers. Often this will result in sequential instead of a holistic processing of information. Another conclusion of Vlek is that complex decision problems more or less invite decision makers to use simplifying decision rules or habitual decision rules. Especially, stress stimulates hasty and sloppy decision making.

Jungermann (1983) distinguishes two conflicting groups (pessimists and optimists) with contrasting interpretations of the divergences from the SEU-model: one that points to the deficiency and one that argues for the efficiency of human judgment and decision.

The first group ("biases are in the people") seeks the explanation for the systematic biases and departure from the .rationality of the SEU-model in the decision maker himself. "This deficiency is not simply seen as a consequence of cognitive overload in highly complex or unfamiliar situations, but as ... rooted in mechanisms working within the human information processing system itself. People are prone to violate principles of rationality" (Jungermann 1983, p. 68). Notable representatives of this group are Kahneman and Tversky and most of the authors in Kahneman et al. (1982).

According to Jungermann (1983), three explanations are given for the deficiencies. Firstly, judgmental errors are made by using Kahneman and Tversky's heuristics of availability, representativeness and anchoring and adjustment (see Chapter 5 for a description of these heuristics). They use these fairly simple procedures, rules and tricks in order to reduce mental effort (Hogarth 1980). Secondly, decisions and preferences can be inconsistent as a result of errors in the representation of the problem. The inconsistent preferences are seen as the result of deficient perception and interpretation of the decision problem. Thirdly, information processing is often defective because of motivational factors. Janis and Mann (1977) distinguish five coping patterns people use when they are confronted with decision problems in stressful conditions. Only one of these patterns, namely the one which operates at medium stress levels, resembles the rational behavior assumed in the SEU-model. In badly defined, complex and dynamic situations other patterns are used, which easily lead to errors in assimilating and combining information.

The second group ("biases are in the research") emphasizes the implicit rationality of human judgment and decision making. They are skeptical of the analysis of decision making performed by the first group. The internal and external validity of the research and the interpretation given to the results are questioned. Representatives of this opinion are Berkeley and Humphreys (1980), Einhorn and Hogarth (1981) and Phillips (1983).

Jungermann (1983) also classifies three arguments for this group. The first argument is the one of metarationality. It means that decisions which are classified as not rational since they are not taken in accordance with the SEU-model could be seen as rational if the cognitive costs of being rational in the SEU sense are taken into account. Especially decision making costs such as time and effort could be reasons why people do not decide according to the SEU-model. The decision strategy is a compromise between costs (time and effort) and benefits (wish to attain an optimal decision). Decisions are therefore almost always multi-attribute and it is not easy to know all attributes in a given situation. In experiments, the decision making task is often limited to only one attribute.

The second argument concerns the continuity of decisions. Judgments and decisions are merely moments in a continuous process. What might be interpreted as bias in a decision problem singled out from the process, could be functional in the light of the continuous process. Many experiments neglect the decision process; decisions are seen as discrete events. For example, in many experiments no feedback is given. The judgmental biases are artifacts of the experiments themselves which are therefore low in external validity.

A third argument concerns the structuring of the decision task. It is seldom explicitly checked whether subjects interpreted the task in the same way as the researcher.

Jungermann concludes that the representatives of this group do not yet accept the description of the human being as an "intellectual cripple". The experiments which try to prove this are surrounded by too many problems. Von Winterfeldt and Edwards (1986, Chapter 13) come to a similar criticism on the way in which experiments on decision making are conducted. They particularly stress that subjects are usually not permitted to use physical tools in experiments (e.g. paper and pencil, calculators, books on probability theory) and that subjects in experiments (most often students, as Berkeley and Humphreys (1982) show) are not stimulated enough to think hard about a problem and thus do not arrive at the 'right' answer (the problem is not important enough to these subjects).

The view of the second group suggests that for well-structured tasks, with important consequences to the decision maker and decision makers who are familiar with the, possibly repetitive, decision problem, the SEU-model might be a useful approximation of choice behavior. Such may be the case for the decision problem in this study: the farmer's choice of a marketing strategy. However, much evidence is available that even in such favorable circumstances, decisions might easily deviate from the normative model. These deviations from the normative model stimulated a lot of research into alternative models. In the next section most of these models will be reviewed and their usefulness for empirical research on decision under risk will be evaluated.

3.4.2 Alternative descriptive models

A fairly large number of alternative models have been formulated which try to account for the deficiencies of the SEU-model found in experiments. Of these, the following models can be mentioned: the *Prospect Theory* of Kahneman and Tversky (1979), the *regret theory* of Bell (1982, 1985) and Loomes and Sugden (1982), the *generalized expected utility model* of Machina (1982), the *opti-*

mism/pessimism approach of Hey (1984), and the *lottery dependent utility model* of Becker and Sarin (1987).[10]

Most of the alternative models are still close to the principles of the SEU-models and can be viewed as extensions or variants of the SEU-model, other models deviate largely from the SEU-theory. The most important representative of the latter category is Prospect Theory.

The models of Hey, Machina, Loomes & Sugden and Becker & Sarin all weaken the independence axiom or replace it with some other assumption. This implies that the utility of the outcomes is made dependent on the probability distribution of outcomes. For example, Machina (1982) defines a local utility function u(x; f(x)) which depends specifically on the particular probability distribution f(x). In a similar vein Becker and Sarin (1987) define their lottery dependent utility. In the regret model of Loomes and Sugden (1982) the utility of a particular outcome is not independent any more of the other possible outcomes. In Hey's optimism/pessimism model (1984) the subjective probability distribution is dependent upon the outcomes. If the outcome is favorable, the subjective probability is adjusted upwards, if unfavorable the probability is adjusted downwards. Hey calls such a decision maker an optimist. A pessimist revises down the probabilities of favorable outcomes and revises up the probabilities of unfavorable events. Only a realist decides according to the expected utility model. Hey presents a clear comparison of his own model and the models Machina, Loomes and Sugden.

In the model of Bell (1982) regret is introduced as a second attribute. In this way, Bell succeeds in explaining many experimental violations of the SEU-model. Regret may occur when a risky choice turns out to be "wrong" after the fact: an alternate choice would have been better given the state-of-the-world that occurred. In Bell (1985) disappointment is introduced. Disappointment is the reaction to an outcome that is below expectations. In this model then, the utility of an outcome depends upon the expected value of the probability distribution. Howard (1988) considers these regret models theoretically rather unattractive since it makes preference dependent on what one might have received, instead of what one actually received.

To conclude, it is clear from all alternative models presented so far that extra parameters are introduced compared to the SEU-model. It should therefore not come as a surprise that these models "explain" the violations of the SEU-model. The utilization of these models, however, is hampered by the difficulty of operationalizing certain elements of the models. For example, how should one measure the optimism/pessimism parameters in Hey's model, the regret parameter in Loomes and Sugden's model, or the local utility function depending on the probability distribution in Machina's model? Contrary to Machina, Becker and

10 Still other models can be mentioned. For example the Allais-model (already discussed in Section 3.2) and Coombs' single-peaked preference model (Coombs 1975). This latter model will be presented in Chapter 6 discussing the results of conjoint measurement. Becker and Sarin (1987) provide a schematic overview of all proposed models.

Sarin (1987) do suggest a method to measure their probability dependent utility function. Their method boils down to measuring a number of negative exponential utility functions with different elicitation probabilities. From these measurements an estimate of the probability dependent function can be obtained.[11] Until now, no empirical studies have employed their method of assessment and tested the model.

In general, the models are theoretically interesting, especially if it can be shown that the basic concepts, tools and results of expected utility do not depend on the much questioned independence axiom (Machina 1982). However, at this moment in time, the alternative models are not empirically testable.

All models discussed so far, originate from people working in utility theory or decision analysis. This is evident by the great emphasis on formal axiomatical and mathematical considerations. The next model to be discussed, Prospect Theory, originates from psychology. In this model the psychology of decision making is emphasized.

Prospect Theory

The most deviant theory from the SEU-model and according to von Winterfeldt and Edwards (1986, p. 372) " ... the most illustrious contemporary competitor as a descriptive theory of choice" is Prospect Theory (Kahneman and Tversky 1979). This theory is built on a number of experimental observations. The two main elements of the model are the editing phase and the computational phase. In the editing phase the options are structured and reformulated so as to simplify the subsequent evaluation and choice. An important operation in the editing phase is the coding of outcomes. Outcomes are recoded as gains or losses with respect to some reference point.

The second element of Prospect Theory concerns the computational phase. Important elements in this phase are a) the value function, b) the decision weight function, c) a combination rule of values and decision weights and, finally, d) the decision rule: choosing the prospect with the highest value.

In Prospect Theory a value function is defined on gains and losses with respect to a reference point. This function is assumed concave for gains (implying risk aversion) and convex for losses (implying risk seeking behavior). Also the convex part of the function is steeper than the concave part: the aggravation one experiences in losing a specified amount of money is greater than the pleasure associated with gaining the same amount. The effect of reversing the risk attitude around a reference point is called the *reflection effect*. Figure 3.4 illustrates such a value function.

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11 One might view the differences between functions as a psychometric problem, that is, the differences are caused by method variance. In this view, it would be appropriate to confront the subject with his inconsistent elicitations and urge him to think hard about his preferences. According to von Winterfeldt and Edwards (1986) this process will mostly end in one consistent utility function.

By calling the evaluation function a value function it is suggested that no risk is introduced in the measurement procedure of this function. However, the authors do not specify a procedure for measuring the function. An important aspect of the theory is the assumption that the decision maker recodes outcomes into gains or losses with respect to reference point. Kahneman and Tversky suggest that the status quo will serve as the reference point, but this might also depend on the expectation, e.g. the aspiration level, of the decision maker (Payne et al. 1980, 1981). Of course, also the framing of the decision problem will influence the choice of the reference point (Tversky and Kahneman 1981).

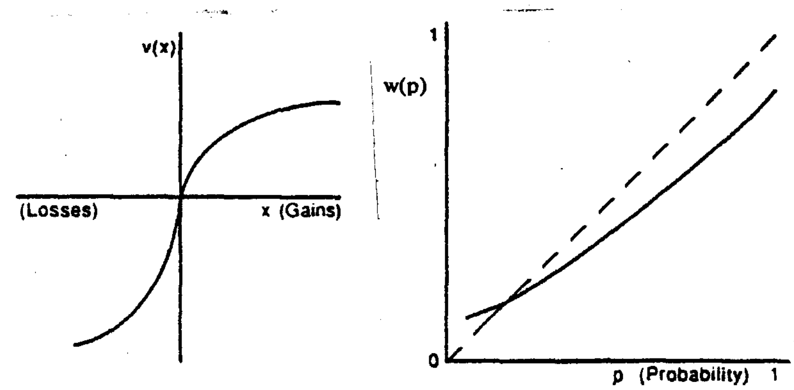

Figure 3.4 *The hypothetical value function v(x) and weighting function w(p) proposed in Prospect Theory*

With the utility component of the SEU-model being replaced according to a value function of a very specific form, the probability component in the SEU-model is even more dramatically transformed in Prospect Theory. Decision weights w(p) are introduced to replace subjective probabilities. Figure 3.4 shows the proposed weighting function, too.

The decision weights measure the impact of probabilities on the desirability of outcomes. They have almost nothing in common with subjective probabilities. For example, the decision weights do not have to sum up to one, their sum can be smaller (subcertainty). Furthermore, according to Kahneman and Tversky, very small probabilities are generally overweighted, that is, the decision weight attached to the rare event is larger than the probability. Except for very small probabilities, the probabilities are generally underweighted, that is, the decision weight is smaller than the probability. For very extreme probabilities (close to 0 or 1) the relationship between decision weights and probabilities is not well behaved. This so-called "quantal effect" is caused by the categorical distinction between certainty and uncertainty.

In a similar vein as in the expected utility model, values and weights are combined in Prospect Theory. Outcomes, transferred into values by the value function, are weighted by the decision weights and then summed. This summed index is the index by which probability distributions are rank ordered and the subject is assumed to choose the distribution with the highest index (expectancy-value models).

Equations 3.12 (expected utility model) and 3.13 (Prospect Theory) show both rules for the evaluation of lottery $[x_1, p, x_2, q, 0, 1-p-q]$; a lottery with three outcomes $(x_1, x_2, 0)$ with the following probabilities (p, q, 1-p-q):

$$EU = p\ u(x_1) + q\ u(x_2) + (1-p-q)\ u(0) \tag{3.12}$$

$$V = w(p)\ v(x_1) + w(q)\ v(x_2) + w(1-p-q)\ v(0) \tag{3.13}$$

where EU denotes the expected utility of the lottery and V the value of the lottery in Prospect theory.

In both models, a multiplication is followed by an addition. Also, again this summed index is maximized. However, in contrast with expected utility, in Prospect Theory no justification, apart from face validity, is given to explain why it would be rational to choose the prospect with the highest value.

It is interesting to note that in some respect Prospect Theory includes the hypothesis of relative risk attitude. More specifically, the hypothesized decision weight function w(p) leads to the conclusion that, in general, decision makers should be relatively risk averse. This can be shown as follows. Prospect Theory and expected utility theory coincide when $w(p) = p$ for all p and when $u(x) = v(x)$. In that case the expected utility of a lottery defined on v(x) equals the value V of the gamble in Prospect Theory (see Equations 3.12 and 3.13). However, according to Prospect Theory the decision maker valuates the lottery less than V due to the general underweighting of probabilities ($w(p) < p$) and subcertainty. Stated otherwise, the decision maker's certainty equivalent of the lottery will be smaller than V (the decision maker is more risk averse than expected on the basis of $w(p) = p$). The same effect can be achieved in the expected utility model (where $w(p) = p$) only if u(x) implies more risk aversion than v(x). Consequently, u(x) is more concave than v(x) which implies relative risk aversion.

A large range of observed violations of SEU theory can be explained by means of Prospect Theory. This should not be a great surprise of course, since the model is built on the basis of the observed violations in experiments. Moreover, since there are many parameters in the model it will be rather easy to find a set of parameters which can provide a suitable "explanation". Given a value function of whatever form, e.g. a twice differentiable function is not needed, some set of decision weights can be found to account for a choice. Particularly the choice of the reference point is relevant in this respect. Since no rules are given on how to select this reference point, one can always find a point which explains the choice. It will therefore be very hard to refute the model if no restrictions are applied to the parameters.

Apart from the problem why a decision maker should maximize V and the difficulty in falsifying the model, some other problems remain with the theory. Firstly, it is not clear whether the rules of probability theory apply to Prospect Theory. For example, assume a decision tree with several chance nodes. The axioms in expected utility imply that this tree can be reduced into a tree with a single node by means of standard probability calculus. Does Prospect Theory allow this reduction too? And what about the decision weight function; is the function applied to only the probabilities in the final reduced tree, or should all probabilities in the tree be replaced by decision weights first, before reduction?

Secondly, it is not clear how one should evaluate alternatives with continuous probability distributions. Since the decision weight function is not well behaved near the ends, these functions cannot be evaluated.

Thirdly, no indication is given of the manner in which attributes should be combined in multiattribute decision making. Is the proposed value function also valid for other attributes than money and how should these functions be combined?

Finally, the authors present no indication on how the value function and the decision weight function should be measured. Not until Currim and Sarin (1989), to be discussed below, were assessment procedures suggested.

Prospect Theory already stimulated a substantial amount of theoretical and empirical work. For example, an interesting exposition of the consequences of Prospect Theory's proposed value function on consumer decision making is given by Thaler (1980, 1985). Not surprisingly, empirical work on Prospect Theory has concentrated on the reflection hypothesis since this is an interesting idea and can be experimentally researched fairly easily. For example, because the reflection effect of Prospect Theory had been based upon between-subjects experiments, that is, subjects had been used which evaluated either lotteries with gains or lotteries with losses, Hershey and Schoemaker (1980) did some experiments with a within-subjects design. They found no clear reflection effect; apart from convex/concave functions they found all other types of combinations of convex and concave functions. However, see also Keren and Raaijmakers (1988) who question the within-subject analysis used by Herschey and Schoemaker. They consider only between-subject experiments valid for testing the reflection hypothesis.

A more important empirical test of the use of Prospect Theory concerns the issue of the predictive validity of the model relative to that of the expected utility model. To our best knowledge, Currim and Sarin (1989) are the first who tested Prospect Theory in this respect. They operationalize the decision weight function and the value function. Based on three experiments with MBA-students, they conclude a high consistency with the postulates of both models. On predictive validity the Prospect model outperforms the expected utility model for paradoxical choices (e.g. the Allais-paradox). However, for nonparadoxical choices they found little difference in predictive validity of both models. Furthermore, they found some evidence that the decision weight function might be different for gains and losses. This latter finding complicates the theory even more.

3.4.3 Conclusion

The decision problem in this study, as structured in Chapter 2, concerns the choice between marketing strategies, described by continuous probability distributions. The SEU-model provides the information on how one should choose between those distributions. This normative principle is not questioned here. The question then is, can the SEU-model be used as a descriptive model and if not, which alternative model should be used?

Our review showed that a large amount of evidence suggests that the SEU-model might be only approximately right in describing choices. This approximation is probably better in well-defined, short term decision problems, with important consequences for the decision maker and with a decision maker who is familiar with the decision problem, as in this study. However, even in those circumstances predictive validity is probably low. The question is whether alternative descriptive models are more accurate than the SEU-model.

In our view, the alternative models reviewed, however, do not provide a real alternative to the SEU-model. A general feature of all these alternative models is that they all imply the maximization of an index which is constructed by means of a multiplicative and an additive computation. In these respects, these models do not differ from the SEU-model. All models are expectancy-value models. Any criticism on this aspect of the SEU-model thus pertains to all the reviewed descriptive models of decision making under risk. Another general feature of the alternative models is that extra parameters are introduced. This makes the models much more complex than the SEU-model. Furthermore, many models contain elements which cannot be operationalized yet and consequently are not empirically testable.

Of the alternative models reviewed, Prospect Theory emerges as the most serious competitor of the SEU-model. The main contributions of Prospect Theory are the strongly emphasized editing phase, the idea that the decision maker might code outcomes into gains or losses with respect to a reference point and the idea of a reflection effect.[12] However, with respect to the computational phase we came across a number of serious problems with this theory. For example, the appropriate definition and determination of the reference point, the measurement of the value function, the assessment of the decision weight function and the

12 An interesting topic of research, not studied here, might concern the reference point. Do farmers evaluate prices for potatoes as a stream of income, as assumed in expected utility theory, or do they code prices into gains and losses? Also, do farmers take the direct costs of ware potato production as a reference point in coding gains and losses, or do they refer to total costs or an aspiration level as a reference point etc.?

discontinuities of this function, hamper the empirical use of this model. Furthermore, although the findings of the study by Currim and Sarin (1989) need further empirical confirmation, their findings suggest that in spite of the greater complexity, Prospect Theory does not outperform the SEU-model. For these reasons we did not choose Prospect Theory as the model for analyzing the farmer's decision making.

We chose the SEU-model for modeling the decision problem in this study. Important merits of the SEU-model are its elegance and tractability (Pitz 1977). Also, the model is very robust (Fischhoff et al. 1983) like all additive models. Moreover, since the SEU-model is a normative model, the comparisons of normative predictions with actual choices highlight the differences. In this way, insight is gained into the extent to which people decide rationally. Furthermore, despite strong criticism, the SEU-model is still the main frame of reference for both modeling decision making under risk and the formulation of alternative descriptive theories. The non-existence of a good alternative model could also be seen as a strength of the SEU-model (Jungermann 1983).

We conclude therefore, not only for the decision problem in this study but in general, that before other models are constructed which are shown to predict preferences and choices better than the SEU-model and which are just as operationally tractable in practical applications, the SEU-model will remain an adequate reference model for studying actual decision making under risk. However, it is acknowledged that the predictive validity of the model will probably be low.

3.5 Applying the SEU-model to the preference for a marketing strategy

The preference for marketing strategy j of farmer i is modeled by two attributes: price and marketing channel (see Chapter 2). Furthermore, in the conceptual model of Chapter 2, the concepts of risk perception and risk attitude were introduced. In this chapter definitions of both concepts were presented and indications were given how both concepts might be operationalized. Furthermore, the theory here makes it possible to specify how risk perception and risk attitude should be combined into a consistent model of preference formation.

In order to evaluate the predictive validity of the subjective expected utility model (SEU-model), this model is compared to the subjective expected value model (SEV-model). The predictive validity of the SEV-model is thus seen as the bench-mark with which to compare the SEU-model. In the SEV-model the farmer is assumed to rank order marketing strategies according to the expected value of the subjective probability distribution of price. This implies that a risk neutral farmer is assumed which means that second and higher moments of the probability distribution do not influence preference.

In the SEU-model, this assumption of risk neutrality is abandoned. The effect on preference of a decision maker's degree of risk aversion is taken into account.

Since farmers will probably be risk averse, it is hypothesized that the SEU-model will outperform the SEV-model in predictive validity. This hypothesis will be tested in Chapter 7. The testing procedure applied will be described there, too.

The two models can be specified as follows.

Model 1 *Subjective expected value model (SEV-model)*

$$U_i(S_j) = \alpha + \beta \int f_{ij}(x)\, x\, dx + \gamma\, MC_j \qquad (3.14)$$

with:

$U_i(S_j)$ = utility of marketing strategy S_j for farmer i,
$f_{ij}(x)$ = probability density of price x with strategy S_j as perceived by farmer i,
MC_j = the type of marketing channel of strategy S_j (a cooperative or private wholesale company).

Alpha, beta and gamma are parameters which will be empirically derived.

Model 2 *Subjective expected utility model (SEU-model)*

$$U_i(S_j) = \alpha + \beta \int f_{ij}(x)\, u_i(x)\, dx + \gamma\, MC_j \qquad (3.15)$$

with:

$u_i(x)$ = utility function of price x for farmer i, measured by means of lotteries.

Other elements in (3.15) have the same meaning as in (3.14).

Model 2 can be simplified if certain restrictions can be put on the probability distribution or the evaluation function. For example, if the probability distribution is normally distributed, only the mean and variance of the distribution will be relevant for calculating the expectancies. Another special case, the so called mean-variance case, results if the evaluation function is a quadratic polynom. Then, irrespective of the form of the probability distribution, expected utility will only be based on the mean and variance of the probability distribution.

As Equations 3.14 and 3.15 show, the sole difference between the two models is that x in the SEV-model is substituted by $u_i(x)$.

According to standard expected utility theory, the function $u_i(x)$ in the SEU-model is a utility function which should be assessed by means of lotteries. However, introduction of the concept of relative risk attitude suggests that also a strength of preference function $v_i(x)$, assessed by means of riskless techniques, could be assumed in the model. It is interesting to test whether a substitution of the utility function by the strength of preference function affects the predictive validity of the model. Of course, if $v_i(x)$ and $u_i(x)$ are linearly related (a relatively risk neutral farmer) the predictive validity is equal. Otherwise, standard expected utility theory predicts that the model incorporating $u_i(x)$ should outperform the model incorporating $v_i(x)$ in predictive validity, since only in $u_i(x)$ the decision maker's risk attitude is included. In Chapter 7 this hypothesis will be tested.

Models 1 and 2 are specified as additive models of the two attributes price and marketing channel. This implies that the set of probability distributions of price is independent on the marketing channel. In essence, this assumption means that the farmer has full opportunity within both marketing channels to construct a combination of selling-options (a marketing strategy) which suits his risk attitude. The parameters beta and gamma in this case are interpreted as the (linear) trade-off between the utility derived from the prices which can be attained by a marketing strategy and the utility derived from choosing a particular marketing channel.

In general we expect a two-phase choice process. First, a farmer chooses a marketing channel on the basis of non-price attributes, and then he chooses a combination of selling-options in accordance with his risk attitude. The difference in preference between both channels could be so large that hardly any difference in price distribution can offset this preference. In such a case, if we asked respondents to rank order a number of marketing strategies S_j with respect to preference, all cooperative or all private marketing strategies would be preferred to the other irrespective of the combination of selling-options. In the models we would find a large standardized coefficient of gamma compared to the one of beta. In Chapter 7 the specification of the models will be discussed further.

3.6 Research questions

After structuring the decision making process in Chapter 2 and discussing the theoretical notions about decision making under risk in this chapter, the following research topics and questions can be derived from the research objectives.

In this chapter three main issues emerged. The first topic concerns the theoretical and empirical relationship between a utility and a strength of preference function. This centers around the concept of relative risk attitude. Until now, empirical research into this concept has been limited and inconclusive.

A second topic is a methodological one and concerns the measurement of subjective probability distributions and risk attitude. In general, it was concluded that a multiple indicator approach should be followed, especially with respect to the measurement of risk attitude. This approach is especially relevant considering the theoretical differences between utility and strength of preference functions.

Another conclusion is that in survey research sparse attention is given to validity and reliability issues in the measurement of risk perception and risk attitude (in Chapter 6 more will be said about this issue). The recommended multiple indicator approach lacks completely in survey research.

Furthermore, the hypothesized preference formation model implies the elicitation of several subjective probability distributions per individual. Research on whether it is feasible in survey conditions to elicit these distributions in a valid and reliable manner is rare.

The third topic deals with the predictive validity of the proposed model of preference formation. On the basis of a review of alternative descriptive models for decision making under risk it was concluded that the SEU-model is the most theoretically attractive and the best empirically testable model for modeling the decision problem in this study. The predictive validity of this SEU-model and the question whether it outperforms the SEV-model in this respect, remain to be studied. Furthermore, the predictive validity of the proposed two-attribute model of preference formation should be assessed.

From a theoretical and methodological point, therefore, the following questions are relevant:

- What is the relationship between a strength of preference function and a utility function: is the hypothesis of a (constant absolute) relative risk attitude confirmed? What is the usefulness of differentiating risk attitude and relative risk attitude?
- What is the reliability and validity of measurement procedures of risk perceptions, risk attitude and strength of preference in survey conditions? Which procedures perform best in these respects? To what extent is the application of multiple measurements of risk perceptions and risk attitude useful and practically feasible in basic research and in applied studies?
- Does the subjective expected utility model predict preferences significantly better than the subjective expected value model does? How well does the subjective expected utility model predict a farmer's preferences for marketing strategies? Are both price and marketing channel significantly affecting preferences for marketing strategies and are both attributes equally important?

Another interest in this study concerns a number of topics which are related directly to the specific decision problem under study: preferences for and choice of marketing strategies. The following topics are especially relevant in this respect.

- How do farmers perceive marketing strategies, especially with respect to price risk and marketing channel? How large are differences in perception between very safe and very risky strategies? How homogeneous is the price perception of farmers in respect of these strategies?

- How do farmers differ with respect to the degree of risk aversion, strength of preference and relative risk aversion? To what extent are these differences between farmers related to personal and situational factors?
- Which marketing strategies are preferred and chosen by farmers? How is this preference related to the risk perception of marketing strategies and the risk attitude of the farmer? To what extent are differences in preferences of farmers for a particular marketing strategy related to personal and situational factors?

In the following chapter the design of the empirical study which was conducted to answer these questions is presented. Results of this study are given in Chapters 5, 6 and 7 and a synthesis and discussion of results can be found in Chapter 8.

CHAPTER FOUR

DESIGN OF THE EMPIRICAL STUDY

In the previous chapters, the decision problem was structured and theories about decision making under risk were presented and evaluated. A conceptual model of the decision making process with respect to choosing a marketing strategy was proposed. In this chapter, the operationalization of the conceptual model will be dealt with.

As will be described below, data were collected by means of a survey. Personal interviews were held with a sample of farmers. Firstly, the design and contents of the questionnaire will be dealt with. Secondly, the research population is defined and sampling plan and data collection procedures will be presented. Finally, a characterization of the sample with respect to a number of background variables will be given.

4.1 Operationalization of the conceptual model

In this section an overview is presented of the most important choices which had to be made in order to be able to empirically test the conceptual model for choosing marketing strategies. Here, attention will be directed towards providing general insight into the operationalizations eventually chosen, without discussing all the details of the measurements. An elaborate discussion and evaluation of specific measurement procedures applied in the study will be given in subsequent chapters dealing with, respectively, risk perceptions, risk attitude, strength of preference and preferences. This section thus intends to show the structure of the empirical study.

An important decision was the choice to interview farmers in two consecutive years. The main reason for this choice is the limited attention given in field studies to the analysis of the stability of risk attitude and risk perception measurements, as has already been pointed out in Chapter 3. A second reason is that the ware potato market circumstances can differ considerably between marketing years, which might induce farmers to change their perceptions and thus their preferences for marketing strategies. If the hypothesized preference model has proven accurate in two possibly widely different marketing years, this will greatly increase confidence in the validity of the model. In the study, each farmer was therefore interviewed in two consecutive years, namely in June 1984 and in June 1985.[1]

Since a large number of measurements was needed, in June 1984 each farmer was interviewed twice with one or two weeks in between. In 1985, however, time

[1] The reason for choosing June as the most appropriate moment of measurement was explained in Chapter 2.

was only available for one interview with each farmer because of budgetary constraints. As a consequence, changes were deemed necessary in some respects in 1985 although for the most part exactly the same measurements took place in both years. These differences between both years of measurement will be pointed out below.

4.1.1 Formulation of a set of marketing strategies

In order to analyze *preferences* for the object of choice, the marketing strategy, a set of marketing strategies has to be formulated, for which a farmer's risk perceptions and preferences should be measured. Care should be taken with the formulation of marketing strategies to provide a stimulus set which can represent the whole range of marketing choices farmers actually make. Also, the stimulus set should consist of strategies which cover the entire range of price risk; both strategies with very small price risk and strategies with intermediate and large price risk should be included. Furthermore, the marketing strategies should be easy to understand by respondents, especially when combinations of selling-options are considered.

These requirements led to the specification of marketing strategies (13 in 1984 and 18 in 1985) which are described in Table 4.1. In the description of the marketing strategies in Table 4.1 blancs (denoted by ...) are shown. These concern either the levels of fixed and bottom-prices that were specified in the respective contracts or the timing of selling on the spot market. Both depend on the moment of delivery. This aspect will be elaborated upon below.

Since private companies offer more selling-options than the cooperative company, more strategies have to be formulated with the private companies as marketing channels in order to arrive at a representative set of strategies. For three strategies, namely Strategies 1, 7 and 11, the cooperative is specified as the marketing channel; for the remaining strategies a private company is specified.

Apart from 100% marketing strategies (Strategies 1 to 6 and 14 in Table 4.1) indicating that a farmer's total potato produce is marketed by means of only one selling-option, a number of *combinations* of selling-options are defined. These combinations consist of only two selling-options in a ratio of 50/50 in order to simplify a respondent's understanding and interpretation of strategies. The most common combinations of selling-options are defined (Strategies 7 to 13, 15 and 16 in Table 4.1). For reasons of completeness, the stimulus set is extended by Strategies 14 to 18 (Table 4.1) in 1985 to arrive at a total of 18 marketing strategies. In this way, two strategies with three selling-options (Strategies 17 and 18) are included as well as a strategy consisting of a three-year fixed-price contract.

With the exception of Strategy 13, in all combinations of selling-options 50% of the total produce is sold by means of spot market sales. As was noted in Chapter 2, selling on the spot market sales is a fairly popular selling-option. For example, in 1979 55% of potato harvest was sold at spot market prices (De Graaf 1981) and in 1983 this percentage was 43% (Smidts 1985).

Selling at spot market prices is subdivided into two propositions: selling at one moment in time or spreading sales by choosing two selling moments. Price perception will probably vary in these options. Again, for purposes of clarity of the strategy's interpretation by the respondent, the differentiation is limited to selling at one or two moments.

Strategy 13 is constructed by combining a fixed price and a bottom price contract, thus yielding a marketing strategy which is probably perceived as a strategy with a small price risk.

In the formulation of marketing strategies the *moment of delivery* is directly taken into account. Four sets of marketing strategies are defined, one set for each important moment of delivery (see Chapter 2): at harvest-time (September), in December, in March and in May/June. In the interview the moment the farmer usually delivers his potatoes is established first. Next, the appropriate set of marketing strategies is selected, and for this set the farmer's preferences and perceptions are measured.

The four sets of strategies differ from one another with respect to the levels of the fixed and bottom-price specified in the respective contracts and the timing of selling on the spot market. Table 4.1 shows these levels and selling moments per moment of delivery. For example, for a farmer who has to deliver in December Strategy 6 is formulated as: *100% spot market* (sell 50% in *October* and 50% in *December*). For a farmer who delivers in May/June Strategy 6 is formulated as: *100% spot market* (sell 50% in *December* and 50% in *May*). Likewise, for a farmer delivering in December Strategy 9 in 1984 is: *50% fixed-price* contract of *23 cts/kg* and selling *50% at the spot market* (sell in *October*), whereas for a farmer delivering in May/June Strategy 9 is: *50% fixed-price* contract of *26 cts/kg* and selling *50% at the spot market* (sell in *May*).

Table 4.1 further shows that when selling only once on the spot market the moment of selling equals the moment of delivery. When selling at two moments on the spot market, the first moment of selling is chosen early in the marketing year (September for farmers delivering in December and December for farmers delivering in March or in May/June), while the second moment of selling again corresponds to the moment of delivery. In the strategies the moment of selling is specified on a monthly basis. The farmer is asked to imagine selling at an appropriate moment in the specified month.

Table 4.1 *Formulation of marketing strategies which are used in the measurement of price perception and preferences in 1984 and in 1985 (Strategies 14 to 18 are used in 1985 only)*

1.	100 %	Pooling Cooperative
2.	100 %	Bottom-price (... cts/kg)
3.	100 %	Fixed-price (... cts/kg)
4.	100 %	Spot market (sell 100% in ...)
5.	100 %	Pooling Private
6.	100 %	Spot market (sell 50% in ... and 50% in ...)
7.	50 %	Pooling Cooperative
	50 %	Spot market (sell in ...)
8.	50 %	Bottom-price (... cts/kg)
	50 %	Spot market (sell in ...)
9.	50 %	Fixed-price (... cts/kg)
	50 %	Spot market (sell in ...)
10.	50 %	Pooling Private
	50 %	Spot market (sell in ...)
11.	50 %	Pooling Cooperative
	50 %	Spot market (sell 25 % in ... and 25 % in ...)
12.	50 %	Fixed-price (... cts/kg)
	50 %	Spot market (sell 25 % in ... and 25 % in ...)
13.	50 %	Fixed-price (... cts/kg)
	40 %	Bottom-price (... cts/kg)
	10 %	Spot market (sell in ...)
14.	100 %	Fixed-price (three years fixed ... cts/kg)
15.	50 %	Fixed-price (three years fixed ... cts/kg)
	50 %	Spot market (sell in ...)
16.	50 %	Pooling Private
	50 %	Spot market (sell 25 % in ... and 25 % in ...)
17.	25 %	Pooling Private
	25 %	Fixed-price (... cts/kg)
	50 %	Spot market (sell ...)
18.	25 %	Pooling Private
	25 %	Fixed-price (... cts/kg)
	50 %	Spot market (sell 25 % in ... and 25 % in ...)

	FIXED PRICE		BOTTOM PRICE		SELLING ON THE SPOT MARKET		
						TWO MOMENTS	
Moment of delivery	1984	1985	1984	1985	One moment	First moment	Second moment
September	20	18	15	15	September	September	-
December	23	20	17	17	December	October	December
March	24	23	18	18	March	December	March
May/June	26	25	20	20	May	December	May

Further differences between the four sets of strategies concern, of course, the level of bottom and fixed-prices in the respective contracts since delivering early in the marketing year implies lower storage costs. These precise differences between strategies are presented in Table 4.1. The prices of bottom and fixed price contracts were set in accordance with the contract prices agreed upon at the moment of the interviews. Three private companies were contacted which provided these prices, one for each moment of delivery. The prices of the companies largely corresponded.

A difference between 1984 and 1985 can be seen with respect to the level of fixed-price contracts. Fixed prices were clearly higher in 1984 than in 1985. There was a demand hausse in May and June 1984, resulting in relatively high fixed-price contracts. An explanation suggested for this upward movement of prices at the time was that farmers were fairly reluctant to contracting because they had experienced very high potato prices on the spot market in 1983, especially at the end of the season. According to spokesmen of the wholesale companies contacted, farmers motivated their reluctance by stating that they did not want "to miss the boat again because of contracting or selling too early". Another explanation might be that farmers, on average, were less risk averse in 1984 as a result of the increase in wealth in 1983. Wholesale companies therefore had to provide relatively attractive fixed-price contracts. In 1985 such an effect was not present since overall 1984 was a year characterised by mediocre prices. Fixed-price contracts in this year are therefore more in accordance with the usual situation.

4.1.2 Measurement of risk perception, risk attitude and strength of preference

The procedures applied in measuring price perception and risk attitude will now be briefly discussed. Table 4.2 provides a short representation of the operationalization of the model in both years and delineates the differences between the years.

Price perception of marketing strategies is measured in two different ways. In the first method the perception of price is viewed as a probability distribution. Many techniques exist to elicit subjective probability distributions, which will be discussed and evaluated elaborately in Chapter 5.

Our evaluation of techniques has led us to the choice of the *interval technique*. By means of this technique, the respondent has to state a minimum (P_{min}) and a maximum price (P_{max}) he expects to receive when choosing a specific strategy. The minimum price is defined as the price for which it is "very unlikely" that prices will turn out lower. In the same way the maximum price is obtained. Subsequently the median price is elicited by asking the respondent to specify the price P_{med} between minimum and maximum so that the probability of obtaining a price between minimum and P_{med} equals the probability of obtaining a price between P_{med} and maximum. In the same manner, the first and third quartile are assessed; the first quartile between P_{min} and P_{med} and the third quartile between P_{med} and P_{max}.

Table 4.2 Overview of measurement procedures applied in the study

Price perception

1. *Interval technique*
   - elicitation of five points of the cumulative probability distribution function
   - limited to 7 marketing strategies
2. *Direct questioning**
   - direct questioning of mean price
   - price risk measured by means of magnitude estimation
   - for total set of strategies

Risk attitude

1. *Lottery technique*
   - assessment of ten points of the utility function by means of 50/50 lotteries
   - three consistency checks are included
   - respondent has to specify the certainty equivalent of the lottery
2. *Conjoint measurement**
   - the profiles consist of 50/50 lotteries
   - full factorial design of 4 levels of mean price and 6 levels of variance
   - respondent has to rank 24 profiles in accordance with preference

Strength of preference

1. *Midvalue splitting technique*
   - assessment of ten points of the value function
   - two consistency checks are included
   - respondent has to specify the equal difference point
2. *Rating technique**
   - assessment of ten points of the value function
   - respondent has to rate ten price levels on a scale from 0 to 10

Preference

1. In 1984 13 strategies are rated on a 7-point rating scale, in 1985 this concerns 18 strategies
2. Complete rank order of strategies with respect to preference

Choice behavior

From marketing year 80/81 to 84/85 choice behavior is registered with respect to choice of marketing channel, choice of selling-options, amount sold per selling-option and, if available, prices obtained

* In 1985 limited to a randomly selected third of the respondents.

Five points of the cumulative probability distribution are thus obtained. A probability distribution function is fitted to these elicited points.

Since test interviews showed that the interval technique does take a lot of interviewing time and is a fairly difficult, strenuous and perhaps also somewhat boring task for respondents, a probability distribution could not be obtained for the total set of marketing strategies. The elicitation task therefore had to be limited to a selection of the 7 most important strategies. This aspect will be elaborated upon in Chapter 5.

A second technique applied in getting information about the price perception of farmers concerns *directly questioning* the mean price (expected value) and price risk of a strategy. In this case price perception of a strategy is not conceived as a probability distribution but as consisting of the values of two attributes, namely *mean price* and *price risk.*

Price risk is measured by means of magnitude estimation, a scaling technique well known in psychophysics. The respondents have to draw a line to express the price risk of a strategy in comparison with a reference line which indicates the price risk of the reference strategy. In this manner an assessment of price risk is obtained for all marketing strategies. It should be noted that in this magnitude estimation task the meaning of risk is left open to the respondent, that is, risk is not specified as e.g. a probability distribution or variance.

By comparing the results of the elicited subjective probability distributions with those of the direct measurement procedure, information is provided about the (convergent) validity of the measurements. Comparing the price perception measurements between both marketing years provides information about possible changes in price perception.

As is the case with price perception, *risk attitude* too is measured by two techniques. An elaborate description and evaluation of available techniques is given in Chapter 6. Here, we limit ourselves to a short indication of the techniques which were eventually chosen in this study.

In the first technique *lotteries* are used to measure the von Neumann-Morgenstern utility function. Specifically, we applied the certainty equivalent technique. This task implies confronting respondents with 50/50 lotteries for which they have to state the certainty equivalent. With this method 10 points of the utility curve are assessed, including three points assessed to check the consistency of the measurements. By means of non-linear least squares suitable utility functions are fitted to the data.

A second procedure applied is *conjoint measurement.* With this technique respondents have to rank order 24 profiles consisting of 50/50 lotteries. These profiles are constructed by means of a full factorial design of 4 levels of mean price and 6 levels of price variance. By applying regression analysis the trade-off between mean price and price risk is obtained from this ranking of profiles. The trade-off can be seen as an estimate of the risk attitude of the respondent.

Contrary to the two measurement procedures described above, in the third and fourth procedure applied, risk is not introduced into the measurement. That is, the evaluation function is measured under certainty, thus resulting in a value or strength of preference function. Specifically the techniques applied are the so-called *midvalue splitting* technique and a *rating* scale. The midvalue splitting technique resembles the lottery technique with respect to the questioning procedure. However, now the respondent has to state his equal difference points instead of the certainty equivalents. In the rating technique the respondent is provided with 10 price levels which he has to rate with respect to attractiveness on a scale of 0 to 10. Both techniques lead to ten points of the value function to which suitable functions are fitted.

The application of four techniques, two with risky and two with riskless outcomes, enables a comparison of the estimates of the attitude obtained. First, the utility and value function can be related directly to test the hypothesis of the relative risk attitude and to study the precise relationship between the functions. Secondly, estimates for convergent and discriminant validity are obtained. One expects to find a higher correlation between either two risky techniques or two riskless techniques than between risky and riskless techniques. Furthermore, since the measurements are repeated in the second year with the same respondents, an indication of the stability of the measurements can be gained. These elaborate measurements enable the use of LISREL models. In Chapter 6 these matters will be extensively analysed and discussed.

As noted above, in 1985 farmers could be interviewed only once. It was therefore not possible to repeat all measurements for each respondent. An efficient survey design was required. Table 4.2 shows the choices made. It was decided to repeat the measurement of the subjective probability distribution of price (interval technique) and the measurement of risk attitude by means of lotteries for each respondent since these measurements are at the heart of the study. Also, the rating technique used for measuring the value function could be repeated for each respondent since it did not take much time and farmers responded easily to the questioning procedure.

The direct measurement of price perception, the conjoint measurement task and the midvalue splitting technique were repeated only for one-third of the respondents. Each respondent in 1985 was randomly assigned to one of these three techniques. As a consequence correlations in 1985 between respective techniques are calculated for different respondents (for example the correlation between estimates of the lottery technique and the conjoint measurement task is calculated for a different group of respondents than the correlation between the lottery estimates and the midvalue splitting technique) or are non-existent (for example the correlation between the conjoint measurement and the midvalue splitting technique). These aspects complicate the analysis in 1985 and in some respects constrain the comparison between both years.

4.1.3 Measurement of preference, choice behavior and background characteristics

Preferences for marketing strategies were measured by asking the respondents to rate the strategies on a 7-point rating scale, according to their preference of choosing the strategy for the coming marketing year. This rating task was followed by a task of ranking the strategies according to preference. Thus, a complete rank order is realised. Furthermore, the respondents had to indicate the strategies which they did not consider choosing, thus indicating the evoked set of strategies.

In the questionnaire *choice behavior* of farmers in the past years was registered. The behavior in five years was established from marketing year 80/81 up to 84/85. This registration enables linking preferences of farmers with their actual behavior and also provides information about changes in choice behavior. Apart from determining which selling-options a farmer had chosen, also the amount sold per option, the moment of selling and, if available, the prices received were listed. After registration, a number of open questions were asked enabling farmers to provide their motives for choosing a particular strategy. Especially, questions have been asked in search of motives for preferring one marketing channel to the other. Complete results concerning the farmer's actual choice behavior and their motives are described in Smidts (1985). In this text only the main results of these aspects will be presented.

In the interview also a number of characteristics of farm and farmer were collected. These personal and situational factors might influence one or more stages in the decision making process, as is assumed in the model. The most important characteristics of the farmer registered are: age, level of education, number of years of experience as a farmer and the availability of a successor in the family. Because the region in which this study took place consists of two polders reclaimed only recently, the Dutch region from which the farmer's family originated is also registered. The characteristics of the farm listed are: acreage, cropping plan, solvability, the region in which the farm is located and type and quality of storage facilities.

4.2 Description of the population

There are two main ware potato cultivating areas in the Netherlands, namely the IJsselmeerpolders and the South-West region. Data collection in this study is confined to the IJsselmeerpolders. The main reason for this confinement is that at the time of this study, in the South-West region many farmers did not have adequate storage facilities. They were therefore limited in their choice of marketing strategies since they had to deliver at harvest-time or very early in the marketing year (December). In contrast, the IJsselmeerpolders farmers' marketing behavior would be less prohibited by the restrictive factor of storage facilities because most farmers had good quality storage facilities. Perceptions and risk attitude in the IJsselmeerpolders region would therefore influence preferences and choice behavior to a larger extent. Therefore the IJsselmeerpolders was a much more suitable region for research.

The IJsselmeerpolders consists of two polders. The Noord-Oost polder was reclaimed in 1942, the other polder, Oostelijk Flevoland, in 1957 (further on in this text the polders will be referred to as respectively NOP and OF). Soil and weather conditions are very suitable for growing potatoes in these areas which is apparent from the large yields per ha. (see Table 2.1). The population of farm(er)s in the region can be described by data available from the Agricultural-census-May. Each year in May all farmers in the region are questioned about their acreage and cropping plan and some personal characteristics.

Table 4.3 shows some statistics on ware potato cultivating farms in 1982 (this was the most recent census information available at the time of data collection). In this table, farms are classified with respect to the proportion of arable land allocated to ware potatoes. Three categories of cultivation intensity are defined with the following ranges: smaller than 0.195, from 0.195 to 0.255 and larger than 0.255 (with 0.333 as the legal maximum). These intensities correspond respectively to a five, four or three yearly crop rotation plan. Subsequently, the category of farms with a cultivation intensity of less than 0.195 is divided into two classes: farms growing less than 5 ha. of ware potatoes and farms growing 5 ha. or more.

Table 4.3 *Descriptive statistics of census population of ware potato cultivating farms in the IJsselmeerpolders in 1982*

	NOP	OF	TOTAL		
COMBINATION OF INTENSITY AND ABSOLUTE POTATO ACREAGE	%	%	%	N	Ware potato acreage
< 0.195* and < 5 ha.	26.2	5.7	16.4	226	4.7
< 0.195 and ≥ 5 ha.	7.6	9.3	8.4	116	8.1
0.195 - 0.255	27.0	45.5	35.8	492	37.6
> 0.255	39.1	39.5	39.3	540	49.3
Total	100%	100%	100%	1374	100%
N	721	653	1374		

* Intensity is measured by the portion of arable land allocated to ware potatoes.

Source: Agricultural census May 1982 and own calculations

The distribution of farms in the population per category and per region is shown in Table 4.3. In 1982, a total of 1374 farms were growing ware potatoes. Of these farms 16.4% can be characterized as farms with low potato cultivation intensity and few hectares (< 0.195 and < 5 ha.). These 16.4% of the farms, mainly situated in the NOP, grow only 4.7% of the total potato acreage in the region. This means that ware potatoes for these farms are a fairly unimportant crop and the farmers' incomes do not depend on this crop. Ware potatoes are also not so important in proportion to other crops (intensity is less than 0.195) nor is the absolute amount of potatoes that the farmer has to sell substantial (less than a yield of 5 ha.). The marketing behavior of these farmers is therefore a less interesting object of study. For this reason, the research population is limited by excluding farms allocating less than 0.195 of arable land to ware potatoes and at the same time having less than 5 ha. of total potato acreage. In this manner, the population is reduced to 1148 farms growing 95% of total acreage of ware potatoes in 1982. The sampling frame consists of these farms.

As can be deduced from Table 4.3, the farms with low cultivation intensity but with more than 5 ha. of potato acreage (116 farms) are fairly large farms; 8.4% of the farmers grow 8.1 % of total potato acreage in spite of their low intensity. These farms are therefore a very interesting group to study.

In Table 4.4 some further statistics on the research population are presented. A total of 46.3% of the farms is located in the NOP region. It is clear that farm structure differs notably between the two polders. In the NOP a relatively large percentage of the farms allocate more than a quarter of arable land to potatoes in comparison with OF (53% compared to 42%).[2]

Nevertheless, average potato acreage in the NOP is lower than in OF, respectively 7.76 ha. and 11.23 ha. (for all the farms the average ware potato acreage is 9.62 ha.). The reason for this smaller potato acreage in the NOP is that the average farm size in the NOP is considerably smaller than in the OF. Whereas in the NOP 59.4% of the farms is smaller than 30 ha., this percentage is only 17.9% in the OF.

Another notable difference between the polders is that in the NOP the farmers are either fairly young (younger than 35) or old (over 54), whereas middle aged farmers (35-54 year) dominate the OF polder.

In brief, the farms in the NOP can be characterized as relatively small farms, cultivating ware potatoes with high intensity and managed by either a young or an old farmer. In the OF, fairly large farms relatively often allocate a quarter of arable land to potatoes and are managed by middle aged farmers.

[2] This effect is consistent even after age of farmer and arable land are controlled for.

Table 4.4 *Descriptive statistics of sampling frame of ware potato cultivating farms in the IJsselmeerpolders, in 1982*

	FARMS			WARE POTATO ACREAGE		
	NOP	OF	TOTAL	NOP	OF	TOTAL
Combination of intensity and absolute potato acreage						
< 0.195 and ≥ 5 ha.	10.3	9.9	10.1	9.6	8.4	8.8
0.195 - 0.255	36.7	48.2	42.9	32.2	43.7	39.5
> 0.255	53.0	41.9	47.0	58.2	49.9	51.7
Total	100%	100%	100%	100%	100%	100%
N	532	616	1148			
%	46.3	53.7	100%			

	WARE POTATO ACREAGE IN HA.		
	NOP	OF	TOTAL
Combination of intensity and absolute potato acreage			
< 0.195 and ≥ 5 ha.	7.20	9.53	8.43
0.195 - 0.255	6.81	10.18	8.84
> 0.255	8.52	12.84	10.58
Total	7.76	11.23	9.62
Arable land (in %)			
< 15 ha.	13.0	.2	6.1
15 < 20 ha.	9.4	.3	4.5
20 < 30 ha.	37.0	17.4	26.5
30 < 50 ha.	32.9	56.5	45.6
≥ 50 ha.	7.7	25.6	17.3
Total	100%	100%	100%
Age (in %)			
< 35	23.1	9.3	15.7
35 - 54	34.4	57.9	47.0
> 54	42.5	32.8	37.3
Total	100%	100%	100%

Source: Agricultural census May 1982 and own calculations

4.3 Sampling procedure and field work

The research population is defined as: family farms in NOP and OF cultivating ware potatoes of the variety Bintje in 1984 *excluding* farms that cultivate less than 5 ha. of ware potatoes if the potato cultivation intensity is lower than 0.195. The sampling frame is derived from the census information in 1982, as described above.

Since it was expected that the proportion of arable land allocated to ware potatoes might influence risk attitude and preferences for marketing strategies, this proportion has been considered a stratification variable. If a farmer allocates as much as a third of his total arable land to ware potatoes, his income depends very much on the yield and price for potatoes. Such a farmer will probably choose a less risky marketing strategy than a farmer who e.g. allocates only a fifth of his arable land to potatoes.

A second reason for stratification is the opportunity to oversample a stratum. This is applied here. Because of budgetary constraints, the sample had to be limited to a maximum of about 250 farmers. In case of proportional sampling only 25 farmers (10% of the sample, see Table 4.4) cultivating potatoes with low intensity (< 0.195) but more than 5 ha. (on average 8.4 ha., see Table 4.4) would be interviewed. In order to enable analyses for this subsample, it was decided to oversample this category of fairly large farms.

A disproportionate stratified sample of 400 farms was drawn (Table 4.5). In the first stratum 80 farmers were sampled (stratum A), the remaining 320 farmers were drawn in proportion to the sizes of the strata B and C.

Table 4.5 shows that the sampling frame and research population did not match completely. Of the sample of 400 farms, 37 farms did not belong to the population (see Table 4.5 for the reasons of this overcoverage). Of the remaining addresses, eventually 40 were not contacted since these farmers had either already been interviewed in the test survey (this concerned 10 farmers) or the maximum number of interviews had been reached.

A total of 323 farmers were contacted by means of an introductory letter followed by a telephone call by the interviewer asking for participation. This initial contact revealed that 34 farmers did not belong to the research population since they did not grow the variety Bintje but some other ware potato variety. Thus 289 eligible addresses remained.

A total of 36 farmers refused cooperation. Almost all refusals concerned the argument of time constraints on the part of the interviewee. Overall, response was very good, namely 87.5% (253/289), especially when taking into account that farmers knew they would be interviewed twice for about one and a half hour per interview. In stratum A the response was higher (97.5%) than in the other two strata. Furthermore, the response rate in NOP was higher than in OF, respectively 92% and 84.1%. This difference is significant ($p < 0.05$, two-tailed). In the second interview held in 1984 238 out of 253 farmers were willing to be interviewed again.

Table 4.5 Description of sampling procedure and response

COMBINATION OF INTENSITY AND ABSOLUTE POTATO ACREAGE (strata A,B,C)	A < 0.195 ≥ 5 ha.	B 0.195- 0.255	C > 0.255	Total
Census population 1982	116	492	540	1148
Sample	80	153	167	400
Overcoverage*	11	13	13	37
Not contacted	23	7	10	40
Addresses contacted in 1984	46	133	144	323
No Bintje variety grown	6	9	19	34
Eligible addresses	40	124	125	289
Nonresponse 1984	1	20	15	36
Response 1984	39	104	110	253
Response percentage 1984	97.5	83.9	88.0	87.5
Response 1985	31	84	90	205
Response percentage 1985	79.5	80.5	81.8	81.0
Estimated research population	85	417	430	932
Distribution of population	9.1	44.7	46.1	100%
Distribution of sample 1984	15.4	41.1	43.5	100%
Distribution of sample 1985	15.1	41.0	43.9	100%

* Overcoverage consisted of farms outside the defined geographic area (n = 8), farms not being a family farm (n = 25) or terminated farms (n = 4).

In order to test whether the nonresponse group differed significantly from the response group, respondents who refused cooperation were asked to answer a limited number of questions by telephone. The majority of these farmers, in effect 25, agreed to participate. Data were collected on the farmer's age, level of education, arable land, cropping plan, usual choice of marketing channel and marketing strategy applied in 1983. A significant difference between response and nonresponse group could not be detected for any of these variables.

In 1985 all the farmers interviewed in 1984 were asked to participate again. Now 81% (205/253) was willing to be interviewed once more. Data of two years are therefore available for 205 farmers. Of course, for certain questions a smaller number of responses may be available because of missing data.

On the basis of the initial sample of N = 400 and the percentages of non-eligible addresses, an estimate of the research population can now be given (see Table 4.5). The total number of farmers in the research population is estimated to be 932 $^{+}/_{-}$ 35 (95% confidence interval). A comparison between the distribution of the strata in the research population to sample distributions shows that stratum

A is oversampled as planned. When relevant, results will be weighted in accordance with the sampling fractions.

Table 4.6 shows mean statistics of the 1984 sample for the total region and both polders separately. The average arable land in 1984 was 38.5 ha. with 34.1 ha. in NOP and 42.3 ha. in OF. The table shows clearly that the farms with low potato cultivation intensity are, in general, fairly large (average farm size in stratum A is 45.3 ha.). Of the total sample, on average 9.5 ha. is allocated to Bintje (7.6 ha. in NOP and 11.1 in OF) and 0.8 ha. is allocated to ware potatoes of a different variety than Bintje (1.4 in NOP and 0.3 in OF). The average age of the farmers is 46 years and the regions do not differ significantly in this respect. However, as described above (Table 4.4), although the average age in both polders is the same, middle-aged farmers dominate in the OF whereas the NOP consists of fairly young as well as old farmers and a relatively small number are middle aged farmers.

Table 4.6 *Description of the sample of ware potato cultivating farms in 1984; total, per stratum and per region (NOP and OF) (mean values)*

COMBINATION OF INTENSITY AND ABSOLUTE POTATO ACREAGE	A < 0.195 ≥ 5 ha.	B 0.195-0.255	C > 0.255	Total*
Arable land in ha.				
Total	45.3	38.7	36.9	38.5
NOP	44.0	33.6	32.6	34.1
OF	46.4	42.0	41.8	42.3
Bintje grown in ha.				
Total	8.8	9.2	10.0	9.5
NOP	8.4	7.0	8.0	7.6
OF	9.1	10.6	11.9	11.1
Other ware potato varieties in ha.				
Total	.9	.7	.8	.8
NOP	1.4	1.5	1.2	1.4
OF	.3	.2	.4	.3
Age of farmer				
Total	42.9	46.6	45.7	45.8
NOP	43.0	46.2	43.5	44.7
OF	42.9	46.8	47.9	46.9

* Weighted in accordance with sampling fractions

Field work

The questionnaire was drawn up after depth interviews with 16 farmers and a number of experts of wholesale companies. The most critical questions in the questionnaire, especially those concerned with the elicitation of risk perception and the assessment of risk attitude and strength of preference, were pretested with several farmers. Complete questionnaires were extensively pretested and analysed with as many as 30 farmers. Revisions were implemented when deemed necessary.

Students attending masters level courses in agricultural economics and marketing were selected as interviewers. Most of the interviewers had interviewing experience. The interviewers were instructed extensively with respect to the purpose of the survey and goals of each separate question. They also received training by conducting trial interviews to become familiar with the questionnaire.

Respondents were contacted by an introductory letter explaining the objectives of research and procedure of interviewing. One or two days after having received the letter, the respondents were contacted by telephone and asked to participate in the interview. A positive reply was followed by an appointment made by the interviewer. If respondents did not want to participate, the interviewer recorded the reason why as well as some further information about the farmer, as described above.

Since many questions had to be asked and a number of questions cost a great deal of time, it was decided in 1984 to break up the interview into two parts. Respondents were interviewed twice, with about a week in between. The first interview was scheduled during the first two weeks of June. In 1985 only one interview was held, also during the first two weeks of June. The time needed to complete the personal interviews was 60 to 90 minutes per interview.

During field work each completed questionnaire was scrutinized by the researcher as soon as possible after the interview in the presence of the interviewer. This procedure created opportunities to clear up possible ambiguous answers or to correct obvious errors. Since in 1984 each farmer was interviewed twice, obscurities could be cleared up during the second interview with the farmer. This latter error correction was necessary only in two cases. As a result of the instruction and training of the interviewers and field work control the impression of high quality interviewing prevails.

Summary

In this chapter, the structure of the empirical study was delineated. After describing the operationalizations of variables in the decision making model, attention was paid to a description of the population, sampling plan and field work. Data were collected in a survey with 253 farmers, who were interviewed in two consecutive years.

Because of the survey context and also for budgetary reasons, data collection had to be restricted in two important respects. Firstly, subjective probability distributions could not be elicited for each marketing strategy but had to be limited to seven strategies. Secondly, three measurement procedures could not be repeated for each respondent but had to be limited to a third of the sample. However, an attempt was made to adjust the design of the study in such a way that possible negative consequences could be kept to a minimum.

In the following chapters extensive discussions of the results of the study will be presented. Chapter 5 starts with a presentation of perception results.

CHAPTER FIVE

PRICE PERCEPTION OF MARKETING STRATEGIES

5.1 Introduction

This chapter deals with the perception of marketing strategies in respect of price. By combining past experiences with market information available at the moment of decision, farmers will have to form an impression of the prices associated with each marketing strategy. Since experience and information will probably differ between farmers, price perception may differ between farmers (this is referred to as heterogeneity in perception).

In this chapter, special attention will be paid to the measurement procedures of perception. In this regard two rather different approaches to measuring price perception will be compared. These two methods of measurement are denoted as the indirect and direct measurement procedure.

In the *indirect measurement* approach the perception of a marketing strategy is modeled explicitly as a *subjective probability distribution.* A number of points of the cumulative probability distribution are elicited and a probability distribution function is fitted to these points. From this distribution function, mean, median, standard deviation and skewness are derived. The method is called indirect since mean, standard deviation, etc. are derived from the distribution and are not directly questioned.

In contrast, the *direct measurement* approach does model perception in a fairly straightforward way. By means of this method the farmer has to state mean price and price risk he associates with a certain marketing strategy. Price risk is measured on a general scale by means of magnitude estimation, a technique originating from psychophysics. The direct measurement procedure therefore does not lead to a subjective probability distribution. This, of course, greatly limits the use of perceptions elicited by this method, since it refrains from incorporating the perception measurements in a model like subjective expected utility.

It is interesting to compare both approaches from the viewpoint of whether the procedures rank the marketing strategies in the same order with respect to mean price and price risk. In that case convergent validity would be established. In addition, comparisons with respect to the ease of handling each procedure in survey conditions will be made. Apart from presenting and discussing the perception of farmers regarding to the marketing strategies, special attention will therefore be paid to the evaluation of strengths and weaknesses of both measurement approaches.

Most attention in this chapter will be paid to the measurement of subjective probability distributions (the indirect method). A subjective probability distribution is an essential element in theories of decision making under risk. Therefore the measurement of this distribution is prerequisite in the testing of expected utility model. Furthermore, trying to elicit several distributions per respondent for a large sample of respondents, is to our knowledge fairly unique.

The main goals of this chapter are thus threefold. The first goal is to present and discuss the farmer's price perception concerning several marketing strategies. These perceptions are needed in the preference formation models (Chapter 7). Furthermore, information about the farmer's perception of marketing strategies with respect to ware potatoes is valuable in itself, since this has never been studied before. The second goal concerns a review of methods of probability encoding and an evaluation of the method used in this study with respect to validity and practical feasibility in survey conditions. Is it possible to elicit subjective probability distributions on such a large scale and if so, are the measurements internally valid? A third goal concerns the comparison of the direct and indirect measurement techniques in order to study the convergent validity of the methods. That is, to compare the results obtained by the elicitation of subjective probability distributions with those obtained by much more simple methods.

In Section 5.2 the indirect method of measuring subjective probability distributions will be dealt with. In Section 5.2.1 the problems associated with measuring subjective probability distributions in general are reviewed. This is followed by a classification and evaluation of elicitation techniques in Section 5.2.2. A description of the elicitation technique actually applied in this study will be presented in Section 5.2.3. Since the technique applied yields only a limited number of points of the probability distribution, a distribution function has to be fitted to these elicited points. The choice of a suitable distribution function and the fitting procedure are described in Section 5.2.4. Next, results will be discussed in Section 5.3, with special attention paid to the validity of results obtained by the indirect measurement procedure.

Subsequently, the direct measurement technique and its results are presented in Sections 5.4 and 5.5. Especially the method of magnitude estimation for measuring price risk will be reviewed.

Both approaches to measuring price perception will be compared and evaluated in Section 5.6 and main findings and conclusions will be presented in Section 5.7.

5.2 Indirect measurement of price perception: description and evaluation of the method

5.2.1 Some general issues in the elicitation of subjective probability distributions

Probability encoding is defined as the process of extracting and quantifying individual judgments about uncertain quantities (Spetzler and Staël von Holstein 1975). These judgments are probably more or less vague, fuzzy and variable. Usually they are not explicit and quantitative so subjects have to think hard before being able to express these judgments quantitatively. *Elicitation techniques* are used with the purpose of helping subjects to express these judgments.

A large body of literature, mostly originating from psychology, exists that relates to probability encoding. It is beyond the scope and aim of this study to discuss this literature extensively. Here we will shortly point out some major findings and conclusions that can be drawn from these studies. These conclusions are based on reviews of the literature of e.g. Hogarth (1975, 1980), Spetzler and Staël von Holstein (1975), Hogarth and Makridakis (1981), Kahneman and Tversky (1982) and Wallsten and Budescu (1983).

First, the cognitive processes which operate when subjects evaluate uncertainty will be briefly discussed. Next, attention will be focused on the reliability and validity of the elicitation techniques.

Biases and distortions in encoding probabilities

In his extensive review of studies Hogarth (1975) concentrates on the cognitive processes that take place when assessing probabilities. He argues that man is a selective, sequential information processor with limited capacity and therefore ill-suited for assessing probability distributions. The elicitation procedure places specific demands on man's judgmental processes, especially on information acquisition and processing. It is therefore necessary to understand the capabilities and limitations of these processes. Hogarth concludes that the limited capabilities of man result in *systematic biases* in probability estimates. He differentiates between more than 20 sources of bias and judgmental error (Hogarth 1980).

In order to clarify the discussion about problems associated with probability encoding, it is important to state here what is meant by *biases*, since we want to distinguish biases from *distortions*. According to Spetzler and Staël von Holstein (1975), biases are conscious or subconscious discrepancies between a subject's responses and an accurate description of his underlying knowledge. This accurate description of his underlying knowledge can be thought off as a "true" probability distribution. The response of a subject to a question about the probability of a particular outcome of the distribution can be modeled as a true score plus an error. This true score thus is the individual's degree of belief that e.g. the ware potato price will be between 15 and 18 cts/kg. When trying to measure this true score by means of elicitation techniques, random errors and possibly systematic errors are introduced. Different elicitation techniques might introduce different systematic effects on response and these systematic effects are denoted here as *bias*.

A second aspect of probability encoding, however, concerns the relationship between an "objective probability" and the perceived probability (the true score of the subject). A systematic difference between perception and "objective reality" is what we denote as *distortions*. Distortions are what von Winterfeldt and Edwards (1986) mean by *cognitive illusions*; cognitive, because of the intellectual tasks to which they refer and illusions, because the phenomena are quite similar to the well known perceptual illusions (e.g. estimating distances according to the haziness of an object irrespective of the clarity of air). Distortions are detected when: a) there is some formal rule or empirical relative frequency that specifies the correct answer, b) an individual provides a judgment, and c) there is a systematic discrepancy between the correct answer and the person's judgment.

A well known example of such a distortion is the phenomenon of *conservatism*: in the light of relevant new information subjects do not revise their prior opinions into posterior opinions as much as is required by the optimal Bayes-rule. Posterior judgments are insufficiently adjusted from prior judgments (Kahneman and Tversky 1982). Other types of distortions are: the gambler's fallacy, overconfidence, insensitivity to base rate information, ignoring regression towards the mean effects, ignoring sample size when constructing sampling distributions, etc. See e.g. Kahneman and Tversky (1982), Hogarth (1980) and von Winterfeldt and Edwards (1986) for a description of each of these distortions.

Of course, in practice it is often difficult or impossible to separate biases from distortions. Assessment of the existence of distortions is only possible when objective probabilities exist and effects appear to be persistent over a wide variety of elicitation techniques, response modes and uncertain quantities. According to Phillips (1983), by far not all distortions reported pass this persistence test.

The distinction between biases and distortions makes it clear that most of the above mentioned criticism of Hogarth (1975) concerning man's ability to assess probabilities relates to the question whether the internal representation, that is the perception, of uncertainty is in accordance with the objective criterion (a formal rule or an empirical relative frequency). He pays much less attention to the possibly systematic effects (biases) introduced by elicitation techniques.[1]

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[1] Hogarth, like Kahneman and Tversky (1982), is rather pessimistic about the possibility of minimising distortions, since he views distortions to be caused by limitations in the individual's information processing capacities. On the other hand, von Winterfeldt and Edwards (1986) are more optimistic about minimising distortions. They state that rules of probability calculus are difficult and not intuitively clear. Especially the Bayes-rule is fairly complicated. It is therefore hardly surprising that people have difficulty combining probabilistic information in the correct way, especially since subjects in experiments often have to make intuitive judgments as they are deprived of physical tools like books about statistics, calculators, or even paper and pencil. Moreover, in most experiments (Wallsten and Budescu 1983) subjects have neither prior experience in probability assessment nor are they reasonably familiar with the uncertain quantities assessed. Training, experience and expertise is vital in making accurate and valid judgments, as is shown by experts like weather forecasters who are extremely well calibrated and much more informative than climatological model forecasts (Wallsten and Budescu 1983). Furthermore, both in experiments and for actual decisions, subjects will not always perceive the effort of arriving at better answers than reasonable approximation, as worthwhile or necessary.

Von Winterfeldt and Edwards therefore conclude that the issue of the quality of human intuitive performance may be more or less irrelevant to the broader question of human intellectual competence: if the problem is deemed important and tools are available people will use them and they will subsequently get the right answers. Cognitive illusions like perceptual illusions are pervasive and people get easily trapped. Thus, tools will be invented and used to prevent people from making (large) mistakes, especially when decisions are important. For other decisions people will make approximate judgments which may be systematically distorted.

The most important and best documented cognitive processes that may lead to severe distortions and biases are the heuristics as defined by Kahneman and Tversky (1982), namely: *availability*, *anchoring and adjustment* and *representativeness*.

- *Availability* means that judgments are affected by the ease with which relevant information is recalled or visualized. For example, recent information is more available to the subject since it is easily recalled and it is therefore given too much weight in the total judgment.
  An example of how the availability heuristic may result in distorted price perceptions of farmers is when the price which farmers received last year (in effect, their most recent information) influences price perception of a marketing strategy more than prices received in former years. Even if prices are hardly related between respective years.
- *Anchoring and (insufficient) adjustment* deals with the effect that readily available pieces of information provide the basis or anchor for formulating responses. Subsequent responses are adjustments to this anchor but which are typically insufficient: inducing different anchor points, e.g. by means of the wording of the question or framing of the problem, will result in different assessments, all biased toward the anchors.
  An example of a bias which may be introduced by the anchoring and adjustment heuristic concerns an elicitation technique in which the median of a subjective probability distribution is elicited first. Next if the quartiles of the distribution are elicited, the respondent will probably use the specified median as an anchor. With insufficient adjustment the resulting subjective probability distribution is tighter than is justified by the respondent's actual state of information (a central bias).
- The heuristic of *representativeness* concerns judgments in which the probability of an event is evaluated to the degree to which it is considered representative of, or similar to, some major characteristics of the process or population from which it originated. Probability judgments are more or less similarity judgments and judgments then become insensitive to information about e.g. prior probabilities or sample size.

These heuristics can be seen as simplifying rules applied to arrive at solutions to complex tasks like probability assessments. Knowledge of these heuristics not only allows us to explain *why* people show distortions and biases in evaluating probabilities, but also provides information about the *type of bias* that may be present in a particular assessment of probabilities and suggests how to conduct the interview when eliciting subjective probability distributions in order to reduce bias. For example, to forego the influence of the anchoring and adjustment heuristic, an elicitation technique in which the extremes of the probability distribution are elicited first, will probably result in a less tight distribution.

This study focuses on minimizing bias introduced by the measurement process. No attention is directed toward detecting distortions. As stated in Chapter 2, in this study we do not focus upon *how* the farmer constructs his subjective probability distribution. Even if farmers' perceptions are distorted, their actual decisions are based upon exactly these perceptions. In order to be able to explain and predict preferences and behavior of farmers, measuring these, possibly distorted, perceptions with minimal bias is essential. We therefore now turn to a brief overview of the reliability and validity of elicitation techniques.

Reliability and validity issues in eliciting probabilities

Wallsten and Budescu (1983) review a great number of studies from a psychometric stand-point in order to evaluate reliability and validity of the elicitation of probabilities. In their presentation and discussion, results for non-experts are differentiated from those for experts like weather forecasters, military intelligence officers and statisticians. Most of the studies Wallsten and Budescu review deal with binary distributions instead of continuous distributions, thereby restricting their conclusions. Nevertheless some general conclusions can be drawn.

With respect to reliability, they first conclude that reliability is reported in relatively few studies. Secondly, reliability estimates reported mostly concern test-retest reliability which is often quite high. Alas, they furthermore conclude that, up until now, it has not been possible to state which elicitation technique is most reliable in which circumstances. This is also concluded by Ludke et al. (1977) who showed that the performance of a technique depends upon the skewness of the distribution to be elicited.

With respect to the validity of the techniques, Wallsten and Budescu state that convergent validity is high. This means that the positive correlation between estimates with the use of two or more different elicitation techniques is high, that is, higher than is usually found in psychological measurement. Experts in probability assignment like weather forecasters showed more consistent results in this respect than non-experts. Although in general, correlations between estimates by different elicitation techniques are high, probabilities often differ in absolute magnitude between the techniques. When intending to use the judgments for forecasting purposes, this difference between techniques of course poses a severe problem, since one has to choose which technique provides the most accurate estimate or one has to combine the estimates from different techniques one way or another. Overall, Wallsten and Budescu conclude that various elicitation techniques are relatively valid.

The results of general stability and convergent validity of the techniques reported strengthen our confidence that a consistent quantification of judgment is possible. It should be noted, however, that these conclusions, especially with respect to non-experts, are based mainly on experimental studies in laboratory circumstances or in decision analysis situations and that they mostly concern binary distributions. Few studies exist in which these techniques are applied and evaluated with respect to reliability and validity in large scale survey research. The limited time available for training and motivating respondents and for eliciting, often continuous, probabilities will probably influence the stability and validity of the technique. Therefore, if possible, more than one technique should be applied when assessing probability distributions. A description of elicitation techniques and a discussion of their suitability for use in survey research will now be given.

5.2.2 Review of techniques for eliciting subjective probability distributions

A number of elicitation techniques is available. Descriptions of these techniques can be found in e.g. Winkler (1967), Raiffa (1968), Schlaifer (1969), Spetzler and Staël von Holstein (1975) and Anderson et al. (1977). A short description of the most important techniques will be given here, following on the classification of Spetzler and Staël von Holstein (1975).

These authors use two dimensions to differentiate between the techniques: the quantity a respondent has to specify and the response mode. The elicitation techniques differ according to whether the respondent must specify either: probabilities (**P-methods**), values of the uncertain quantity (**V-methods**) or both (**PV-methods**). The second dimension concerns whether the respondent must specify numbers as answers (this is called the **number response mode**) or has to choose between alternatives or bets (the **choice response mode**). In the latter case, probabilities or values in the alternatives/bets are adjusted so that the respondent becomes indifferent between the alternatives/bets. Thus, points are obtained from the probability distribution. The combination of both dimensions of response mode and quantity to be specified results in five types of techniques. These are shown in Table 5.1.

Table 5.1 Classification of elicitation techniques

RESPONDENT SPECIFIES	RESPONSE MODE: Choice	Number
Probability	Probability wheel	Cumulative probability technique
Value	Interval technique	Fractile technique
Probability and value	-	Drawing a graph Visual counter technique

In the number response mode the *cumulative probability technique* implies that the respondent is asked to assign the cumulative probability at a given value (e.g. how big is the chance that the price with this marketing strategy will be lower than 15 cts/kg?). If such questions are asked for a number of values, a cumulative distribution function can then be fitted to these points.

In the *fractile technique* the respondent has to assign values corresponding to probabilities (e.g. at what price is there a chance of 10% of receiving a lower price?). This fractile technique seems rather difficult to respondents not accustomed to thinking in probabilities.

In the *visual counter technique* respondents are given a number of, e.g., coins and they are asked to divide these coins among a number of specified price intervals in accordance with the chance of occurrence, that is, they have to assign a density function. It is also possible to ask respondents to sketch the density distribution or the cumulative probability distribution (*drawing a graph*).

In the choice response mode two types of techniques exist. The *probability wheel technique* makes use of a disc with two sectors of different colors (e.g. red and yellow) which are adjustable in size. By adjusting the relative size of the sector, the probability of a sector/color is changed. A pointer, fastened to the centre of the disc, is spun and will stop in one of the two sectors. Given a certain relative size of the sectors, the farmer is asked what he perceives as more probable:

a) the price with this marketing strategy will be equal to or below 20 cts/kg, or
b) the event that the pointer will stop in the yellow sector.

The farmer makes his choice, the relative size is changed and then the farmer is asked the same question. After a number of iterations the farmer will be indifferent between alternatives a) and b) which implies that he perceives the chance of receiving a price equal to or below 20 cts/kg as being equal to the relative size of the yellow sector. The elicitation continues by selecting another price and then the same iteration process starts again. Of course, it is also possible to fix the size of the yellow sector and iterate with the price towards indifference between a) and b).

Often, with the probability wheel technique the respondent is asked to choose between gambles instead of alternatives. E.g. choose between:

a) receive Dfl 100,= if the price with this marketing strategy exceeds 35 cts/kg and receive nothing otherwise;
b) receive Dfl 100,= if the pointer stops in the yellow sector and receive nothing if it stops in the red sector.

Again, by adjusting the relative size of the sectors, farmers will become indifferent between these gambles, implying that the chance of receiving a potato price exceeding 35 cts/kg equals the chance of the pointer stopping in the yellow sector.

An advantage of the probability wheel technique over other techniques is that chances are visualized and that only preference statements are required. Making preference statements is likely to be easier than directly expressing the magnitude of probabilities or values as is required by the number response mode techniques. The probability wheel method is less suitable for very small chances since one sector becomes very small. This method should therefore only be used for potato prices for which chances are relatively large.

A second choice response mode technique which is also frequently applied is the *interval technique* or *bisection technique*. In this technique an interval of prices, which is for example shown to the respondent on a ruler, is split into two parts. The farmer is then asked to state what he considers more likely:

a) the price will fall below the dividing point, or
b) the price will fall above the dividing point.

After having chosen, the dividing point is adjusted until, after a number of iterations, the farmer considers both parts equally likely. This means that the median of the probability distribution has been elicited. Proceeding this technique both below and above the median results in the quartiles of the distribution, then octiles, etc.

Application of elicitation techniques with farmers as respondents

In studies with farmers as respondents the visual counter technique is used rather frequently for eliciting probability distributions. Francisco and Anderson (1972) applied this technique to obtain subjective probability distributions for woolprices and rainfall. Bessler (1979) elicited yield estimates for a number of crops using this technique and Lee et al. (1985) elicited income distributions for alternative conservation practices. According to Grisley and Kellogg (1983, 1985) even low educated farmers are capable of using this technique. They elicited price and yield distributions with farmers in Northern Thailand. Their method, however, was severely criticized by Knight et al. (1985).

Direct questioning procedures were applied by Carlson (1970) and Pingali and Carlson (1985). The latter asked farmers to specify minimum, maximum and modal values of pest damage. A triangular distribution was fitted to these points.

Huijsman (1986) also applied the latter technique to farmers in the Philippines. He elicited, with two-week intervals, triangular yield distributions for the major crops. Comparing this technique to the visual counter technique, he concluded that farmers felt more comfortable about the direct questioning of minimum, maximum and modal values. He evaluated the visual counter technique as being too abstract for his low educated farmers. A problem with the direct technique, however, was that farmers had difficulty specifying the modal value. They showed a tendency to assess the *best possible* outcome and then to adjust downwards insufficiently, which resulted in much too optimistic estimates. Also, approaching harvest-time, the distributions narrowed somewhat but stayed fairly wide until the very moment of harvest, although actually uncertainty already had been resolved to a large extent amply before harvest-time.

Choice of the elicitation technique to be applied in this study

Although the visual counter technique is rather popular in studies which concern agricultural producers, this technique will not be used in this study. Many coins and intervals would be necessary in order to express rather subtle differences between the marketing strategies, thereby complicating the procedure. Also Spetzler and Staël von Holstein (1975) doubt whether people are capable of expressing their judgments in terms of a density function without introducing large biases. More specifically, they suggest that symmetric distributions will result relatively often.

Reviewing strengths and weaknesses of various techniques, Spetzler and Staël von Holstein (1975) recommend the use of the probability wheel technique for respondents unfamiliar with probabilities. After a number of elicitations, the wheel device can be replaced by a number response mode technique. The interval technique should be used as a consistency check. Ideally, according to the authors, the following process should be adhered to:

- First, elicit the extremes of the subjective probability distribution. In order to avoid the availability heuristic, the subject should be asked to think of scenarios which could lead to more extreme outcomes. By having to think explicitly about extreme scenarios, thereby making them more available, subjects may be induced to assign larger probabilities to extreme values. Central bias is minimized in this manner.
- Next, a number of points of the cumulative probability distribution are elicited, using the probability wheel.
- By means of the interval technique, median and quartiles of the distribution are elicited and combined with the points elicited by the probability wheel technique. By using a fitting criterion and procedure, a distribution function is fitted to the elicited point.
- Verification of the subjective probability distribution is obtained by drawing bets from the elicited probability distribution. The respondents should agree with the implications of the bets. Otherwise, the whole process will start anew until agreement is reached.

It will be clear that the whole process of informing the respondent and training him in measurement techniques, quantifying a number of points and then verifying these judgments, takes a lot of time. In a decision analysis context this may be reasonable. In surveys, however, this is too time-consuming, especially when several subjective probability distributions have to be elicited for each respondent. It was therefore decided to apply only one elicitation technique and not to verify the elicited subjective probability distribution with bets.[2]

In order to be able to choose between the probability wheel and the interval technique, these techniques were compared in test interviews with about 30 farmers. Very soon, it became clear that farmers did not feel very comfortable about the probability wheel technique. Most of them considered the technique cumbersome and lengthy. The process of iteration was evaluated as very boring, especially when the response mode with gambles was applied. Very soon, they started to provide direct answers without using the wheel or iteration. However, our evaluation of those direct answers is that they were given too quickly without careful thought. Contrariwise, the interval technique took less time and farmers considered it less lengthy and boring. Consequently the farmers remained motivated to think hard about their answers. We therefore decided to use only the interval technique in this study. The exact data collection procedure implemented is described in Section 5.2.2.

Conclusion

This section as well as the former contained a review of the techniques that exist for eliciting subjective probability distributions and the problems that are associated with encoding probabilities. Many studies, mainly originating from experimental psychology, report distortions and biases in human judgment when assessing probabilities and combining probabilistic information. Well documented cognitive processes like the heuristics of availability, anchoring and adjustment and representativeness are described which may cause these response biases. On the other hand, empirical research also reports relatively high stabilities and convergent validity correlations between various elicitation techniques, although this research mostly concerns binary distributions which are elicited in controlled laboratory circumstances or in decision analysis. More research is needed concerning the validity and reliability of techniques applied in survey conditions.

Evaluating the evidence, it is clear that eliciting probabilities is a difficult task with many pitfalls which should therefore be conducted very carefully. Biases may easily be introduced into the measurement process. Elicitation techniques should be applied with care to minimize this bias. In order to achieve this situation, it is very important that the decision context be structured and clearly

[2] Note that for the assessment of convergent validity two approaches of measuring price perception are already applied: a) the elicitation of subjective probability distributions and b) the direct questioning procedure for mean price and magnitude estimation of price risk.

defined. Respondents should be convinced that structuring conforms to their experience and perception of the decision situation.

The interviewer is also an important factor since it is his responsibility to make sure that respondents perceive the task in the correct way and that they are motivated in thinking thoroughly and carefully about their subjective probabilities. He must be weary of biases which may be introduced by heuristics in the elicitation process. For survey research, this means that extensive training and instruction of the interviewer is very important. On the other hand, systematic biases caused by the interviewer may be introduced, because the interviewer plays such a vital and active role in the encoding process.

With respect to the possibility of biases it is important to state in what way we will make use of the elicitations. We do not want to elicit the subjective probability distributions for normative purposes, that is, we do not want to *prescribe* the farmer which marketing strategy he should choose given the probability distributions assessed, nor do we want to evaluate the farmer's expertise in forecasting. Furthermore, we are only slightly interested in making comparisons between farmers, e.g. in seeking systematic differences between them. The main aim of eliciting subjective probability distributions in this study is to explain and predict the farmer's preferences for marketing strategies.

Essentially, our main interest is directed towards making comparisons between marketing strategies for each individual concerned (a within subject analysis). That is, we intend to explain why a farmer prefers, say Strategy A to Strategy B and B to C. Therefore, even biases introduced by the elicitation technique, for example a central bias, do not pose a big problem as long as it can be assumed that the bias is equal for all strategies elicited for that specific farmer.

5.2.3 Implementation of the interval technique

The interval technique is used for encoding the subjective probability distribution. At least three points of the cumulative probability distribution should be elicited by means of this technique. It was decided to try to elicit five points, namely the three quartiles and two extremes. The extremes of the probability distribution are elicited first. By first eliciting the minimum and maximum price before eliciting the median and first and third quartile, we have tried to minimize possible central bias caused by the anchoring and incomplete adjustment heuristic.

The following data collection procedure was implemented. From the set of marketing strategies, described in Chapter 4, a marketing strategy is randomly selected and the farmer is asked to imagine selling his total ware potato harvest in accordance with that strategy. Then the farmer is asked to state the price in cts/kg which he at least expects to receive in accordance with this marketing strategy. After this initial statement, the farmer is asked if he is "almost completely sure" that market circumstances will not turn out to be so bad that the price to receive will be worse than his initially stated price. In this way, the farmer is given the opportunity of careful consideration and is stimulated to think about scenarios which might lead to low potato prices. It is thus tried to reduce effects of availability. Analogous questions result in the maximum price farmers expect to receive in accordance with the selected marketing strategy. These expected minimum and maximum prices are taken to represent the 01 and 99 percentiles of the cumulative distribution function, although these chances were not specified in the question. We only asked whether the farmer was "almost completely sure".

Next, both extreme prices elicited were marked on a ruler of about 30 cm long with prices ranging from 5 cts/kg to 100 cts/kg, with intervals of 0.5 cts/kg. Then, a third price some where in between the minimum and maximum was marked on the ruler. The farmer was then asked what he considers more likely: either receiving a price in the price range between the minimum and middle marker, or receiving a price between the middle and maximum marker. By positioning the middle marker close to the minimum or maximum marker, it is easy for the farmer to choose. After his initial choice, the middle marker is moved over the price interval and the same question is asked again. By further iterating the procedure, the middle marker is moved until the farmer states that it is equally likely to receive a price in both intervals, so that the median of the distribution is elicited.

The same procedure is used for eliciting the first quartile between minimum and median and the third quartile between median and maximum. With five points now having been elicited, the farmer is asked if he considers receiving a price this year in each of the four intervals marked down on the ruler, equally likely. If not, price intervals are changed until the farmer is satisfied with the elicited points. By asking the farmer to compare the four intervals, careful thought about his opinion is stimulated and previous answers are verified.

The procedure is continued by randomly selecting another marketing strategy and the whole process starts over again. A farmer's "own marketing strategy" was used to train him for the elicitation procedure.

Farmers responded fairly easily to the whole procedure in test interviews, since they only have to deal with the question of equal or unequal chances, without making statements of the magnitude of probabilities. However, the elicitation procedure per marketing strategy was rather lengthy and after a number of subjective probability distributions the farmers became weary and somewhat bored by the procedure. From the viewpoint of keeping respondents motivated and of constraining the total time spent on these perception questions, it became apparent in test interviews that about 7 marketing strategies, taking about half an hour time in total, were deemed the maximum number of strategies to be elicited. Therefore, for this task a selection of the marketing strategies as presented in Table 5.2 had to be made.

The strategies selected for elicitation should be: representative of the whole set of strategies, easy to understand and rather different from each another. Consequently, the 100% strategies are thus contained in the sample and of the strategies with *combinations* of selling-options, only 50% strategies are considered.

We selected 6 out of 13 marketing strategies in 1984 and 11 out of 18 in 1985. Table 5.2 shows the marketing strategies selected. Evaluating the results of 1984, it turned out that it would be interesting to extend the number of strategies, thus enabling more comparisons between strategies. Therefore, in 1985 each farmer responded to Strategies 1, 2, 4, 5, 6 and 9 plus one strategy which was randomly selected from the set 7, 8, 10, 11 and 16. Because of the constraints set by respondent motivation and time, the probability distributions of these extra strategies could only be elicited for one fifth of the respondents.

Table 5.2 Indication of marketing strategies for which the subjective probability distribution (spd) is elicited in 1984 and 1985

Marketing strategy		1984	1985
1	100% Pc	x	x
2	100% Bp	x	x
3	100% Fp1	-	-
4	100% Sm1	x	x
5	100% Pp	-	x
6	100% Sm2	x	x
7	50% Pc/50% Sm1	x	xx
8	50% Bp/50% Sm1	-	xx
9	50% Fp1/50% Sm1	x	x
10	50% Pp/50% Sm1	-	xx
11	50% Pc/50% Sm2	-	xx
12	50% Fp1/50% Sm2	-	-
13	50% Fp1/40% Bp/10% Sm1	-	-
14	100% Fp3	-	-
15	50% Fp3/50% Sm1	-	-
16	50% Pp/50% Sm2	-	xx
17	25% Pp/25% Fp1/50% Sm1	-	-
18	25% Pp/25% Fp1/50% Sm2	-	-

x means that the spd. is elicited for all respondents
xx means that the spd. is elicited for a fifth of the respondents

Abbreviations used in naming the marketing strategies:

Pc = Pooling at a cooperative company
Pp = Pooling at a private company
Fp1 = Fixed-price contract, 1 year fixed
Fp3 = Fixed-price contract, 3 years fixed
Bp = Bottom-price contract
Sm1 = Spot market sales, selling at one moment
Sm2 = Spot market sales, selling at two moments

It is clear that interviewers play a very active role in the elicitation process. The iteration task of arriving at indifference, the reactions on remarks of the respondent, as well as the task of verifying the implications of the initial elicitations, all require a high involvement on the part of the interviewer. Therefore, notwithstanding the standard questioning procedure and clear instructions to the interviewers, biases by the interviewer may have resulted. This possibility will be checked in Section 5.3.2.

5.2.4 Fitting a probability distribution function to the elicitations

Having elicited at least three points of the cumulative probability distribution for several marketing strategies and for each farmer, the problem arises of how to analyse these elicitations. Of course, it is possible to perform some analyses on the elicited scores, but it is probably much more convenient and instructive to fit a distribution function to the points and to use the parameters or the moments of the distribution in further analyses.

In principle, it is possible to fit a separate cumulative distribution function to each marketing strategy and for each farmer, using some best-fitting criterion. This could mean that e.g. a beta distribution fits the points of Strategy 4 of farmer 1 best, the lognormal distribution fits Strategy 6 of farmer 1 best, while the normal distribution function fits Strategy 6 of farmer 2 best etc. Following this procedure, not only the parameters of a distribution function, but also the type of distribution function would differ between marketing strategies and farmers.

It is clear that this procedure is rather cumbersome, since eventually about 3000 distributions must be fitted (250 respondents x 6 strategies x 2 years of measurement). With a set of, say, four types of distribution functions this would mean fitting more than 12000 distributions. Also, chosing the best fitting distribution function **per individual per strategy** is impossible since often no more than 3 points per strategy have been elicited so that only one degree of freedom is left for testing. It was therefore decided to fit the same distribution function to each marketing strategy and for each farmer, so that differences between strategies and farmers are only expressed by differences in parameters of this distribution function.

A suitable distribution function should satisfy the following requirements. First of all, the function should be flexible in order to account for a whole range of skewed distributions.[3] Secondly, the number of parameters to be estimated should be small in order to accommodate the cases in which only 3 points were elicited. Thirdly, the estimation method should be as simple as possible because of the

[3] By comparing in the data set the median to the minimum and maximum prices per strategy, it became clear that most distributions are skewed to the right. As expected, the median is closer to the minimum price than to the maximum price.

large number of distributions that have to estimated. Preferably, ordinary least squares should be applied.

Out of the class of linearizable cumulative probability distribution functions with two parameters, we selected the Weibull and lognormal distributions (Johnson and Kotz 1970) as suitable alternatives.

The cumulative lognormal distribution is:

$$F(x) = N(\ln x; \mu, \sigma) = N((\ln x - \mu)/\sigma; 0, 1) \tag{5.1}$$

where N is the normal distribution function.

This function can be estimated linearly by:

$$\ln(x_j) = \mu + \sigma w_j + e_j \qquad j = 1, \ldots, 5 \tag{5.2}$$

where e_j is an i.i.d. random disturbance term.

In Equation 5.2 x_1 to x_5 are (from low to high) the price levels given by the respondent and w_1 to w_5 are the points of the standard normal distribution with p-levels: .99, .75, .50, .25, .01, respectively. Vector w thus consists of the values (-2.576, -.67, 0, .67, 2.576).

By applying ordinary least squares to the observations, estimates of mu and sigma are obtained (i.e. the regression coefficients) per marketing strategy for each respondent. If the respondent provides only 3 or 4 data points, then Equation 5.2 can still be estimated.

The estimates of mu and sigma are used for computing mean, median, standard deviation and skewness of the fitted lognormal distribution (see Aitchison and Brown 1957).

The cumulative Weibull distribution is:

$$F(x) \equiv z = 1 - e^{(-x/a)^b} \tag{5.3}$$

where a and b > 0.

This function can be written as:

$$\ln(x) = \ln a + \frac{\ln \ln \left(\frac{1}{1-z}\right)}{b} \tag{5.4}$$

which can be estimated linearly by:

$$\ln(x_j) = \alpha + \beta \ln \ln \left(\frac{1}{1 - z_j}\right) + e_j \tag{5.5}$$

where

$$a = e^{\alpha} \quad \text{and} \quad b = \tfrac{1}{\beta} \tag{5.5a}$$

and e_j is an i.i.d. random disturbance term.

In Equation 5.5 x_1 to x_5 are (from low to high) the price levels given by the respondent and z_1 to z_5 are the p-levels: .99, .75, .50, .25, .01, respectively. The regression estimates of alpha and beta in (5.5) are used in calculating the moments of the Weibull distributions by means of a Gamma function (see Johnson and Kotz 1970).

For a number of marketing strategies, both distributions will be fitted and the cumulative probability distribution function that results in the lowest residual variance averaged over all farmers will be selected for further analysis (Theil 1971).

5.3 Results of indirect measurement of price perception

In this section the results of price perception measurement by means of the interval technique will be presented and discussed. After a review of the percentages of response to the elicitation questions, we will discuss which of the probability distributions, lognormal or Weibull, fits the data best (5.3.1). In Section 5.3.2, the average results are presented and a detailed analysis of the measurements will be made by testing the effects of moment of delivery, number of selling moments and interviewer on price perception. Heterogeneity in perception will be reviewed in Section 5.3.3 by testing the differences in perception between farmers actually dealing with a cooperative or with a private company. The differences between subjective probability distributions of strategies are analyzed by means of stochastic dominance rules and are dealt with in Section 5.3.4. A conclusion comes at the end of this chapter (Section 5.3.5).

5.3.1 Response to the elicitation question and adequacy of fit of the lognormal and Weibull distributions

Eliciting a subjective probability distribution is not an easy task for the respondent, as has become clear from the discussion in the former section. He has to answer rather unusual questions about his price expectations of a marketing strategy. Moreover, he has to answer them not only for one strategy but for several marketing strategies. This might induce a large number of non-response. Table 5.3 shows the number of respondents per marketing strategy for which at least the minimum, maximum and median have been obtained.

Table 5.3 *Response to the subjective probability distribution elicitation question for marketing strategies that had to be answered by all respondents*

STRATEGY	NUMBER OF RESPONSES		PERCENTAGE OF RESPONSES	
	1984	1985	1984	1985
Own strategy	211	179	88.6	87.3
1. 100% Pc	199	166	83.6	81.0
2. 100% Bp	199	151	83.6	73.6
4. 100% Sm1	193	166	81.1	81.0
5. 100% Pp	--	158	--	77.1
6. 100% Sm2	202	151	84.9	73.6
Number of respondents interviewed	238	205		
Mean response	201	162	84.4	78.9

The overall response percentage is around 85% in 1984 and 79% in 1985. Response is highest for the farmer's own marketing strategy, probably because this strategy is always the first one to be elicited and because farmers are most acquainted with this strategy. The subjective probability distribution of at least two marketing strategies (excluding the own strategy) is elicited for a total of 206 (86.6%) respondents in 1984 and 179 (87.3%) in 1985. Considering the difficulty of the task to the respondent, these response percentages are high.

Interviewers reported that they had difficulties with some farmers, as they viewed the elicitation task as being unrealistic. Sometimes statements were given like: "One can't see in the future, anything can happen" and "I am no forecaster". Those remarks point to the fact that some farmers had the idea that they should give perfect forecasts. Interviewers were instructed to make clear that the task did not concern forecasting but the respondent's own opinion about the uncertainty of the price he expects. Often, when a farmer made a statement like e.g.: "anything can happen", it helped to put the markers at the extremes of the ruler and to ask: "So according to you the price with this strategy this year could be 5 cts/kg as well as 100 cts/kg?" Most farmers, of course, denied this implication, so that the interviewer could move the markers, etc. Also, when farmers were giving remarks that suggested a uniform probability distribution, the interviewer derived the implications of assuming such a distribution in order to make sure that a uniform distribution was what the farmer really expected and meant. Mostly, farmers changed their ideas as a consequence.

Apart from non-response to the elicitation question itself, there is non-response because all 5 points of the cumulative probability distribution were not always elicited. The minimum, maximum and median could be measured in most cases. However, it turned out that farmers expected fairly low prices in both years. The maximum price elicited was often quite low, which resulted in a small range between minimum and maximum price. After eliciting the median, still smaller ranges between minimum and median and median and maximum resulted. Frequently, these ranges were too small to enable elicitation of the first and third quartile.

No more than three points per strategy are elicited for a rather large percentage of farmers especially in 1984. The response percentages are presented in Table 5.4. Five points are obtained for 44.9% of all strategies, four points are elicited for 8.7% and three points are elicited for 46.4% of all strategies in 1984. In 1985 these percentages are respectively: 71.8%, 7.4% and 20.8%, indicating much more complete elicitations in 1985.

The remarkable difference between 1984 and 1985 illustrates that the number of points elicited depends on the range between minimum and maximum. In 1984, as will be seen later, the farmers were rather sure about the price they expected to receive, so the range between minimum and maximum was rather small (average range is 14 cts/kg). Consequently, in extreme cases it was virtually impossible to try to elicit the quartiles. In 1985, the farmers were less sure about the prices, so the range is larger (average range is 19 cts/kg); it was therefore often possible to elicit the first and third quartile of the distribution.

Table 5.4 Number of points of the cumulative probability distribution elicited per year, over all marketing strategies, in percentages

	ELICITED NUMBER OF POINTS			
	3	4	5	Total
1984	46.4	8.7	44.9	100%
1985	20.8	7.4	71.8	100%

Comparison of fit of the lognormal and Weibull distribution function

For half of the observations in 1984, selected randomly, both the lognormal and the Weibull probability distribution were fitted to the elicited points by means of OLS per individual and per marketing strategy (see 5.2.3). The difference in fit between both functions is quite large. To illustrate this, the mean R-square of the lognormal distribution is 0.945, whereas the mean R-square of the Weibull distribution is 0.852. A pairwise test of the difference in fit by means of the sign test shows a larger fit of the lognormal distribution in virtually all cases, which of course is significant. It is clear that the lognormal distribution performs better than the Weibull distribution.

Although it is possible that distribution functions other than the lognormal function could give better results in some instances, the lognormal distribution overall provides a fairly accurate and satisfactory description of most of the cumulative probability distributions.

In order to illustrate the lognormal distribution, in Figure 5.1 two probability density functions are shown. The median of function A is 23.5 cts/kg, the mean is 24 cts/kg and the standard deviation is 4.97 cts/kg. For function B these values are respectively: 21 cts/kg, 22 cts/kg and 6.87 cts/kg.

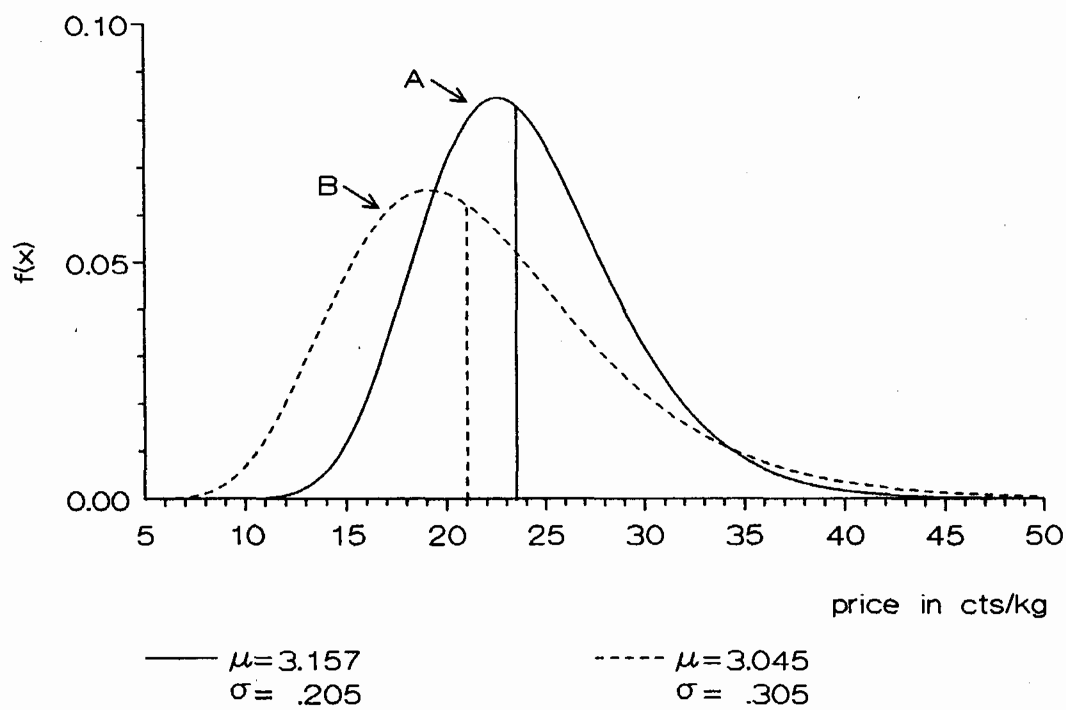

Figure 5.1 *Two examples of the probability density function of the lognormal distribution*

5.3.2 Perception of marketing strategies: the moments of the subjective probability distributions

The estimated parameters of the lognormal distribution are used to calculate the mean, median, standard deviation and skewness of the distribution. Table 5.5 shows the average results of those statistics. It is important to clarify the notation used. First of all, the mean (expected value) of the probability distribution a farmer associates with a strategy is indicated by IMEA (I being an abbreviation of the indirect measurement of the moments of the distribution). The I is required in order to be able to discriminate the mean from the mean price specified by the direct questioning procedure (see 5.4) which will be noted as DMEA (direct estimate of mean). The median, standard deviation, skewness and coefficient of variation are noted respectively as: IMED, ISTA, ISKE and ICV.

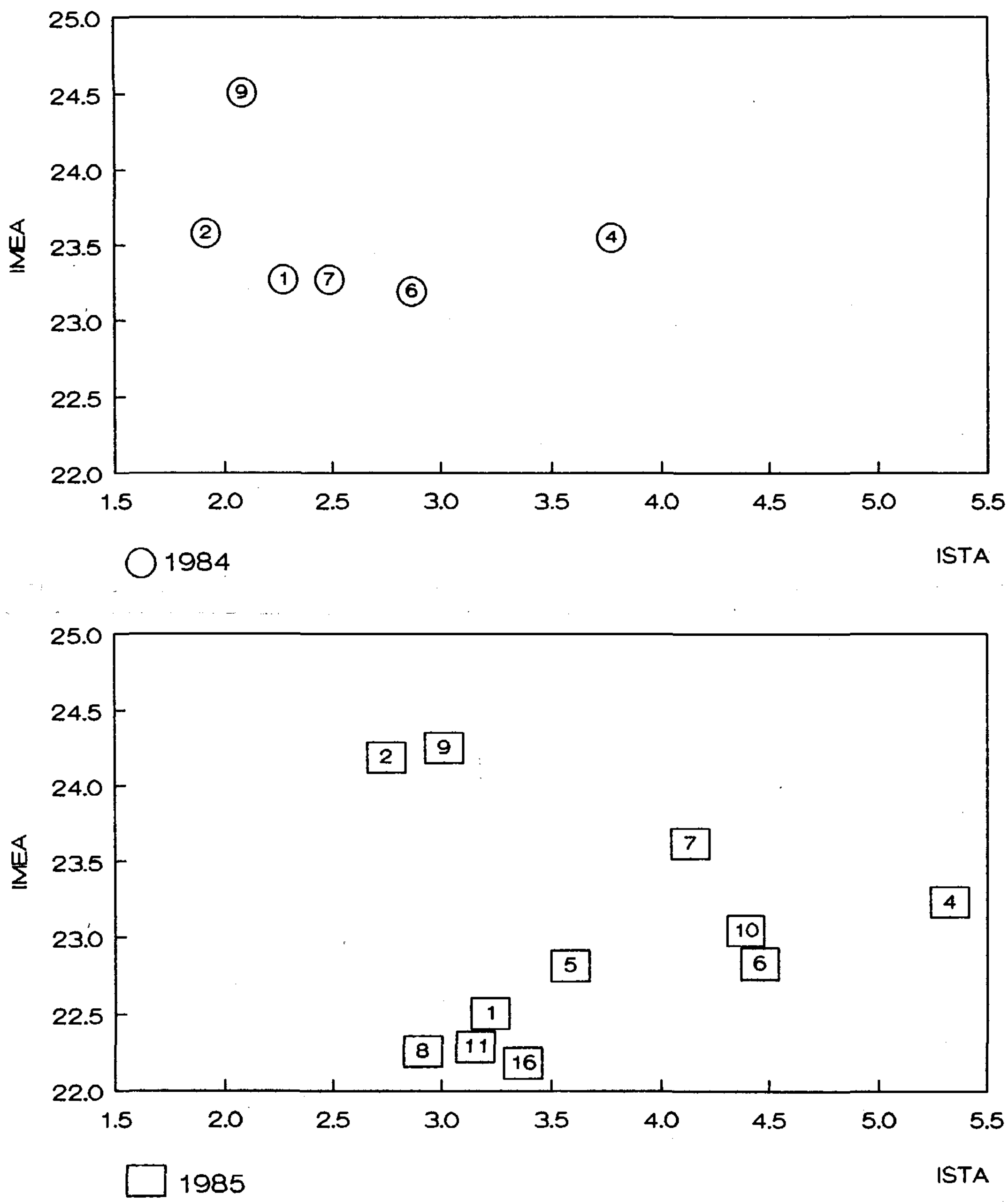

Figure 5.2 *Average perception of marketing strategies with respect to mean price (IMEA) and standard deviation of price (ISTA), in both years, in cts/kg (data Table 5.5)*

Secondly, because there is a sample of respondents, the average value of IMEA is indicated by MU, the median by MED and the standard deviation by SD. Thirdly, the marketing strategies are indicated by a number; in 1984 from 1 to 13, in 1985 from 1 to 18. To discriminate between both years, 1984 will be noted as a and 1985 as b.

Taking this all together: e.g. MU(IMEA7a) indicates the sample average of the perceived expected price (IMEA) in 1984 for marketing Strategy 7, and MU(ISTA1b) stands for the sample average of the perceived standard deviation in 1985 for Strategy 1.

The following observations can be drawn (see Table 5.5 and Figure 5.2):

- Differences between strategies in average mean price are small in 1984. The average mean price lies around 23.5 cts/kg. An exception in this respect is Strategy 9 (a combination of fixed-price and spot market sales) which shows the highest perceived mean price (24.5 cts/kg). A difference of 1 ct/kg does not seem much, but for an average farm where 15 ha. of ware potatoes are grown with a return of 50 tons/ha, a difference of 1 ct/kg amounts to an extra income of Dfl 7500,=.
  The main reason for the price associated with Strategy 9 to be so high may be the level of the fixed-price in the description of the marketing strategy. Prices for the fixed contract were set at 22, 23, 24 or 26 cts/kg depending on the moment of delivery (see Chapter 4). Apparently, these fixed-price levels are higher than the farmers' expectations of the mean price of other selling-options.[4]

- In Figure 5.2 average perceptions of mean price and standard deviation are shown for both years. Let us first consider 1984. Strategy 4 (100% spot market, selling at one moment) is perceived as most risky, followed by Strategies 6 and 7. It is illustrative to compare Strategy 2 (100% bottom-price) to 4; on average they are equal with respect to mean price, but the standard deviation of Strategy 4 is much larger than that of 2. In case a risk averse decision maker with this average perception, would only take the first two moments (mean and variance) of a probability distribution into account, then he would prefer Strategy 2 to 4. The former strategy dominates the latter. On the other hand, a risk seeking decision maker would prefer Strategy 4 to 2 in this case. A comparison of Strategy 9 with 1 and 2 shows that, although the risk associated with these three strategies is approximately equal, the mean price of 9 is much higher than that of 2 or 1. A decision maker will therefore prefer Strategy 9 to 2 or 1.

[4] As stated in Chapter 4, the price levels for the fixed contract have been set realistically and in accordance with the prices stated in contracts dealt in at the moment of the interviews. Actually, there was a hausse in fixed-price contracts at that moment.

Table 5.5 ***Descriptive statistics of the moments of the lognormal subjective probability distributions of price, estimated per marketing strategy and per farmer in 1984 and in 1985 (in cts/kg kg)***

Year 1984

	STRATEGY	MU IMEA	SD IMEA	MU IMED	SD IMED	MU ISTA	SD ISTA	MU ISKE	SD ISKE	MU ICV	SD ICV
1.	100% Pc	23.29	3.83	23.13	3.74	2.35	1.71	.30	.19	.10	.06
2.	100% Bp	23.58	3.27	23.46	3.13	2.01	1.64	.24	.16	.08	.05
4.	100% Sm1	23.56	5.35	23.10	5.18	3.83	3.53	.49	.42	.16	.13
6.	100% Sm2	23.21	4.69	22.95	4.59	2.94	2.32	.38	.27	.12	.09
7.	50% Pc/50% Sm1	23.28	3.63	23.09	3.55	2.57	1.85	.33	.21	.11	.07
9.	50% Fp1/50% Sm1	24.52	3.40	24.39	3.34	2.17	1.54	.26	.17	.09	.06

Year 1985

	STRATEGY	MU IMEA	SD IMEA	MU IMED	SD IMED	MU ISTA	SD ISTA	MU ISKE	SD ISKE	MU ICV	SD ICV
1.	100% Pc	22.42	4.18	22.11	3.98	3.31	2.36	.43	.26	.14	.08
2.	100% Bp	24.18	3.51	23.96	3.30	2.85	2.10	.33	.21	.11	.07
4.	100% Sm1	23.23	5.63	22.46	5.17	5.33	4.23	.67	.45	.21	.14
5.	100% Pp	22.82	4.25	22.44	4.01	3.65	2.69	.46	.29	.15	.10
6.	100% Sm2	22.86	4.99	22.32	4.62	4.48	3.37	.56	.36	.18	.11
7.	50% Pc/50% Sm1	23.62	4.66	23.16	4.29	4.19	3.06	.50	.31	.16	.10
8.	50% Bp/50% Sm1	22.28	4.26	22.00	3.99	3.00	2.57	.38	.26	.13	.08
9.	50% Fp1/50% Sm1	24.26	3.88	24.00	3.74	3.10	2.28	.37	.25	.12	.08
10.	50% Pp/50% Sm1	22.97	4.67	22.46	4.44	4.43	2.77	.57	.31	.19	.10
11.	50% Pc/50% Sm2	22.31	3.99	22.01	3.78	3.24	2.31	.42	.25	.14	.08
16.	50% Pp/50% Sm2	22.18	3.75	21.86	3.61	3.45	2.02	.46	.23	.15	.07

If the strategies in Figure 5.2 would be the sole strategies available to a risk averse farmer who takes only mean and variance into account, then an efficiency frontier can be drawn, which consists of Strategies 2 and 9. These strategies are most favorable with respect to perceived mean price and standard deviation of price. Which of these strategies he will choose depends on the degree of the risk aversion. Strategy 9, however, is very attractive since the mean price is 1 cts/kg higher, whereas the extra risk (standard deviation) is only 0.1 cts/kg.

- Average skewness (MU(ISKE)) is positive for each strategy (Table 5.5), which means that the subjective probability distribution is skewed to the right (notice that average median is smaller than average mean). This positive skewness is in agreement with our expectations. Skewness is largest for the 100% spot market selling strategies (Strategies 4 and 6). Farmers perceive a larger chance of high prices with these marketing strategies than they do with other selling-options.

- Of course, only average perception has been discussed until now. Table 5.5, however, shows that individual perceptions can differ widely from this average perception, see e.g. the standard deviation of mean price (SD(IMEA) and of price risk (SD(ISTA)). Differences between farmers especially show up with respect to the spot market Strategies 4 and 6. Part of the variation between farmers can be explained by the differences in moment of delivery. It seems obvious that farmers will perceive mean price to increase with moments of delivery later in the marketing year. Another part of this variation may be due to heterogeneity in perception within the group of farmers with the same moment of delivery. Both aspects will be dealt with later in this section.

The interpretation of 1985 is analogous to the results of 1984. Results are presented in Table 5.5 and in Figure 5.2. The discussion will therefore be focused on the *comparison* of average results in both years. Figure 5.3 shows a graph of average mean price and standard deviation of strategies in both years.

- The average perceived mean price in 1985 also fluctuates around 23 cts/kg, which is in accordance with the mean price farmers had received for their potatoes over a number of years (see Table 2.2 in Chapter 2). This could mean that farmers perceived 1984 and 1985 as "average" years, at least at the time the interview took place (in June). Eventually, it turned out that both years were quite disastrous with respect to prices. The average spot market price was 13.4 cts/kg in 1984 and 10 cts/kg in 1985.
  The perceived mean price for marketing strategy 1 (100% pooling, cooperative) in 1984 is significantly higher (pairwise t-test) than in 1985 (23.29 compared to 22.42), whereas the mean price for Strategy 2 (100% bottom-price) in 1984 is significantly lower than in 1985 (23.58 compared to 24.18). Other differences in mean price between the same strategies in both years are not significant.[5]

- A very clear difference exists between 1984 and 1985 with respect to price risk as is indicated by the standard deviation of the probability distribution (compare MU(ISTA) between both years). The average perceived price variability for all strategies, in 1984 is significantly smaller than in 1985 (see Figure 5.3). Apparently, farmers viewed the market situation in 1984 as more predictable than in 1985 at the moment of the interview. Since differences in mean price are small between both years, the larger standard deviation in 1985 implicates that, on average, the perceived minimum price (and first quartile) must be lower in 1985 than in 1984 while the perceived maximum price (and third quartile) must be higher.[6] Also notice that this smaller range in 1984

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[5] It should be noted here that in this chapter a significant effect means $p < 0.05$ (two-tailed) unless stated otherwise.

[6] For example for Strategy 4 the average minimum price elicited is 15.8 cts/kg and the average maximum is 39 cts/kg in 1984, whereas in 1985 these numbers are respectively: 13.5 and 45 cts/kg.

explains the smaller number of elicited points per marketing strategy in 1984 compared to 1985.

- In 1985, distributions were elicited for five extra marketing strategies, namely 5, 8, 10, 11 and 16, each for a fifth of the respondents. Although the average perception of these strategies is presented in Table 5.5 and Figures 5.2 and 5.3, one should be careful when comparing the average perception of these strategies directly with the over *all* respondents averaged perception of other strategies. Only pairwise analysis of differences between strategies will clarify which differences in perceived mean price or standard deviation are significant. Figure 5.2 shows that comparable strategies like Strategy 1 and 5 are rather close to one another. 100% Pooling at a private company (Strategy 5) is, on average, viewed as somewhat higher in expected price and riskier than pooling at the cooperative (Strategy 1). One can also compare for instance Strategies 7 and 11 or 10 and 16. These latter marketing strategies differ only in number of selling moments at the spot market. Further on in this section it will be shown that neither of these differences is statistically significant.

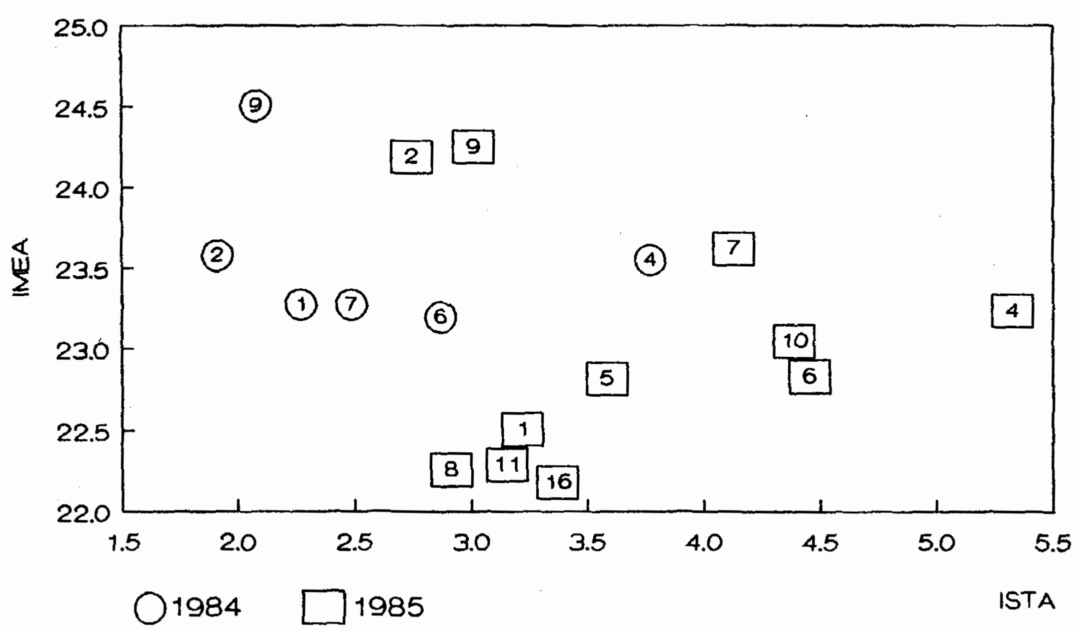

Figure 5.3 Average perception of marketing strategies: a comparison of 1984 with 1985

From Table 5.5 and Figures 5.2 and 5.3 it is clear that, on average, the rank order of strategies with respect to mean price and standard deviation of price is rather alike in both years. The rank order with respect to price risk (standard deviation) in both years is, in increasing order: Strategy 2<9<1<7<6<4. With respect to mean price the rank order is, in decreasing order: 9>2>7>4>6; only the position of Strategy 1 differs between the years. However, it is even more interesting to study the correspondence in rank order on the individual level.

Information about the order on the individual level is useful, since it gives an indication of the difference between both years in rank order of preference of strategies to be expected. If we assume risk attitude to be a fairly stable characteristic of a farmer which does not change much on a yearly basis and if the farmer acts in accordance with the expected utility model, then differences in preference for strategies between both years should be attributed to differences in perception.

In order to measure the correspondence of the order between both years, the Pearson correlation coefficient is calculated between 1984 and 1985 *over* strategies and *per* individual both for mean price (IMEA) and for standard deviation of price (ISTA). The mean, median and standard deviation of these correlations are computed over all farmers. These statistics are shown in Table 5.6. Only Pearson correlations are shown in this table, since Spearman rank order correlations showed similar results. Correlations per individual are calculated over minimally three and maximally 6 strategies (observations).

The average correlation for IMEA is 0.36 with a median of 0.34 and 38% of the correlations being negative. With respect to ISTA, this resulted in a mean correlation of 0.59, a median of 0.60 and 25% negative correlations. The average correlation appears to be clearly smaller for mean price than for the price risk of strategies. One reason for this difference may be that IMEA of Strategy 1 (100% pooling cooperative) is significantly larger in 1984 than in 1985, whereas the reverse is true for Strategy 2 (100% bottom-price contract; see above). In view of the fact that each correlation is based on a small number of strategies, these reversions apparently are of such magnitude that they change the order, thus resulting in a low correlation. Contrariwise, ISTA in 1985 is perceived as being larger than in 1984 for all strategies. Not only do all differences appear to be in the same direction, but apparently they are also more or less equal, thereby not disturbing the rank order (the rank order did not change but the magnitude of risk did). This leads to a relatively high correlation per individual for the attribute risk (ISTA).

It should be noted here that on first sight one might view the correlations between both years for the respective measurements as indicators of stability. However since measurements took place with a year in between and each measurement concerns the perception of market prices in the marketing year to come, this is not the case here. In this case one might expect perceptions to change, since market circumstances and, consequently, market prices probably differ between respective years.

Table 5.6 Sample statistics of Pearson correlations computed per farmer over marketing strategies between estimates in 1984 and 1985 of IMEA and ISTA respectively

CORRELATIONS BETWEEN	Mean*	Median	St. dev.*	% < 0	N
IMEA 1984 and IMEA 1985	.357	.339	.845	38	146
ISTA 1984 and ISTA 1985	.589	.603	.854	25	146

* After Fisher r-to-z transformation

Effect on perception of type of wholesale company

The interesting question is whether farmers expect to receive a different price when they sell their potatoes via a similar strategy to a cooperative or to a private company. This difference can only be estimated if a farmer can choose between strategies, which only differ with respect to type of wholesale company (a within-subject analysis). For this reason comparisons are only possible for three strategies, all concerning 1985, (see Table 5.5) namely: *100% pooling* (Strategy 1 with 5), *50% pooling, 50% spot market* (selling at *one* moment) (7 with 10) and *50% pooling, 50% spot market* (selling at *two* moments) (11 with 16).

Testing the effects (pairwise t-test), no significant difference in perception shows up in all three cases, neither with respect to IMEA nor with respect to ISTA or ICV. This means that farmers perceive the same subjective probability distribution of price for similar strategies, whether the strategy implies selling to a cooperative or to a private company.

However the test of the hypothesis is not yet complete. If farmers who actually sell their potatoes to the cooperative wholesale company perceive e.g. a higher IMEA for 100 % pooling at a cooperative than for 100 % pooling at a private company, whereas farmers who sell to a private company perceive the reverse, then it is possible that differences in perception can be cancelled out when taking private and cooperative farmers together in one sample. Stated otherwise: there might be an interaction effect between perception and the farmer's actual choice of wholesale company. Such an effect would be plausible since one reason for selling potatoes to a company might be the higher price farmers expect to receive from that company. Such an interaction effect could also be a result of rationalization of actual choice behavior.

A pairwise test on perceived differences between the three similar strategies has been performed separately for both groups of farmers (cooperative and private farmers). Although differences were found between both groups in the hypothesized direction i.c. each group perceives the marketing strategy of the company they actually deal with as being higher in IMEA and lower in ISTA, these differences are not statistically significant. One reason for this result may be the rather small number of respondents (+/- 35) per pair of strategies for which the effects could be tested.

It is concluded that no significant difference can be detected in the perception of mean price and price risk between the two types of wholesale companies in 1985. This finding will be elaborated upon furtheron in this section.

Analysis of the validity of elicitation

A more detailed analysis of perception data, centered around the question of the validity of measured perceptions will now be presented: are the perception results reasonable and in accordance with our expectations? The effects of the following variables on perception will be analysed: moment of delivery, number of selling moments (one or two) and interviewer.

Effect on perception of moment of delivery

The strategies formulated are differentiated by the moment of delivery. The four moments are (the percentages of farmers choosing each moment are given between brackets): September (3%), October up to December (10%), January up to March (35%) and, finally, April up to July (52%). A probability distribution is elicited only for the farmer's usual moment of delivery which is rather stable over the years. Because of the small number of observations in September, only 11 farmers in 1984 and only 5 in 1985, the observations of these respondents are added to the observations of the period October-December.

It is expected that a group of farmers who delivers later in the marketing year will perceive a higher mean price than a group of farmers delivering earlier because of the compensation for storage costs. This compensation is the reason for higher fixed-prices, higher bottom-prices and, in the long run, higher average spot market prices. A confirmation of this hypothesis would provide an indication of the validity of the elicitation.

After testing this between subjects effect by means of analysis of variance per marketing strategy, the hypothesis was confirmed for all strategies in 1984. Appendix II shows the average results for each moment of delivery. The largest differences in mean price exist between the period September-December on the one hand and January-July on the other hand. Differences between the moments January-March and April-July are small but differences always occur in the hypothesized direction for all marketing strategies.

The results are less clear in 1985. Only 4 strategies (namely 2, 4, 9, 11) show significant effects in the hypothesized direction. It is, however, not very surprising not to find any significant differences for Strategies 8, 10 and 16, since the number of observations for these marketing strategies is rather small (+/- 35).

Strategies 1, 6 and 7 show effects in the hypothesized direction but these effects are not significant because of large interindividual variation.

It is concluded that, in general, a consistent significant effect of moment of delivery on perceived mean price exists for most strategies. Significant effects would probably have been detected for other strategies as well had the number of observations been larger.

With respect to effect of moment of delivery on the standard deviation of distributions (ISTA), we expect strategies with spot market sales to be perceived as riskier when delivering later. Delivering later implies selling later in the marketing year (see the formulation of marketing strategies in Chapter 4). The reason for this expected effect is the increasing variability in prices later in the marketing year which was already noted in Chapter 2. We therefore expect to find significant effects for Strategies 4 and 6 and, to a lesser extent, also for Strategies 7 and 9. Indeed, a significant effect is found in the hypothesized direction for Strategies 4, 6, 7 and 9 in 1984, whereas such an effect only appeared for Strategy 4 in 1985 (see Appendix II). A further confirmation of the hypothesis is that the effect of moment of delivery is not found for Strategies 1 and 2.

Reviewing the results, we conclude that a consistent effect of moment of delivery on perceived mean and standard deviation of the elicited subjective probability distribution is shown. These significant differences certainly strengthen our confidence in the elicitation procedure, especially since the effects are tested between groups of farmers.

Effect on perception of number of selling moments

Farmers have the opportunity to sell at any number of selling moments and whenever they like when selling at spot market prices. In the strategies used in this study however, a differentiation is only made between selling at one moment (in the last month before delivery) at spot market prices and selling at two moments (that is, selling in the last month before delivery and in a month early in the marketing year, in an equal quantity per moment). In general, mean price and price variability increase as the marketing year progresses. Combined with the assumption that farmers sell at any randomly selected day in each month, we expect farmers to perceive IMEA and ISTA to be lower when selling at two moments than when selling at one moment. In this manner, more selling moments reduces expected value and price risk.

In order to test this hypothesis, pairwise comparisons are made between Strategies 4 (100% spot market (selling at one moment)) and 6 (100 % spot market (selling at two moments)). In both years, the differences between strategies are significant (pairwise t-test) and in accordance with the hypothesis: IMEA and

ISTA are perceived as being higher when selling at one moment than when selling at two moments.[7]

It is concluded that farmers perceive selling at one moment at the spot market as being somewhat riskier than selling at two moments, but in their perception this larger risk goes together with a higher mean price. This finding confirms the hypothesis and this again indicates the validity of the elicited subjective probability distributions.

Interviewer effects

As described above, the elicitation of a subjective probability distribution assumes an active role on the part of the interviewer. Each interviewer acts in his personal way when actually interacting with the respondent, even after careful instruction of the interviewer and training him in unobtrusive behavior. Systematic differences between interviewers might therefore show up.

The largest influence of the interviewer is expected to be exercised by eliciting minimum and maximum price, since interviewers can stress the meaning of "almost completely sure" differently. Thus, especially the standard deviation and the skewness of the distribution might differ systematically between interviewers. The interviewer effects on the values of mean (IMEA), standard deviation (ISTA) and skewness (ISKE) were tested for each marketing strategy by means of dummy variable regression analysis after controlling for the effect of moment of delivery. Thirteen interviewers conducted the survey in 1984, nine of them conducted it in 1985. Interviewers were assigned randomly to farmers.

No significant interviewer effect for any marketing strategy is found on mean price in 1984. The standard deviation and skewness of the distribution, however, are systematically affected by the interviewer. A significant effect appeared for all strategies in 1984. More specifically, two interviewers systematically, that is for all strategies and all respondents, elicited a small ISTA and ISKE: relatively rather tight and symmetric distributions. Also, fairly high ISTA and ISKE are found by two other interviewers. These latter interviewers probably emphasized more firmly that farmers had to be "almost completely sure that the price would not be higher (lower) than the initial maximum (minimum) price elicited", thereby systematically widening the range, and indirectly the skewness, of the distribution.

In order to illustrate the magnitude of differences, here the maximum difference found is given. This maximum difference comes up with Strategy 4. The difference in average ISTA between the two most extreme interviewers is

7 Extra tests in this respect are that in 1985, Strategy 7 can be compared to 11 and 10 to 16. Differences between these strategies have to be tested by means of a two-sample test in stead of a pairwise test. In both cases no significant differences are found, although MU(IMEA) and MU(ISTA) are higher for strategies with two selling moments (see Table 5.5). Because of the small number of observations in connection with the two sample test, these differences are not significant).

4 cts/kg. Of course it is not possible to state which of the interviewer groups provides a more valid description of the "real" distribution. However, we should perhaps have more confidence in the larger estimates, because we know from many experiments that people tend to make *too* tight subjective probability distributions.

In 1985, with different interviewers, differences between interviewers in IMEA, ISTA and ISKE elicited were larger than in 1984. IMEA also differed systematically between interviewers in this year. Two interviewers systematically elicited probability distributions with a low maximum and two interviewers elicited relatively high maximum prices. One interviewer elicited a high minimum as well as a high median price, which implies that all farmers interviewed by him were systematically more optimistic than the other farmers.

It is clear that some interviewer bias is present, especially with respect to the price risk of the strategies. Of course this raises some doubts about the elicitations made. If elicitations were intended to be used as forecasts, such a finding would be distressing. However, the elicitations in this study are used primarily for the analysis of differences *between* strategies *per* individual, e.g. with respect to differences in preference of a farmer. Systematic interviewer bias is therefore no problem as long as it can be assumed that all strategies elicited for a farmer are biased in the same systematic way. Also in perception analysis, we should concentrate on *pairwise* differences between strategies per farmer. This means that it is more valid to study the differences in say IMEA between two strategies for the same farmer, than to discuss the realism of IMEA being e.g. 25 or 27 cts/kg. However, notwithstanding the systematic interviewer bias, plausible results still showed up in the between subjects analysis of effect of moment of delivery, which generally indicates that no dramatic effects are caused by interviewer bias. Effects of moments of delivery are clearly larger.

5.3.3 Heterogeneity in perception: difference between farmers dealing with a cooperative or private company

Table 5.5 clearly showed that farmers differ in their perception of marketing strategies (see SD for IMEA and ISTA). After removing the between-subjects effect caused by differences in moment of delivery and interviewer, differences between farmers still remain (see e.g. Appendix II). It is interesting to find out whether we can account for this heterogeneity. Are the differences strictly personal or are they related to specific characteristics of the farmer?

The analysis of heterogeneity in perception is confined here to testing (between-subjects) the effect of the farmer's actual choice of type of wholesale company (cooperative or private). This characteristic is seen as the most plausible and interesting variable for which effects may show up. It is expected that farmers who actually sell their potatoes to the cooperative will perceive a higher mean price and a lower price risk for the marketing strategies of the cooperative than the farmers dealing with a private company. For strategies implying selling to a private company, it is expected that cooperative farmers will perceive a lower mean price and a higher price risk than farmers dealing with a private company.

Testing these hypotheses per marketing strategy by means of regression analysis (controlling for both the influences of interviewer and moment of delivery), the following results are found. A significant effect is detected for only one strategy in 1984, namely Strategy 1 (100% pooling, cooperative). Farmers actually selling to the cooperative perceive a higher IMEA and a higher ISTA than do those selling to a private company. Only two significant effects are found in 1985. Cooperative farmers now perceive a higher ISTA for both Strategy 5 (100% pooling private) and for Strategy 10 (50% pooling private company, 50% spot market (at one moment)) than do private farmers. No significant effect, however, is detected with respect to IMEA.

On the basis of this information we conclude that perception is homogeneous with respect to the actual choice of type of wholesale company, with the interesting exception that, although differences are small, private farmers tend to perceive less risk when pooling than do cooperative farmers. That is, farmers dealing with a private company perceive pooling as a more safe strategy than do cooperative farmers. An explanation for this difference may be the larger experience cooperative farmers have with pooling than do private farmers. This because pooling is a relatively recent choice alternative for private farmers (see Chapter 2), whereas many cooperative farmers have already been used to pooling ever since the seventies. This might implicate that cooperative farmers estimate the price risk associated with pooling more accurately. They experienced years with high as well as years with low prices. Another explanation may be that private farmers are more used to larger risks because many of them usually sell a relatively high percentage of their yield at spot market prices. They may therefore perceive pooling as a relatively secure strategy. The most significant finding, however, is the small number of differences in perception of both groups.

5.3.4 Stochastic dominance analysis of subjective probability distributions

Up till now, the analysis has been limited to separately discussing the results for each moment of the subjective probability distribution. In order to obtain more insight in the price perceptions of farmers between strategies, the whole probability distribution should be taken into account. Subsequently these distributions should be compared *per individual*. One way of performing such an analysis is by means of stochastic dominance.

Stochastic dominance is a well known and simple rule for reducing the number of alternatives to an efficient set of alternatives, without knowing the exact utility function of the decision maker (Anderson et al. 1977). Some general assumptions concerning the utility function suffice.

At first sight it may seem inappropriate to introduce the stochastic dominance concept in this chapter concerning perception results. The analysis would seem more appropriate in Chapter 7 which deals with preference analysis, since at least some assumptions concerning the utility function, that is the preference of a decision maker, are required for stochastic dominance. However, as we will see, the required restrictions on the utility function (i.e. a monotonically increasing concave utility function) are undemanding and reasonable and since clear insights into perception can be gained by this analysis we will present it here. We will, of course, make use of the results discussed here in Chapter 7.

First now, the concept of stochastic dominance is briefly delineated. A presentation and discussion of stochastic dominance rules is usually limited to three degrees: first, second and third degree, with cumulative restrictions placed on the utility function. For all three degrees of stochastic dominance the ranking rule is transitive: if a probability function F stochastically dominates G and G stochastically dominates H then F must dominate H.

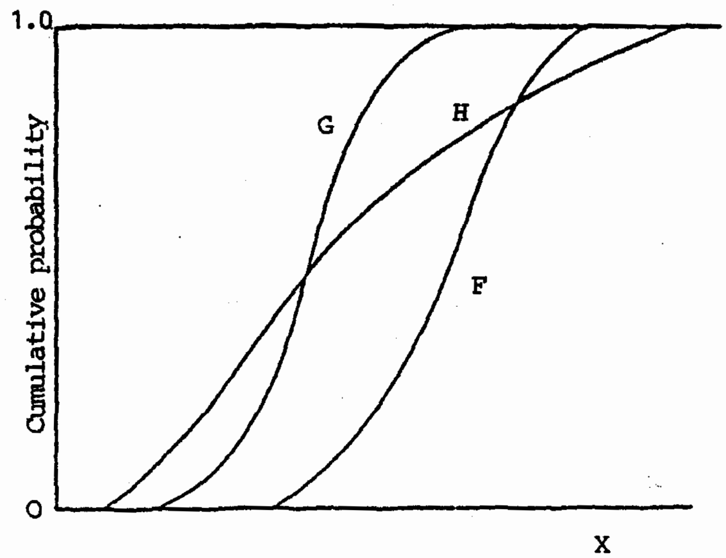

Figure 5.4a Illustration of FSD (F dominates G but not H)

First degree of stochastic dominance (FSD) requires a monotonically increasing utility function. It states that, for expected utility maximizers, alternative F with cumulative probability distribution function F(x) stochastically dominates alternative G with cumulative distribution function G(x) iff. $F(x) \leq G(x)$ for all x with at least one strong inequality (that is, < holds for at least one value of x). Graphically FSD means that the stochastically dominant distribution curve must not lie anywhere to the left of a dominated curve (see Figure 5.4a).

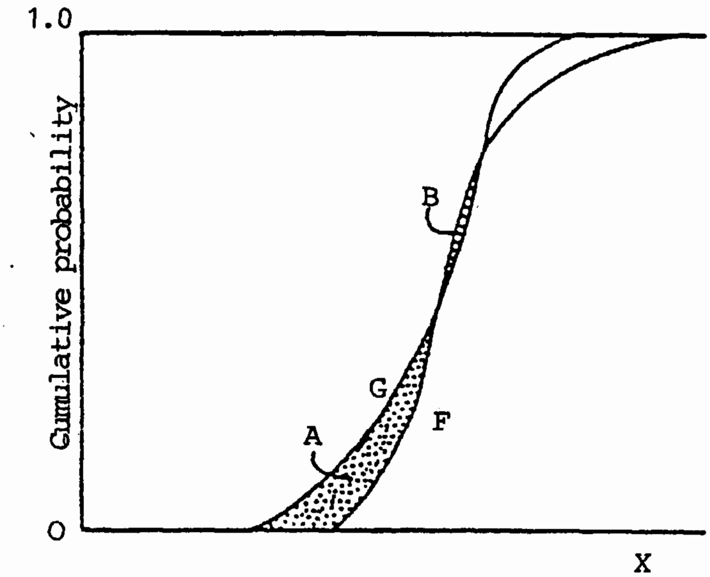

Figure 5.4b Illustration of SSD where cumulative probability distributions cross twice (area A > area B)

Second degree of stochastic dominance (SSD) requires the additional assumption of a strictly concave utility function, i.e., the decision maker should be risk averse. For all risk averse decision makers alternative F SSD alternative G iff.

$$\int_0^y [G(x) - F(x)]\, dx \geq 0 \tag{5.6}$$

for all y in [0,1] with at least one inequality. Graphically this means that area A in Figure 5.4b is larger than area B.

Third degree of stochastic dominance (TSD) requires the additional assumption of a decreasingly risk averse decision maker. This behavioral assumption about the utility function of the decision maker is rather strong. Also, empirically, according to Anderson et al. (1977), the SSD efficient set is often hardly reduced by applying the TSD rule. The computational task of establishing TSD may therefore not cover the marginal benefit of identifying a slightly smaller efficient set. As a consequence, the SSD rule is applied most often.

Applying the SSD rule to some families of probability distributions leads to simple results. For *normal* probability distributions alternative A SSD alternative B iff. the expected value of A ($E_A(\underline{x})$) is larger than or equal to the expected value of B ($E_B(\underline{x})$) *and* the variance of A ($Var_A(\underline{x})$) is smaller than or equal than the variance of B ($Var_B(\underline{x})$), with at least one inequality:

$$E_A(\underline{x}) \geq E_B(\underline{x}) \quad \text{and} \quad Var_A(\underline{x}) \leq Var_B(\underline{x}) \tag{5.7}$$

An SSD rule also exists for *lognormal* probability distributions. In this rule the variance of $\underline{x}$ in the rule for normal probability distributions is replaced by the variance of ln $\underline{x}$:

$$E_A(\underline{x}) \geq E_B(\underline{x}) \quad \text{and} \quad Var_A(\ln \underline{x}) \leq Var_B(\ln \underline{x}) \tag{5.8}$$

Note that $Var_A(\ln \underline{x})$ is the parameter sigma in Equation 5.2. For further details about the SSD rule for lognormal probability distributions, see e.g. Levy (1973).

When stochastic dominance is applied to a number of alternatives by means of pairwise comparisons between the alternatives, this seldomly leads to one dominant alternative. Mostly, only an efficient set of alternatives is obtained. More specific information is needed about the decision maker's utility function, e.g. the degree of risk aversion, in order to be able to choose from this efficient set.

By assuming risk averse farmers, which is a reasonable assumption (see Chapter 6), the SSD rule can be applied to the elicited lognormal probability distributions. The probability distributions of strategies are compared pairwise per individual. Table 5.7 shows the results obtained for the total sample for 1984 and 1985. In this table, the percentages of farmers for which the column strategy stochastically dominates (SSD) the row strategy are given. E.g. in 1984 Strategy 1 (100% pooling, cooperative) SSD Strategy 2 (100% bottom-price) for 15.8% of the farmers, whereas the same strategy is dominated by the 100% bottom-price strategy for 34.2% of the farmers. No dominance either way could be established for the remaining farmers (100-15.8-34.2=50%) by the SSD rule. The other percentages in the table can be interpreted likewise.

Overall, the order of the strategies in 1984 based on the mean column percentage of dominance, at decreasing preference, is: 9>2>1>7>6>4. That is, Strategy 9 (a combination of fixed-price and spot market sales), dominates other strategies most often, followed by Strategy 2 (100% bottom-price contract), etc. These two Strategies 9 and 2 are apparently perceived as rather advantageous compared to competing strategies and, if farmers are risk averse and expected utility maximizers, should be positively evaluated (see also Figure 5.2).

Both spot market strategies (4 and 6) are dominated most frequently (42.9% and 40.8%, respectively) which means that they are perceived as rather unattractive in 1984. Selling at one moment is viewed as worse than selling at two moments at the spot market.

More or less the same rank order of strategies is obtained in 1985 (included now is Strategy 5 (100% pooling, private). Based on the mean percentage of dominance the rankorder, at decreasing preference is: 2/9>5>7/1>6>4. Again Strategies 2 and 9 dominate the other ones most often, while the spot market strategies are most frequently dominated.

Table 5.7 Pairwise comparison the spd of marketing strategies per farmer, by means of second degree of stochastic dominance (in percentages)

Year 1984

STRATEGY	1	2	4	6	7	9	Row Mean
1. 100% Pc	--	34.2[b]	9.7	13.8	17.0	42.3	23.4
2. 100% Bp	15.8[a]	--	8.7	12.0	14.6	26.8	15.6
4. 100% Sm1	36.6	44.6	--	27.3	40.1	66.0	42.9
6. 100% Sm2	38.5	46.9	14.8	--	34.7	69.2	40.8
7. 50% Pc/50% Sm1	25.3	43.2	12.3	16.5	--	57.1	30.9
9. 50% Fp1/50% Sm1	12.4	18.6	2.1	3.3	10.2	--	09.3
Column mean percentage of dominance	25.7	37.5	9.5	14.6	23.3	52.3	27.2
Mean percentage of no dominance	51.0	46.9	47.6	44.6	45.8	38.4	45.7[c]

[a] For 15.8% of all farmers, marketing strategy 1 stochastically dominates marketing strategy 2

[b] For 34.2 % of all farmers, marketing strategy 2 stochastically dominates marketing strategy 1

[c] Percentage of all pairwise comparisons (over strategies and farmers) for which the SSD rule gave no dominance between the marketing strategies (100% - 2 x 27.2%)

Year 1985

STRATEGY	1	2	4	5	6	7	9	Row Mean
1. 100% Pc	--	54.2	14.8	20.1	15.3	18.0	46.6	28.1
2. 100% Bp	7.6	--	4.9	8.5	6.7	5.0	22.9	09.3
4. 100% Sm1	30.3	55.6	--	32.0	23.9	36.4	58.1	39.4
5. 100% Pp	21.5	54.9	11.3	--	15.4	22.8	47.9	29.0
6. 100% Sm2	27.1	60.7	16.2	36.4	--	34.3	69.0	40.6
7. 50% Pc/50% Sm1	24.0	59.0	9.1	29.1	14.0	2.8	52.1	31.2
9. 50% Fp1/50% Sm1	8.2	17.1	0.0	8.2	1.4	--	--	06.3
Column mean percentage of dominance	19.8	50.3	9.4	22.4	12.7	19.9	49.4	26.3
Mean percentage of no dominance	52.1	40.5	51.2	48.6	46.6	48.9	44.3	47.5

Part of the rankorder in both years can be explained by the realization that farmers expected mediocre or low prices in 1984 and 1985. Spot market strategies are therefore perceived by many farmers as resulting in relatively low prices. Fixed-price contracts (Strategy 9) and the 100% bottom-price contract with its specified bottom-price are advantageous and effective in situations in which market prices are low. Strategies 9 and 2 are therefore perceived as favorable in both years in comparison with other strategies, especially 100% spot market strategies.

Furthermore, it can be concluded from Table 5.7 that the SSD rule results in a selection between strategies in almost 54% (100% - 45.7%) of all pairwise comparisons of strategies in 1984 and 52.5% (100% - 47.5%) in 1985. Thus, for a minority of all pairwise comparisons more information about the utility function is needed for further selection.

This stochastic dominance analysis suggests therefore that for the elicited subjective probability distributions the necessity to know the exact utility function in order to select the *most preferred* alternative is limited. For many farmers the degree of risk aversion will only be necessary in order to be able to choose between Strategy 9 and 2. However, should one want a complete preference rank order of strategies, then a utility function will surely be necessary, since the SSD rules still yields no solution for about 45% of all comparisons. We will see how the utility function will rank order strategies in Chapter 7.

5.3.5 Summary and conclusion of measuring price perception indirectly

In the former sections, the results of measuring price perception by means of the interval technique were presented and discussed. By means of this technique, five points of the cumulative probability distribution are elicited per marketing strategy and a distribution is fitted to the elicited points. Overall, a lognormal probability distribution proved to fit the points better than a Weibull distribution function. For all strategies and all farmers the subjective probability distributions are therefore represented by the parameters of the lognormal distribution.

Results show that the elicitations yield reasonable and plausible perceptions. In both 1984 and 1985, farmers expected on average a price of around 23 cts/kg, which is close to the mean market price calculated over the past 14 years. Perceptions differ most drastically between 1984 and 1985 with respect to price risk: price risk was perceived as being much larger in 1985 than in 1984.

The internal consistency of elicitations is evaluated by testing the effects of moment of delivery and number of spot market selling moments on price perceptions. A later moment of delivery resulted in a higher perceived mean price, whereas a larger number of selling moments resulted in a lower perceived mean price and a smaller risk; both results therefore confirm the hypotheses. With respect to the type of wholesale company, no perceptual differences have been found between strategies that are similar except with respect to the type of company: that is, farmers do not perceive a different probability distribution when potatoes are sold by means of pooling to a cooperative instead of to a private company.

Comparing the subjective probability distributions pairwise per farmer by means of stochastic dominance analysis shows that a dominant strategy can be selected in more than half of all pairwise comparisons between strategies. For very many farmers, especially the strategy: 100% bottom-price contract and strategy: 50% fixed-price, 50% spot market (selling at one moment) dominate other strategies. The 100% spot market strategies, either selling at one moment or at two moments, are most often dominated by other strategies. These results confirm the notion that in years with low or mediocre market prices, which farmers expected in 1984 as well as in 1985, contracts with fixed-prices or bottom-prices are more favorable with respect to mean price and price risk than strategies which imply selling the total, or a large part of, the harvest at spot market prices. In years with high market prices one expects the reverse to be true.

Heterogeneity in perception is analyzed by testing the effect of the farmer's actual choice of wholesale company. A difference only shows up for pooling: farmers selling to a private wholesale company perceive a lower mean price and a smaller price risk than do farmers selling to a cooperative company. It was suggested to attribute this difference in perception to the fact that cooperative farmers are on average more experienced with pooling compared to private farmers and thus may be more able to evaluate the probability distribution of pooling accurately.

The plausible results summed up above strengthen our confidence in the validity of the interval technique for eliciting subjective probability distributions in survey conditions. It appears to be possible to elicit consistent spd's for a large number of respondents and many distributions per respondent in survey conditions. It should be noted however, that it proved to be a fairly difficult question in the survey. Apart from about 15% of the farmers who failed to respond to the question, farmers had difficulty expressing their vague and unarticulated ideas about prices they expected in explicit and quantitative statements. They had to think hard before forming their opinions. This may especially hold for strategies farmers are less acquainted with because they never choose them in practice (e.g. a farmer selling to a private company who has to make statements about strategies implying selling to the cooperative). Furthermore, farmers tended to lose interest and got bored because the elicitation procedure is repeated for a number of strategies. This made it necessary for us to limit the number of probability distributions elicited per farmer to six. The whole task took about 20 to 30 minutes to complete.

In eliciting subjective probability distributions the interviewers have to play an active role in motivating and stimulating the farmer, explaining the procedure and correcting careless answers, getting him to think hard etc. Our results show that some systematic interviewer bias is present; especially the elicitation of the minimum and maximum price proved sensitive to the interviewer. This inter-

viewer effect limits comparisons between farmers. However, this interviewer bias does not pose severe problems since we are primarily interested for the purpose of this study in within-subject comparisons of strategies.

It would be interesting to study whether the above mentioned problems can be minimized by using interactive computer programs to elicit subjective probability distributions in large scale survey research. These programs could be constructed so as to make the task more interesting to the respondent, e.g. by graphing the probability distribution elicited on the screen, and more use could perhaps be made of different elicitation techniques to verify the answers obtained by any technique within a reasonable amount of time.

A second interesting subject, to which we will now turn, is a comparison of the direct estimates of price perceptions with respect to both results and difficulty of the respondent's task with the indirect measurements discussed above. Measurement procedures and results of these direct procedures will be presented and discussed in the next sections. Subsequently, in Section 5.6. the results obtained by indirect measurement will be correlated to the direct perception measurements in order to evaluate the convergent validity of the measurement of perception.

5.4 Direct measurement of price perception: description and evaluation of the method

5.4.1 Direct measurement of mean price per marketing strategy

In their review of elicitation techniques, Spetzler and Staël von Holstein (1975) question the capability of respondents of stating the moments of a probability distribution directly. We agree that standard deviation and skewness are very difficult to state quantitatively, even for subjects well acquainted with statistics. However, it is probably less difficult to explain the meaning of "expected value" to subjects not acquainted with statistics, especially if reference is made to the idea of a price averaged over years. Without such reference, it is likely that respondents will assess the modal price when asking for the expected value. Therefore, instead of asking the expected value of price of the coming year, farmers are asked to state the mean price they would have received had they sold via a particular marketing strategy over a number of years. This is probably a rather common way of thinking about strategies for farmers.

In this study the direct questioning procedure starts with selecting the farmer's own and therefore most familiar marketing strategy. Then, the following question is asked: "Imagine you would have applied this strategy consistently over 5 to 10 years. In some years you probably would have received a low price, in other years a high price. After a number of years you are able to calculate the mean price you received for your ware potatoes. Which mean price do you judge you would have received with this strategy?" Next, another strategy is randomly selected from the total set and the farmer is asked the same question again.

The mean price of all 100% marketing strategies is estimated in this manner. The elicitation task is limited to 100% strategies since in test interviews farmers automatically, i.e. without interviewer's suggestions in this direction, averaged mean prices they stated for 100% strategies to arrive at the mean price for 50%/50% marketing strategies. This observation strengthens the notion that farmers indeed understand the procedure and assess mean price instead of modal price.

As with the elicitation of subjective probability distributions, it is possible that distortions and biases are introduced by this question procedure. Because the question starts off with the farmer's own marketing strategy, the anchoring and adjustment heuristic may cause biases. The mean price a farmer states for his own marketing strategy may act as an anchor for the mean price he assesses for subsequent strategies; he may thus not adjust mean price sufficiently from this anchor. Also, by focussing on the prices in previous years, the availability heuristic might lead to an overweighting of prices a farmer received in the most recent years. In view of these possible disturbing effects the mean prices elicited will be mainly used for within-subjects analyses. The results of the direct measurement of the mean price will be presented in Section 5.5.

5.4.2 Magnitude estimation of price risk

Up until now, perception of a marketing strategy has been viewed as a probability distribution. Price risk is indicated by the second and higher moments of this distribution, e.g. the standard deviation is an adequate measure of risk in case of a symmetric distribution. Alternatively, one could leave the meaning of price risk open to the decision maker and assume the decision maker trades off risk against expected value. Such a view is articulated e.g. in the portfolio theory of Coombs (1975).

Not defining risk beforehand as a characteristic of a probability distribution is also more in accordance with usual scaling practices in the social sciences. One simply states that each farmer has some unarticulated and vague idea about the riskiness of a marketing strategy and that this idea can be measured by means of a general risk scale e.g. a 7-point category scale ranging from "very small risk" to "very large risk". No reference is made to probability distributions, standard deviations and so on. Such a procedure will probably be much easier for the respondent compared to the probability elicitation.

Of course, the subjective expected utility model cannot be used any more for determining the preference for a marketing strategy when perception is no longer defined as a probability distribution. However, one could just assume a simple trade-off model of expected value and risk to explain preferences. Price risk in this case is taken as a second attribute which decision makers take into account when evaluating choice alternatives (i.e. alternative marketing strategies). This manner of analyzing preferences is very common in e.g. and consumer research (see the perceived risk approach in consumer behavior). It is very interesting to study if such a simple model of preference formation performs much worse with respect to predictive validity than does the theoretically consistent expected utility model. In case the simple model performs equally well or only minorly worse, especially in survey conditions, the extra time and effort needed to elicit subjective probability distributions may not be warranted.

In order to test the above mentioned simple preference model and to compare the ease of measurement and results of the hard way (eliciting probability distributions) with the convenient way, price risk is left undefined and is measured by a direct scaling procedure.

The category scale could be used for this purpose. In the social sciences, this scale is well established and frequently applied in scaling responses. However, category scales suffer from a number of serious weaknesses (Lodge 1982). First of all, information is lost because of a limited number of response categories. Two stimuli placed within the same category are only "more or less" alike. Secondly, in principle only ordinal information is obtained, thereby constraining analyses. Many researchers use ordinal scales as if they are interval scales and they often do so with great success, e.g. the regression method appears to be rather robust: violations of internal assumptions does not usually lead to serious errors in parameter estimation (Bohrnstedt and Carter 1971). However, one is never certain about the interval properties of a category scale. Subjects must be able to scale differences between stimuli in a consistent way. Wegener (1983) showed that not all subjects are capable of performing this task. A third problem encountered with category scales is that the response of subjects is perhaps affected because the number of categories is both fixed and the same for each subject. Judgments are therefore constrained whenever the subjective range of people's impressions exceed the category response range.

Contrariwise, magnitude estimation is evaluated to be a better scaling procedure. This technique originates from psychophysics (see Stevens (1975) or Baird and Noma (1978) for a state of the art review of psychophysics).

In psychophysics, magnitude estimation is applied to scale the relationship between a physical stimulus, e.g. loudness or brightness, and the subjective sensation of the stimulus. Subjects are instructed to assign numbers to stimuli in proportion to their subjective magnitudes. In other words, subjects have to form number ratios in correspondence with subjective stimuli ratios. In practice, a reference stimulus is presented to a subject and the subject is then asked to form a number ratio of the intensity of a new stimulus with respect to the intensity of the reference stimulus. So if the brightness of a reference spot is given to equal 50 points, and if another spot is shown which is, according to the subject, twice as bright as the reference spot, then the subject should assign the number 100 to the latter spot. Other response modes than the number mode can be used, e.g. drawing a line or squeezing a calibrated hand dynamometer.[8]

Recently it has been suggested to apply magnitude estimation in scaling "social stimuli" like the progressiveness of a political party or social status of professions. Subjects appear to be capable of expressing ratio judgments in a consistent and reliable way for physical stimuli (however, Wegener (1983) found interindividual differences in this capability), so it is assumed subjects should be capable of making ratio judgments for social stimuli as well. Magnitude estimation has already been applied successfully for a large number of diverse social stimuli, such as the opinion of political candidates (Lodge 1982), the status of professions (Neijens et al. 1981) or the importance of perceived risks associated with buying an automobile (Grunert 1984). Here we will use magnitude estimation in order to measure the perceived risk of a marketing strategy.

We are interested in applying magnitude estimation in this study mainly because of the unlimited response scale respondents can use for expressing their perceptions and because of the ratio nature of risk. It is easy to imagine the price risk of a marketing strategy as being twice as large as the risk of another strategy. We consider this ratio nature of risk as being more apparent than the ratio nature of, say, the progressiveness of a political party. We expect magnitude estimation to produce more accurate estimates of risk perception, and to also be more comparable with the subjective probability distribution elicitations than a category scale of risk.

Our questioning format is in accordance with the recommendations of Saris et al. (1977) and Lodge (1982) concerning the use of magnitude estimation in large scale research. As a response mode we choose the so called line-production technique which is an easy to handle technique in survey situations. With this response mode a marketing strategy is presented to the farmer as a reference and the risk of this strategy is expressed by a line of arbitrary length. Next, a randomly selected strategy is presented to the farmer and the farmer is asked to compare the price risk he perceives with this strategy to the price risk of the reference strategy. If he perceives the price risk of the strategy as being twice as large as the price risk of the reference strategy, he should draw a line twice as long as the reference line. Should he consider the price risk as being a third of the risk of the reference strategy, then he should draw a line with a third of the length of the reference line etc. In this manner, all strategies are rated with respect to the reference stimulus. The task is organized in such a way that respondents make a comparison between a newly selected strategy and the reference each time, without being able to see their former responses.

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8 By applying magnitude estimation in a large number of experiments, using all sorts of stimuli, Stevens always found a power function relating the magnitude of the physical stimulus to the subjective response as measured by magnitude estimation. The consistent relationship found between the intensity of the physical stimulus and the subjective response is often called the psychophysical power law or Stevens law.

It is common practice in psychophysics to take as a reference stimulus a stimulus around or somewhat below the (subjective) middle of all stimuli to make sure there are stimuli perceived as smaller as well as larger than the reference stimulus. In test interviews 100% pooling at a cooperative company (Strategy 1) proved to be a suitable reference, not only because of the perceived mediocre riskiness in comparison with the other strategies, but also because of the clear and unambiguous understanding of this rather straightforward and well-known strategy.

To make sure farmers understood the procedure and would make ratio judgments instead of ordinal judgments, the farmers practised the technique with a number of surface areas as stimuli. As expected, farmers had little difficulty grasping the meaning of the technique and responded quite easily and quickly.

In this study, we only applied line-production as a response mode. Lodge (1982) recommends using at least two response modes (e.g. line-production and numerical estimates) to be able to test the internal validity of the scaling procedure (this is called the cross-modality matching method). However, because of the severe time constraints in this survey and the large number of questions farmers already had to answer, it was judged impossible to apply both response modes. Many studies in magnitude estimation with different types of stimuli and all sorts of subjects showed a good internal validity (see Lodge 1982), therefore we considered it justifiable to limit ourselves here to one response mode.

The results of directly estimating the mean price and price risk per marketing strategy will be presented in Section 5.5.

5.5 Results of directly measuring price perception

5.5.1 Results of direct measurement of perceived mean price

As discussed in Section 5.4.1 the mean price farmers associated with each marketing strategy were stated only for 100% strategies. Furthermore, the question was asked for only a subsample of farmers in 1985, thus limiting the number of observations in 1985. To differentiate between the direct estimates and the indirect estimates elicited by means of the interval technique (IMEA), the estimates are denoted as DMEA (direct estimate of mean price).

Table 5.8 shows the average results of DMEA in both years. The 100% spot market strategies (Strategies 4 and 6) are perceived in 1984 as strategies with the highest mean price. Especially selling at one moment at spot market prices is perceived to result in a high mean price, namely 26.8 cts/kg. For selling at two moments this figure is 25.1 cts/kg. The remaining three marketing strategies are perceived as being fairly equal in mean price. Strategy 4 again scores highest in 1985 but the difference with other strategies is much smaller than in 1984.

Table 5.8 Average results of direct estimates of mean price, per marketing strategy and per year, in cts/kg

		1984			1985		
	STRATEGY	MU DMEA	SD DMEA	N	MU DMEA	SD DMEA	N
1.	100% Pc	25.00	3.93	197	24.14	4.15	65
2.	100% Bp	24.90	4.06	190	24.39	3.36	66
4.	100% Sm1	26.84	6.67	191	24.61	4.87	63
5.	100% Pp	24.87	5.27	190	24.25	3.19	63
6.	100% Sm2	25.13	5.44	191	23.90	3.90	61

Comparing the average results of DMEA between both years shows that the average mean price for all strategies is higher in 1984 than in 1985, but this difference is only significant for Strategy 4 (pairwise t-test). An explanation for the higher mean prices in 1984 may be offered by the availability heuristic. According to this heuristic the most recent prices that farmers received, probably influenced the estimate of mean price most. Market prices were very high in 1983 and low in 1984. We therefore expect farmers to perceive a higher DMEA in 1984, after the year 1983 which was characterised by very high market prices, than they will expect in 1985, after a year characterised by low prices. The results confirm this expectation, although, because of the rather small number of pairwise observations, a significant difference is found for only one strategy.

Again, as with the interval technique, the order of strategies with respect to mean price is compared per individual. Table 5.9 shows the sample distribution of the Pearson correlations, calculated per farmer. The mean correlation is 0.32 with a median of 0.39 and 38% of the correlations being negative. Compared to the mean and median correlations of the interval technique, namely 0.36 and 0.34, the correlations of direct measurements are of the same magnitude.

Table 5.9 Sample statistics of the Pearson correlations computed per farmer between estimates of DMEA in 1984 and 1985 for corresponding marketing strategies

CORRELATIONS BETWEEN	Mean*	Median	St. dev.*	% < 0	N
DMEA 1984 and DMEA 1985	.318	.386	.654	38	53

* After Fisher r-to-z transformation

Effects of moment of delivery, number of selling moments and interviewer on perception

Appendix III shows the average results of direct estimates of mean price broken down by moment of delivery. Except for Strategy 1 in 1984 (100% pooling cooperative), the moment of delivery showed a significant effect in the hypothesized direction: the group of farmers delivering late in the marketing year perceive a higher mean price than the group of farmers delivering early. Again, as with the interval technique, farmers appear to be capable of incorporating the effect of storage costs in their perceptions in a valid manner.

To assess the effect of the number of selling moments, Strategies 4 and 6 (100% spot market) are compared pairwise. A significant effect is obtained in 1984: according to the respondents selling at one moment at the spot market results in a mean price which is 1.7 cts/kg higher than selling at two moments. A smaller effect is observed in 1985 and the significance of the pairwise t-test is $p = 0.054$ (one-tailed). The effect of the number of selling moments on perception are in line with those of the interval technique. In contrast with the interval technique, no significant effects of the interviewer are found for the direct estimates.

Heterogeneity in perception

The effect on price perception caused by the type of wholesale company farmers actually deal with is tested. Only in two occasions a significant difference shows up. Cooperative farmers perceive a significantly lower mean price for Strategies 4 and 6 (the 100% spot market strategies) in 1984 than do private farmers. Perhaps because cooperative farmers do not have the option of selling 100% at spot market prices they may be underestimating mean price. However, such an effect did not show up with the interval technique (using this technique, differences with respect to *pooling* between both groups of farmers showed up). Since no significant differences were found between both groups of farmers for all other strategies in 1984 and 1985, the effects for the two strategies found are incidental.

Furthermore, in dealing with the effect of type of wholesale company, Strategies 1 and 5 are compared pairwise. These strategies are similar except for the type of wholesale company. As was found by means of the interval technique no significant difference is found in the perception of mean price between the two companies, neither in 1984 nor in 1985.

It is concluded that in general no clear differences show up in our data with respect to perceived mean price between both groups of farmers. This conclusion suggests that farmers neither tend to rationalize their choice of a wholesale company nor do they choose a company because they expect a higher mean price (for similar strategies). Therefore, other motives are probably important for choosing between a cooperative and a private wholesale company.

Summary

Reviewing the results, it is concluded that directly measuring mean price yields reasonable and plausible outcomes. In contrast with the view of Spetzler and Staël von Holstein (1975) it appears to be possible to elicit in a valid manner the mean of a distribution even for respondents unacquainted with statistics. Compared to the indirect elicitation of mean price, results suggest the direct measurement to be even less susceptible to interviewer bias. Although distortions may have been introduced in the measurement by the farmer's use of availability and anchoring and adjustment heuristics, it can be said that in within-subject analyses these effects pose no problems.

5.5.2 Results of magnitude estimation of price risk

The perceived price risk of all strategies, 13 in 1984 and 18 in 1985, is estimated by means of magnitude estimation. In 1985, however, this was only done for a subset of respondents. The magnitude estimates are differentiated from other estimates of risk perception by denoting them RISK estimates. Table 5.10 shows the average results. In this table the line lengths drawn by the farmers are transformed into ratios with respect to the reference line.

In 1984 farmers perceive averagely 6 strategies as being riskier, 3 strategies as being of comparable risk and 3 strategies as being less risky than 100% pooling cooperative. In 1985 these figures are: 8 strategies riskier, 4 of equal risk and 5 strategies less risky. Thus, 100% pooling at a cooperative company indeed is perceived as a strategy of mediocre risk and therefore in line with the requirements for a suitable reference stimulus.

On average and in conformity with the expectations, the 100% spot market strategies (Strategies 4 and 6) are perceived as most risky; Strategies 7, 8 and 10 also are perceived as risky. Not surprisingly, the fixed-price strategies (3 and 14) are perceived as most secure.

In comparison with the risk perceptions of 1984 small differences show up in 1985. None of these differences is, tested pairwise, significant. Attention should be drawn, however, to what one ought to expect of these differences. Because strategies are compared to a reference strategy, differences will only show up if the ratio between a strategy and the reference differs between the years. It is perfectly possible that the absolute magnitude of risk farmers perceive of strategies in 1985 is e.g. larger than in 1984, as is the case with the indirect measurement of perception (ISTA), without changing the ratios between strategies. However, with magnitude estimation no differences between years are detected if the ratios do not change. This shows the relative nature of the magnitude estimates compared to the absolute estimates of price risk obtained by eliciting subjective probability distributions.

Table 5.10 Results of measurement of price risk obtained by magnitude estimation, in ratio's with respect to marketing strategy (100% Pc)

	STRATEGY	1984 (N = 223) MU RISK	1984 (N = 223) SD RISK	1985 (N = 67) MU RISK	1985 (N = 67) SD RISK
1.	100% Pc*	1.00	.00	1.00	.00
2.	100% Bp	.95	.29	.96	.22
3.	100% Fp1	.29	.40	.42	.45
4.	100% Sm1	1.53	.53	1.51	.48
5.	100% Pp	1.02	.21	1.00	.19
6.	100% Sm2	1.26	.39	1.35	.39
7.	50% Pc/50% Sm1	1.13	.27	1.15	.23
8.	50% Bp/50% Sm1	1.12	.31	1.15	.28
9.	50% Fp1/50%Sm1	1.00	.33	.99	.30
10.	50% Pp/50% Sm1	1.15	.28	1.14	.27
11.	50% Pc/50% Sm2	1.07	.25	1.08	.23
12.	50% Fp1/50% Sm2	.97	.28	.98	.31
13.	50% Fp1/40% Bp/10% Sm1	.86	21	.94	.32
14.	100% Fp3	-	-	.36	.40
15.	50% Fp3/50% Sm1	-	-	.94	.30
16.	50% Pp/50% Sm2	-	-	1.11	.23
17.	25% Pp/25% Fp1/50% Sm1	-	-	1.02	.28
18.	25% Pp/25% Fp1/50% Sm2	-	-	1.09	.30

* Reference stimulus

The rank order of strategies with respect to RISK is quite similar in both years when considering average estimates (Spearmans rho computed on average data in Table 5.10 is 0.94). Also, the Pearson correlation between RISK measurements is calculated *per individual* in 1984 and 1985. The sample mean correlation is 0.48, with a median correlation of 0.50 and 25% of the correlations being negative. Thus, correlations for RISK are somewhat smaller than those for ISTA; the average correlation for ISTA is 0.59 compared to 0.48 for RISK and the median correlation for ISTA is 0.60 compared to 0.50 for RISK. However, differences are not substantial. Both measurements show the high correspondence in price risk order between 1984 and 1985.

Effect of moment of delivery

Dealing with the effect of moment of delivery on price risk perception, the same argument as was held for the difference between years is valid. Since farmers only evaluate strategies for one specific moment of delivery and always with respect to the same reference line, an effect of delivery period will never show up if the *ratios* between strategies are constant over moments of delivery. The question to be answered then is whether one can expect ratios to change with the moment of delivery. Although it is difficult to make precise statements about the ratios, spot market strategies probably show the largest chance of finding ratios to change with the moment of delivery. Since price variability increases from harvest (in September) to July the perceived risk of selling at spot market prices later in the marketing year should be larger than selling earlier in the year. Because the risk of Strategy 1 remains constant over the whole marketing year, a larger risk ratio for later moments of delivery should be found with spot market strategies, especially 4 and 6, in later delivery periods.

Testing the constancy of the risk ratios over moments of delivery shows mixed results. A significant difference in ratios between moments is only found for 5 out of 29 strategies. Firstly, farmers perceive a larger risk for Strategy 4 in 1984 and 6 in 1985 when delivering late in the season than do farmers delivering earlier. This confirms our expectations. However, no significant effects showed up for Strategy 6 in 1984 or Strategy 4 in 1985. Thus, the two significant effects are rather incidental. Secondly, significant effects are found for Strategies 2 and 7 in 1984 and 8 in 1985. However, these effects are somewhat peculiar since the risk ratio does not increase or decrease monotonically with the moment of delivery, e.g. the ratio is highest for the period January - March. Taking this all together then, the effects of moment of delivery found seem fairly incidental and it is therefore concluded that in general risk ratios are constant over these moments.

Effects on risk perception of number of selling moments, type of wholesale company and interviewer

In both years, farmers perceive selling at one moment at the spot market as being riskier than selling at two moments (pairwise t-test). This confirms our expectations and is in line with the results of indirect measurement.

No significant differences are found when testing pairwise the differences between strategies which are similar except for the type of wholesale company (Strategies 1 and 5, 7 and 10, 11 and 16). The risk of selling e.g. via 100% pooling at a cooperative company is not perceived as more (or less) risky than selling via 100% pooling to a private company. Furthermore, no difference in risk perception is found between farmers actually dealing with a cooperative and farmers dealing with a private company. Their perception is homogeneous in this respect. These results are thus in accordance with the results of indirect measurement.

Interviewer effects are found for 8 out of 12 strategies in 1984 and for 3 out of 18 in 1985. It therefore seems that magnitude estimation is susceptible to interviewer bias as is the measurement of standard deviation by means of indirect measurement. We should thus focus primarily on within-subject use of measurements.

5.5.3 Summary and conclusion of measuring price perception directly

In Figure 5.5 the direct estimates of mean price and price risk are presented, both for each year separately and combined in one picture. Circles concern measurements carried out in 1984, squares concern those carried out in 1985. Strategies which closely approach each other are shown in one square or circle. The direct estimates of mean price of 100% strategies are used to compute the average mean prices for combinations of strategies. So, if the average mean price for 100% spot market is, say 26 cts/kg and for 100% pooling 24 cts/kg, then the average mean price for the strategy 50% pooling, 50% spot market is 25 cts/kg.

Figure 5.5 shows that the average mean price in 1984 is higher than in 1985: all circles are positioned above the squares. However, only for Strategy 4 this difference is significant (Section 5.5.1). Secondly, the risk ratios are similar in both years. In 1984, the most favorable strategies, forming an efficiency frontier, are: Strategy 3 (100% fixed-price) with a fairly low mean price but also very small risk, Strategy 9 (50% fixed-price, 50% spot market (selling at one moment)) with a mediocre mean price but also a medium amount of risk, and Strategy 4 (100% spot market (selling at one moment)) which is highest in mean price but also perceived as most risky. It depends on the degree of risk aversion of the decision maker which of these three strategies he prefers. On average, the remaining strategies are dominated by the three strategies mentioned above with respect to mean price and price risk.

The results of 1985 are fairly similar to those of 1984 although Strategy 2, the 100% bottom-price contract, is now on the efficiency frontier instead of Strategy 9. Strategies 8, 10 and, to a lesser extent, 7 are also on the efficiency frontier. These three strategies all concern a combination of a 50% contract selling-option (respectively bottom-price and pooling) with 50% spot market (selling at one moment). This shows the theoretically expected effect of diversification: a combination of selling-options leads to medium levels of expected value and risk in comparison to strategies consisting of a single selling-option (extreme in expected value and risk). Farmers' perceptions are well in line with these theoretical expectations.

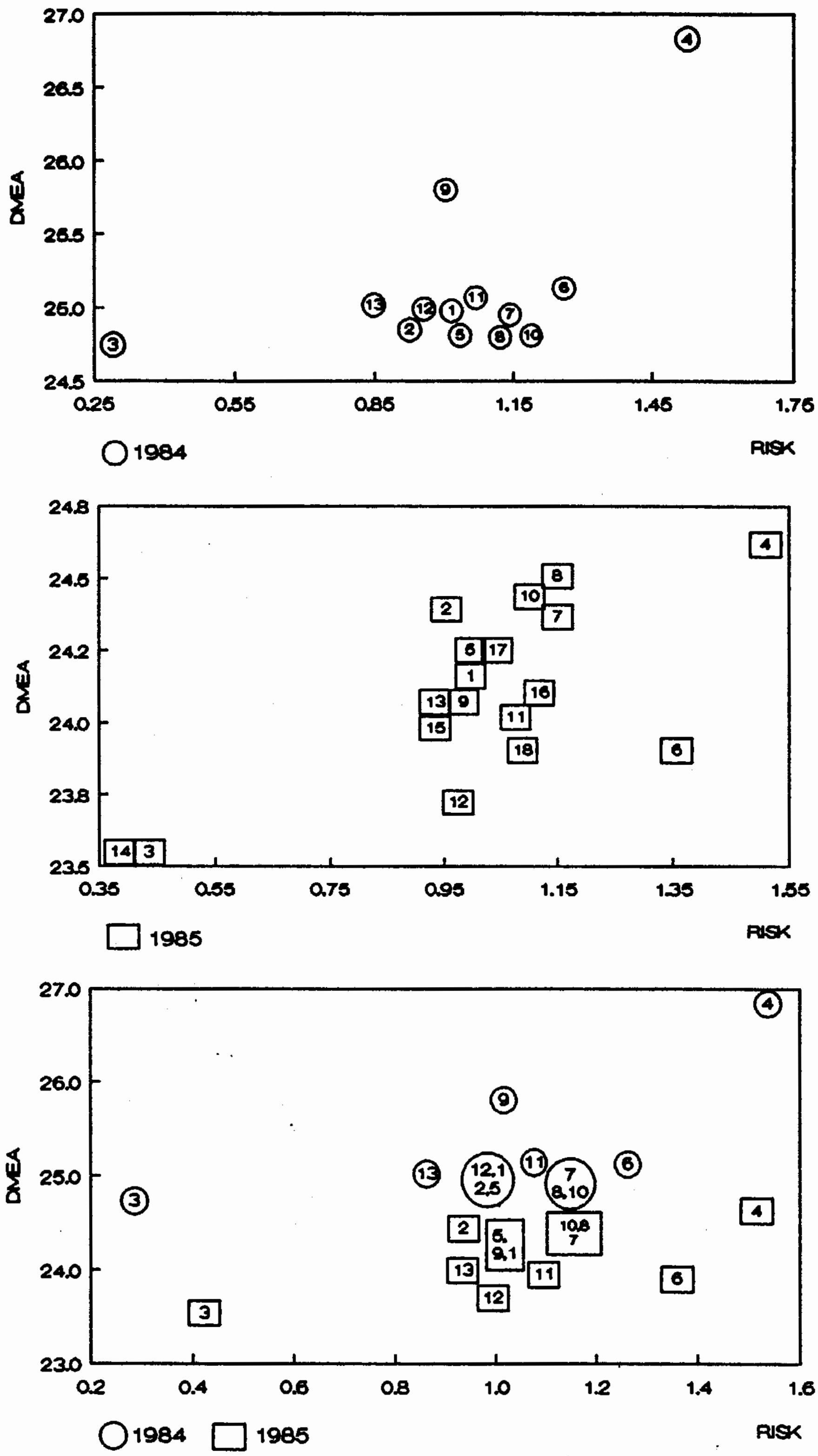

Figure 5.5 *Average perception of marketing strategies with respect to mean price (DMEA) and price risk (RISK), in both years (data in Tables 5.8 and 5.10)*

In both years, Strategy 6 is perceived as unattractive to a fairly dramatic extent. The position of this strategy is quite surprising. Farmers perceive this 100% spot market strategy with two selling moments as resulting in a fairly poor mean price whereas the risk level is hardly less than the one associated with the 100% spot market strategy with one selling moment (Strategy 4). Apparently, farmers are of the opinion that diversified selling *within* the marketing year hardly reduces risk, whereas expected price is reduced relatively strongly. With the indirect measurement differences between Strategies 4 and 6 were more in line with expectations.

In this section the results of two direct and easy questions dealing with price perceptions of marketing strategies were discussed. Respondents showed no difficulties in answering the questions about mean price and magnitude of price risk. Both questions took only 3 to 5 minutes each to complete. The validity of the measurement was confirmed in testing the effects of moment of delivery and number of selling moments. The direct elicitation of mean price may be susceptible to heuristics like anchoring and adjustment and availability, and a systematic interviewer bias showed up for magnitude estimation. However, the measurements provide a reasonable and consistent picture of farmers' perceptions, in so far as this can be tested. The measurements may yield satisfactory results in predicting preference, especially when applied to within-subject analysis.

5.6 Comparison of direct and indirect measurement

This section presents an analysis of the correspondence between direct and indirect measurement results. Attention should be paid to convergent validity in order to evaluate the validity of the measurements. Convergent validity implies a correspondence between measurements obtained by independent measurement procedures which intend to measure the same construct. Convergent validity is established if IMEA and DMEA on the one hand and ISTA and RISK on the other hand are fairly highly positively correlated.

At the same time, it is expected that correlations between estimates of mean price and estimates of price risk are also positively correlated. An expected high value should go together with a high price risk. That is, an expected low value should be compensated by a relatively low risk. Otherwise dominance between strategies exists.

Before turning to a presentation of the correlations between the various measurements, we first concentrate on the comparison of absolute measurements of mean price estimates. In Table 5.11, the perceived mean price is presented per strategy, per year and for both techniques. It is clear that the direct estimate of mean price is higher for all marketing strategies in both years. For all strategies these differences are significant (pairwise t-test). On average, the difference in mean price between the techniques is at least 1.3 cts/kg for the 100% bottom-price contract (24.90-23.58) and no less than 3.3. cts/kg for Strategy 4 (100% spot market (selling at one moment)) in 1984. The differences are smaller and not significant in 1985 (note, however, that in 1985 only +/- 40 pairwise observations are available for testing, thus making it difficult to find significant effects).

The difference in mean price between both measurements procedures is perhaps induced by the questioning procedure. In the *indirect* measurement procedure, farmers are explicitly asked to assess the probability distribution concerning the price of the *coming* year. The wording of the *direct* question, however, more directed towards the *past*. In the direct question, farmers may have assessed a historic mean price without attaching full weight to specific information about the coming marketing year. Their adjustment from the historic mean price may be insufficient. If DMEA is viewed as representing a historic mean price, then it can be concluded that farmers (in June) perceived prices in both 1984 and 1985 as below average (as is indicated by indirect question). As became clear afterwards, prices in both years indeed were below average (see Table 2.2).

A comparison with respect to the dimensions of mean price and price risk between both measurement procedures (compare Figure 5.3 with Figure 5.5) especially points to the difference in position of Strategy 4. By means of the indirect measurement procedure, this strategy is perceived as high in risk and low in mean price (and consequently unattractive to a risk averse farmer), whereas direct measurement shows this strategy to be perceived as high in risk but also high(est) in mean price. Again, this difference may well be induced by the above mentioned difference in focus of the question. The historic mean price of Strategy 4 is probably perceived as fairly high (direct measurement) but farmers expected a lower price than this historic mean price in both 1984 and 1985, while focussing on the year to come (indirect measurement). Market information in these years apparently induced them to adjust their expectations based on past experience with respect to the mean price of Strategy 4, in a downward direction for both years.

Table 5.11 Comparison of indirect and direct estimates of perceived mean price, per marketing strategy and per year, in cts/kg

		1984		1985	
	STRATEGY	MU IMEA	MU DMEA	MU IMEA	MU DMEA
1.	100% Pc	23.29	25.00	22.42	24.14
2.	100% Bp	23.58	24.90	24.18	24.39
4.	100% Sm1	23.56	26.84	23.23	24.61
5.	100% Pp	-	24.87	22.82	24.25
6.	100% Sm2	23.21	25.13	22.86	23.90

The results of the correlations calculated over strategies and per farmer are presented in Table 5.12. The sample average and median are shown for each correlation. Only Pearson correlations are shown since they did not differ much from Spearman correlations. Correlations printed in *italics* concern the agreement between orders of strategies in 1984 and 1985. These correlations were already presented in the above sections, but are reproduced here with the purpose of enabling direct comparisons. Correlations printed in **bold** concern the convergent validity of the measurement, whereas the remaining correlations indicate the correspondence between expected value and price risk.

Table 5.12 shows an average convergent validity correlation with respect to convergent validity in 1984 between IMEA and DMEA of 0.34 with a median of 0.32 (and 32% of the correlations being negative (not shown in the table)). These figures are somewhat smaller in 1985: an average of 0.16, a median of 0.25 and 38% negative correlations. A Pearson correlation coefficient is also computed over both strategies and individuals, after standardising the data per individual. These correlations are 0.24 for 1984 and 0.23 for 1985 and they are both significant. With respect to the percentages of negative correlations, it should be noted that each correlation is based on a small number of observations (5 to 7). In such a case, even random influences can easily result in low or negative correlations.

The convergent correlations between the risk measurements, ISTA and RISK, are larger in both years than correlations between measurements of mean price. In 1984, a mean correlation of 0.53 results with a median of 0.56 and 22% of the correlations being negative. In 1985, these figures are: a mean correlation of 0.33, a median of 0.39 and 37% negative correlations. Computed over strategies and individuals the correlations are 0.40 in 1984 and 0.32 in 1985 and they are both significant. Again, correlations in 1985 are smaller than those in 1984, which also holds for the mean price estimates. This is probably due to the relatively smaller differences between the strategies 1985 compared to those in 1984. To some extent, the farmers perceive the strategies as more or less alike in 1985, so correlations between two measurements procedures tend to attenuate.

When comparing convergent correlations of mean price with those of price risk, the latter turn out to be higher. The risk order of marketing strategies is apparently less sensitive to the measurement technique than the order of expected values (also the risk order of strategies in 1984 corresponds better with the order in 1985 than does mean price: median is 0.60 compared to 0.34). An explanation of this finding might be that estimates of expected value are probably closer in absolute value between strategies than estimates of standard deviation or risk ratios. In such a case, small random response errors easily lead to low correlations between procedures measuring this expected value. Stated otherwise: farmers apparently perceive relatively less differences between strategies with respect to mean price than between those with respect to risk.

The correlations between mean price and price risk are predominantly positive but fairly small (Table 5.12). The indirect measurement shows the largest positive correlation between mean price and price risk. However, the percentages of correlations that are negative are fairly high. With respect to the correlations between IMEA and ISTA these percentages are 41% in 1984 and 40% in 1985. Between DMEA and RISK these percentages are 45% and 41% respectively. It can thus be concluded that for many farmers a high expected value not necessarily goes together with a high price risk. In Chapter 7 more attention will be given to the consequences of this finding in relation to the testing of the expected utility model.

Table 5.12 *Pearson correlations between the indirect and direct measurement of perceived mean price and price risk, computed over strategies per farmer (pairwise deletion of missing values, N ranges from 53 to 206)*

Average correlations*

	IMEA		DMEA		ISTA		RISK	
	1984	1985	1984	1985	1984	1985	1984	1985
IMEA	*.36*							
DMEA	**.34**	**.16**	*.32*					
ISTA	.17	.23	.14	.01	*.59*			
RISK	-.14	-.06	.05	-.06	**.53**	**.33**	*.48*	

* After Fisher r-to-z transformation

Median correlations

	IMEA		DMEA		ISTA		RISK	
	1984	1985	1984	1985	1984	1985	1984	1985
IMEA	*.34*							
DMEA	**.32**	**.25**	*.39*					
ISTA	.19	.21	.15	-.08	*.60*			
RISK	-.14	-.12	.07	.09	**.56**	**.39**	*.50*	

Italics: correlations of same techniques between both years
Bold: convergent validity correlations
Normal: correlations between mean price and price risk

Overall, because correlations between convergent measurements are clearly positive and significant, the conclusion of a satisfactory correspondence between the indirect and direct measurement technique seems warranted. Especially when taking into account the survey conditions of limited time available for training and motivating the respondents, the active involvement of the interviewer in the measurement process and the confrontation of respondents with tasks unfamiliar to them, one would not expect to find very high correlations between corresponding measurements. However, since no studies are available with which to compare our correlations, it is impossible to state whether the convergent validity of the measurements is lower than would be appropriate for such measurements under these conditions.

5.7 Major findings and conclusions

This chapter dealt with the prices farmers perceive to be associated with different marketing strategies. These perceptions are an essential element in explaining preferences for marketing strategies. Two approaches to measure these perceptions have been applied.

In the first approach, price perception of a marketing strategy is represented by a farmer's subjective probability distribution. Expected utility theory offers a framework for combining this probability distribution with a farmer's risk attitude in order to form preferences. The interval technique is applied for eliciting the subjective probability distribution. The farmer has to specify the price he expects to receive with a certain marketing strategy for five points on the cumulative probability distribution. Then a probability distribution function is fitted to these five elicited points, to estimate mean, standard deviation and skewness of the distribution. A lognormal distribution proved to fit the data better than a Weibull distribution. This way of measuring perception is called the *indirect method* since mean and standard deviation are indirectly obtained by means of questions about percentiles questions and a function fitting procedure.

The second approach is called the *direct method*. By means of this method, the farmer is asked to state directly the mean price he expects with a certain marketing strategy. Subsequently, the price risk of a marketing strategy is obtained by magnitude estimation. The farmer expresses the risk he perceives with a strategy by drawing a line. It should be noted that the exact meaning of risk is not defined (e.g. as standard deviation) in this procedure, but left open to the respondent.

The main difference between both approaches of course is that the direct method does not lead to a probability distribution and that the expected utility model therefore cannot be applied to the formation of preferences. However, a straightforward model consisting of two attributes, namely mean price and price risk, can be formulated to predict preferences for marketing strategies.

Detailed conclusions about the results of each technique and a direct comparison of both techniques with respect to findings and validity of the measurements are presented in Sections 5.3.5, 5.5.3 and 5.6. Here we will focus on some major findings.

The price perception of marketing strategies

Findings show that the farmers expected mediocre market prices in both years (expected values of strategies are +/- 23 cts/kg) . In both years however, the farmers were clearly too optimistic considering that the actual spot market price turned out to be 13 (1984) and 10 cts/kg (1985). Farmers perceived more price risk in 1984 than in 1985. Apparently in 1985 the farmers were less sure about prices.

Considering the mediocre market prices that they expected, it is not surprising to find that the farmers think that two fairly safe strategies will do well in these circumstances. More specifically, Strategy 2 (100% bottom-price) and Strategy 9 (50% fixed-price, 50% spot market (selling at one moment)) are perceived in such a way, that they can be considered very attractive strategies by risk averse farmers. Many farmers perceive both strategies on the efficiency frontier in both years. Contrariwise, many farmers perceive the 100% spot market strategies (Strategies 4 and 6) in such a manner that they are unattractive if the farmer is risk averse. Both strategies can be characterized by a high price risk which does not go together with a substantially high expected value. Especially selling at two moments at spot market prices is unattractive in this respect.

The validity of the measurements

The effects of moment of delivery, number of selling moments and interviewer were tested systematically in order to establish the validity of the measurement. Furthermore the heterogeneity in perception was researched. The following effects were found for both measurement techniques.

- Farmers perceive, as expected, a higher mean price when delivering later in the marketing year.
- Selling at two moments at the spot market reduces mean price and price risk compared to selling only at one moment.
- Farmers perceive no difference between strategies which are similar in every aspect but type of wholesaler. Also, no significant differences in perceptions have been found between farmers actually dealing with a cooperative or a private company. This means that farmers neither rationalize their choice of a wholesale company nor choose a company with the expectation of receiving higher mean prices with equal or smaller risks. Other motives than price apparently play a role in the choice of a marketing channel.
- Systematic interviewer effects on perception of mean price and standard deviation of price were found for the indirect method. Also, the magnitude estimation of price risk is significantly affected by the interviewer. Considering these effects, perception data preferably should be analysed within-subjects.

- The direct method resulted in higher mean prices than the indirect method. An explanation for this finding was provided by pointing out the difference in focus of the methods.

Convergent validity of the measurements is studied by correlating per individual measurements obtained by the indirect method with those obtained by the direct method. This resulted in a positive and significant sample median correlation for mean price and an even higher median correlation for price risk. Although the correlations are fairly low, it is not clear what one can denote as high or low as there is a lack of comparable studies. Considering the survey circumstances in this study the fact that average and median correlations are positive and significant is at least a promising indication of validity of the measurements.

Overall, results indicate that plausible perceptions are obtained and that measurement procedures can be denoted as reasonably valid. An interesting point which has not yet been dealt with concerns the question of which of the two measurement procedures should be preferred. The advantages and disadvantages of both procedures are briefly summed below.

Advantages and disadvantages of each method

The main advantage of the indirect method is that a subjective probability distribution is obtained, which is an essential element in sophisticated theories of decision making under risk, like e.g. the subjective expected utility model.

The main disadvantage of the indirect scaling method is the complexity of the procedure. The elicitation of subjective probability distributions is judged as fairly difficult (no responses have been obtained for about 15% of the farmers), quite time-consuming (about half an hour for 6 or 7 strategies), requiring an active role on part of the interviewer thus making the question vulnerable to interviewer bias, and, finally, as rather boring if a number of probability distributions have to be elicited. This necessitates the assessment of only a limited number of distributions, given the limited time available for an interview. One might speculate that computerized elicitation may be an improvement of the procedure, if it can especially influence positively the motivation of the respondent, thus enabling more elicitations to be made. From the viewpoint of practical feasibility, the technique, as applied in this study, is not very suitable for large scale survey research. However, considering the problems associated with eliciting probability distributions in survey conditions, the consistent and plausible results that are found here seem even more surprising.

Compared to the indirect method, the direct questioning procedures of mean price and price risk are easy and quick (less than 5 minutes each). Respondents did not show any difficulty in answering these questions, resulting in hardly any nonresponse. Also, estimates could be obtained for all alternatives (marketing strategies), whereas the indirect method elicitations had to be limited to 6 or 7 strategies. Direct procedures, as used in this study, seem much more suitable for survey research with severe time constraints and limited opportunities for training and motivating respondents.

The main disadvantage of the direct method, of course, is the fact that no subjective probability distribution is obtained. The direct estimates, as elicited in this study, can therefore only be used in theoretically naive models like a linear model with expected value and price risk as attributes to be traded-off against one another.

Theoretically speaking therefore, knowledge of the subjective probability distribution of a farmer should provide a much better way of explaining and predicting choices under risk, provided this probability distribution can be validly elicited. In order to counterbalance the costs and effort involved in measuring probability distributions, a prediction of preference by means of these probability distributions should be of *substantially* better quality than prediction by means of a model using the direct estimates. In Chapter 7 the difference in predictive validity of both measurements and their respective preference formation models will be extensively studied. Then the indirect approach has to prove its worth.

CHAPTER SIX

RISK ATTITUDE, STRENGTH OF PREFERENCE AND RELATIVE RISK ATTITUDE

6.1 Introduction

This chapter is concerned with the analysis of a farmer's risk attitude. The primary reason for measuring the risk attitude is to get an evaluation function which can be used to rank order probability distributions. This evaluation function is thus intended to be incorporated in the subjective expected utility model in order to explain and predict the farmers' preferences with respect to marketing strategies. The usefulness of the evaluation function to these ends will be analyzed in Chapter 7. The assessment of the evaluation function, however, is only one of several goals of the analysis in this chapter. Another aim, related directly to the decision problem of the farmers and of wholesale companies dealing with farmers, is to provide a characterization of a sample of farmers with respect to risk attitude and to study the relationship of this concept with various characteristics of the farmer or his farming situation.

Scientifically more interesting, however, are the following two topics. Firstly, to test the concept of relative risk attitude (Dyer and Sarin 1982). The hypothesis of a relative risk attitude makes it necessary to include the concept of strength of preference in the analysis. Empirical research into the concept of relative risk attitude and the specific functional relationship between risk attitude and strength of preference has been conducted only sparingly (see Chapter 3).

The second topic concerns the evaluation in survey research of the validity, reliability and suitability of procedures used to measure risk attitude and strength of preference which originate from and are applied mainly in controlled and well defined settings of decision analysis. Evaluations of risk attitude assessments have been performed chiefly in decision analysis and in laboratory experiments. In both contexts, but especially in experiments, much attention is devoted to the detection of judgmental biases and errors in utility assessment. The findings of these studies show the sensitivity of the assessment to a variety of factors. In contrast, survey studies, often involving a large number of decision makers, typically make use of only one measurement procedure in risk attitude assessment. In these survey studies no or only some attention is devoted to the validity and reliability issue of assessments. By applying four measurement procedures in this study, consisting of two risky and two riskless procedures, and by repeating each measurement for the same respondent, insight into the research topics mentioned above is gained.

In analyzing the mentioned above topics, two data analysis approaches can be applied which are linked to a distinct conception of risk attitude and strength of preference. Generally stated, one might link the first approach to a conception of risk attitude and strength of preference typically found in utility theory and decision analysis, while the second approach is more in line with that generally found in the social sciences, particularly in psychology. The latter approach will be referred to as latent variable approach. Both conceptions will now be briefly described.

The first approach is directly linked to expected utility theory. In the context of the subjective expected utility model, measuring someone's risk attitude implies assessing a utility function u(x) by means of lotteries. The shape of this function indicates the risk attitude (and this shape is characterized completely by the Pratt-Arrow coefficients of risk aversion). The function itself is essential since in this approach the ultimate goal of analysis is to order probability distributions by means of the assessed function.

It is standard practice to use lotteries in measuring this utility function. By using lotteries, decision makers' preferences of are assessed in the presence of risk and, as a consequence, these preferences reveal the decision maker's attitude towards risk. In contrast, it has been suggested to use a riskless measurement procedure in assessing a so-called strength of preference or value function v(x) (see Chapter 3). Some contend that this value function will or should be linearly related to the utility function (e.g. Allais 1979, von Winterfeldt and Edwards 1986). Others hypothesize that the relationship between the functions is not necessarily linear (e.g. Bell and Raiffa 1982, Dyer and Sarin 1982). Since the utility function is measured in the presence of risk and the value function is measured under certainty, in their view the first function reveals a decision maker's risk attitude whereas the latter shows his attitude in riskless conditions. The latter attitude will be referred to as a decision maker's strength of preference. Moreover, in case of a non-linear relationship between the utility and value function, this departure from linearity is interpreted as a measurement of the true/real risk attitude of a decision maker and is referred to as the relative risk attitude. This utility theoretic conception of risk attitude, strength of preference and relative risk attitude then makes it necessary to measure a utility and a value function, followed by an analysis of the shape of each function, the differences in location of the functions and their functional relationship.

In the second approach, i.e. the latent variable approach, the risk attitude of a decision maker is not restricted to a utility or value function. Risk attitude is conceived as a latent, that is, not directly observable, variable which can be measured by means of one or more indicators. Such a conception and operationalization of risk attitude is in line with standard psychometric practice. Measuring risk attitude or strength of preference in this manner is analogous to procedures applied in measuring concepts like intelligence, self esteem or a person's attitude towards an object. In this latent variable approach no evaluation function is obtained so that it is not possible to order probability distributions per individual and thus analyze preferences for marketing strategies. The focus is on characterising a decision maker with respect to risk attitude and not on ordering probability distributions.

This second approach should imply the development of a sample of indicators of both risk attitude and strength of preference. For example, asking a respondent to indicate his extent of agreement with a number of statements concerning risky choice behavior. However, instead of collecting extra data in this manner, a more simple and better way of analyzing this latent variable concept of risk attitude and strength of preference is to make use of the data that have been collected in the first approach.

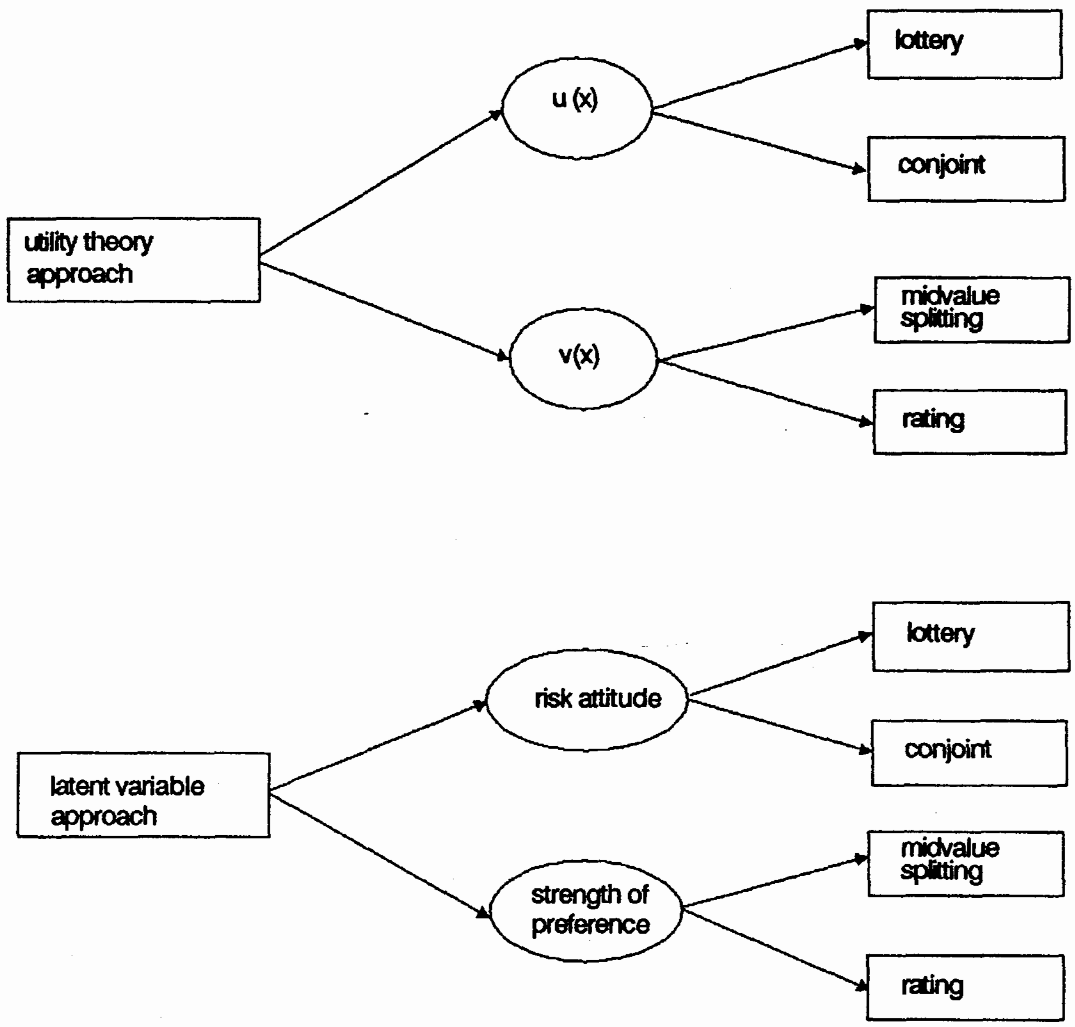

Figure 6.1 Two approaches in structuring the analysis of risk attitude and strength of preference

In Figure 6.1 both approaches are shown schematically. Four measurement procedures are applied, twice for each respondent. The two risky procedures concern the lottery technique and conjoint measurement. By means of these techniques an assessment is obtained of the utility function u(x) and of the risk attitude as a latent variable. The two riskless procedures consist of the midvalue splitting and rating technique. The value function v(x) and the latent variable strength of preference are obtained with these techniques. Focus in the utility theory approach is on the function that is obtained by each technique (typical analyses concern the shape of the function, the degree of risk aversion, the magnitude of temporal shift of the function from 1985 to 1984). Especially the functional relationship between u(x) and v(x) will be given attention to, i.e. the hypothesis of a relative risk attitude.

In the latent variable approach, the four procedures serve as indicators of, respectively risk attitude and strength of preference. Of course, the functions obtained by the techniques cannot be directly used to this end. The functions will therefore be uniquely represented by the Pratt-Arrow coefficients of risk aversion, yielding one score for each procedure for each respondent. Typically, analyses in this approach consist of calculating correlations between the indicators over respondents, resulting in a multitrait-multimethod matrix. In this manner convergent validity and temporal stability of each concept can be assessed. Subsequently, the relationship between both concepts can be analyzed.[1] The analytical framework of LISREL (Jöreskog and Sörbom 1976, 1977, 1984) appears very suitable in analyzing such multitrait multimethod matrices. In each of the following Sections 6.5, 6.6 and 6.7, both approaches will be paid attention to.

The structure of this chapter is as follows. Firstly, the design and results of the two risky procedures, the lottery technique (in Sections 6.2 and 6.3) and conjoint measurement (in Section 6.4), will be presented. Subsequently, in Section 6.5 the correspondence of these techniques will be analyzed with specific attention given to stability and convergent validity of risk attitude assessment. In Section 6.6 the design and results of the two riskless procedures, the midvalue splitting and rating technique, are dealt with. This is followed by an analysis of the correspondence between the techniques in assessing strength of preference. In Section 6.7, the correspondence between strength of preference and risk attitude will be analyzed. The mutual location of the functions u(x) and v(x) will be analyzed and the hypothesis of the relative risk attitude will be tested.

These analyses are followed in Section 6.8 by an analysis of the relationship between the risk attitude and variables characterizing the farmers and/or their farming situation. In this section, it is tested whether e.g. old farmers are more risk averse than young farmers or whether farmers with large farms differ in risk attitude from farmers with small farms. An analogous analysis will be performed

1 It is important to note here the relationship between both approaches with respect to the concept of relative risk attitude. If, for all or most of the respondents, $u(x) = a + b\,v(x)$ $(b > 0)$, then the correlation between the latent variables risk attitude and strength of preference computed over respondents will be highly positive (these findings would imply a refutation of the hypothesis of a relative risk attitude). If u(x) and v(x) are not related linearly, then the correlation between latent variables risk attitude and strength of preference computed over respondents will be low or might even be negative (these findings would imply a confirmation of the hypothesis of a relative risk attitude).

with respect to strength of preference and relative risk attitude. A summary of the major findings and the main conclusions conclude this chapter (Section 6.9).

6.2 Measurement of risk attitude by means of lotteries

In this section, a review of the techniques for assessing utility functions will be given first (6.2.1). This review results in the choice of using the so-called midpoint chaining method in assessing points of the utility function. The selection of suitable functional forms and the method for estimating the parameters of these functions will be dealt with in 6.2.2. Finally, in 6.2.3 the results of the measurement will be described.

6.2.1 Review of techniques for assessing utility functions

A von Neumann-Morgenstern utility function can be assessed by means of a number of techniques. In this section a review of optional techniques will be given and strengths and weaknesses of the techniques will be presented. First now, two general remarks have to be made.

Firstly, it is important to state here that for all techniques presented below, it is assumed that respondents respond in accordance with expected utility theory, that is, in the assessment task respondents conform to the axioms of expected utility. Essentially then, the method of measurement is not independent of the theory. This, of course, is precisely the argument of e.g. Allais (1979) in his criticism of expected utility theory. Since in the view of Allais decision makers do not choose in accordance with the independence axiom, the assessment of a utility function, representing the risk attitude, is not possible.

Secondly, as Farquhar (1984, p. 1285) states in his extensive review of utility assessment techniques: " ... behavioral research on decision making demonstrates the labile nature of preference judgments. Seemingly subtle changes in problem structure, question format, response mode, individual perspective, or other aspects of the assessment process can sometimes dramatically change the preference responses of an individual decision maker". Many such biases have been reported (see e.g. Hogarth 1980 and Hershey et al. 1982) and some will be discussed later on in this section. To say the least, behavioral research indicates that assessment of utility functions should be considered a difficult task which must be handled with great care. Important elements in careful assessment are: providing a clear and unambiguous decision context, specifying the attribute of interest clearly, training the respondent and interviewer in the assessment task, and checking for inconsistencies in responses. Furthermore, it is recommended to utilize more than one technique in order to study convergent validity. Predictive validity will of course be a final check on the validity of the assessment.

Classification of assessment techniques

An elaborate review of assessment techniques of utility functions can be found in Farquhar (1984). He differentiates as much as 24 different variants. In almost all variants *binary lotteries* (i.e. lotteries with two outcomes) are used in the assessment, mainly because binary lotteries are the easiest to grasp for respondents. Moreover, a respondent has to compare only *two* binary lotteries at a time. It is reasoned that assessing the utility function in this most simple manner will minimize response error and maximize the chance that respondents behave according to the expected utility model.

In the presentation below, a binary lottery will be denoted as $[x_1, p, x_2]$ which stands for a lottery which yields outcome x_1 with probability p and outcome x_2 with probability $(1 - p)$. If either $p = 0$, $p = 1$ or $x_1 = x_2$, the lottery is degenerate because a particular outcome is certain.

A preference comparison of two binary lotteries involves the following expression:

$$[x_1, p, x_2] \; R \; [x_3, q, x_4] \qquad (6.1)$$

where all items but one are fixed beforehand and the respondent has to specify the remaining item, so that Equation 6.1 holds. R in 6.1 denotes the preference relation between the lotteries, and consists of: > (is more preferred than), < (is less preferred than) or = (is indifferent to). For example, if the respondent is offered two lotteries in which the four outcomes as well as the probabilities p and q are fixed, he then has to specify the sole unspecified item: the preference relation R between the two lotteries. If, on the other hand, the four outcomes (x_1 to x_4) and probability p are fixed and if R is specified as = , the respondent then has to specify probability q so that he is indifferent between the lotteries.

The assessment techniques can be classified with respect to two variables (see Table 6.1). Firstly, techniques can be divided into *standard gambles* and *paired gambles*. In a standard gamble, a degenerate lottery (i.e. a certain outcome) is compared to a binary lottery. In paired gamble techniques, two binary lotteries are compared. A second division between techniques concerns the item that has to be specified by the respondent: the preference relation R (*preference comparisons* techniques), the probability (*probability equivalence* techniques), one of the outcomes (*value equivalence* techniques) or the outcome in a degenerate lottery (*certainty equivalence* techniques). Table 6.1 shows the classification into 7 basic groups of techniques which results from these two variables. It should be noted that the item that is bold as well as underlined in Table 6.1 has to be specified by the respondent, since all other items are fixed beforehand.

In order to assess a complete utility function the respondent has to make a series of comparisons between binary lotteries. In each of the 7 groups of techniques in Table 6.1 therefore, variants of techniques exist which differ with respect to the manner in which the series of lotteries is completed.

Table 6.1 *Classification of techniques for assessing utility functions by means of lotteries*

	Standard-gamble[a]	Paired-gamble[b]
1. Preference comparison (PC)	$[x_1,p,x_2]\ \underline{R}\ x_3$	$[x_1,p,x_2]\ \underline{R}\ [x_3,q,x_4]$
2. Probability equivalence (PE)	$[x_1,\underline{p},x_2] = x_3$	$[x_1,\underline{p},x_2] = [x_3,q,x_4]$
3. Value equivalence (VE)	$[\underline{x}_1,p,x_2] = x_3$	$[\underline{x}_1,p,x_2] = [x_3,q,x_4]$
4. Certainty equivalence (CE)	$[x_1,p,x_2] = \underline{x}_3$	--

[a] $x_1 < x_3 < x_2$
[b] $x_1 < x_3$ and $x_4 < x_2$

Comparison of standard-gamble and paired-gamble techniques

In a standard-gamble a sure outcome is compared to a lottery, whereas in a paired-gamble method two lotteries are compared. This fundamental difference between both categories of techniques suggests an advantage of the paired-gamble approach because this technique is not susceptible to either the *certainty effect* (Kahneman and Tversky 1979) or the *utility for gaming* effect (denoted *plaisir de jeu* by Allais 1979).

The certainty effect refers to the much found empirical observation that decision makers tend to attach too much weight to outcomes that are certain in comparison with outcomes that are merely probable. As a consequence, standard-gamble techniques would lead to more risk averse utility functions than paired-gambles. The utility for gaming effect means that someone might value a lottery more strongly than would be expected on the basis of his risk attitude, solely due to the (expected) pleasure of "playing" the lottery in comparison with the "dull" sure outcome. Such an effect is probably very important in e.g. casino gambling; this effect is not very plausible for economic decision making. In order to refrain from utility for gaming with a standard-gamble technique, a serious assessment of the utility function requires much care in order to create a realistic decision context.[2]

[2] In our study the standard-gamble version represents a realistic decision context, since in the actual decision situation farmers can choose a 100% fixed-price contract (the sure option, a degenerate lottery) or choose a marketing strategy with risk (a lottery).

A disadvantage of the paired-gamble technique concerns the difficulty of the assessment task to both the respondent and the interviewer. For example Novick et al. (1981, p. 563) conclude, with respect to the probability equivalence version (referred to as PE-version, see Table 6.1) of the paired-gamble techniques, that they are not convinced of the usefulness of the technique: "... it is difficult even for experienced subjects. Fatigue and boredom are definite problems". Notwithstanding this conclusion by Novick et al., in studies with agricultural producers as respondents, a number of well known cases exist in which the paired-gamble technique is applied successfully. For example, Officer and Halter (1968), Lin, Dean and Moore (1974) and recently Hildreth and Knowles (1986) applied the so-called Ramsey-technique (the VE-version of the paired-gamble techniques).

In Officer and Halter (1968) a direct comparison of the Ramsey-technique, PE- and CE-standard-gamble technique was made. The Ramsey and CE-technique showed greater predictive validity than the PE-technique. They reported further that the five farmers they interviewed were more responsive and had a greater appreciation of the Ramsey-technique than of the CE-technique. The farmers judged the Ramsey-technique to be more realistic because of the two uncertain alternatives that have to be compared. A clear disadvantage of the Ramsey-technique was the larger number of questions farmers had to answer. However, definite conclusions about the pro's and con's of both techniques cannot be drawn from this study due to the small number of farmers. Farquhar (1984) concludes that relatively few research has been done with respect to biases and distortions associated with paired-gamble techniques. Up until now, the paired-gamble approach has mostly been used in consistency checks. He states that further empirical research is necessary to evaluate whether the theoretical reduction in assessment bias is worth the extra trouble in the assessment task.

In our opinion, the conclusions of Novick et al. and Farquhar concerning the difficulty of the paired-gamble techniques to the respondent do not apply to the preference comparison version of the paired-gamble, since expressing preferences between two gambles is a fairly easy task to the respondent. In this study the preference comparison version of the paired-gamble technique will therefore be applied, within the framework of conjoint measurement (see Section 6.4). It will be shown that this technique provides a measurement of the risk attitude in a respondent friendly manner.

Evaluation of variants of the standard-gamble technique

The standard-gamble techniques are most popular in assessing utility functions. Of the four variants, especially the PE- and CE-technique are often used (for abbreviations see Table 6.1). The PC- and VE-version are much less popular. A disadvantage of the PC-version of the standard-gamble technique is that it does not result in a complete utility function. The VE-version has, according to Farquhar (1984), not yet been applied in expected utility context and strengths and weaknesses have not yet been established. Here, most attention will therefore be directed to a comparison of the standard-gamble versions of the PE- and CE-technique. Differences between both techniques and empirical research concerning the pro's and con's of both techniques will be briefly reviewed below.

In the PE- and CE-technique, the respondent has to specify an item, that is, a probability (in PE) or a certainty equivalent (in CE), so that he becomes *indifferent* between the lottery and the certain outcome. Usually, indifference is arrived at in an iterative manner. A sequence of points is successively adjusted until indifference is established. A key difference (Hershey et al. 1982) between the PE- and CE-technique is whether one arrives at indifference by adjusting concrete amounts of the attribute (CE-technique) or by means of more abstract probabilities (PE-technique). The necessity of using probabilities as a method of adjustment is seen as the most important disadvantage of the PE-technique. For example, Mosteller and Nogee (1951) and Novick et al. (1981) emphasize that the CE-technique is less demanding on the part of the respondent than the PE-technique.

A second difference concerns the manner in which a series of points of the utility function is arrived at. Usually in the PE-technique the certain outcome x_3 (see Table 6.1) is varied whereas the two outcomes (x_1 and x_2) of the lottery remain fixed. For a number of values x_i on the interval $x_1 < x_i < x_2$ the respondent has to specify the probability p_i in the lottery. Then, applying the expected utility model, $u(x_i) = p_i$. These assessments of p_i can be seen as independent measurements.

In contrast with the independent measurements of the PE-technique, the most commonly applied variant of the CE-technique uses *chained responses*. In this so-called *midpoint chaining* technique (Keeney and Raiffa 1976) former responses to lotteries are used in the assessment of subsequent responses. Specifically, the midpoint chaining method starts with the assessment of a certainty equivalent x_c of a lottery with the boundaries of the interval (say x_1 and x_2) as outcomes. By scaling $u(x_1) = 0$ and $u(x_2) = 1$ and if $p = 1/2$ then $u(x_c) = 1/2$. Subsequently the respondent has to assess the certainty equivalents of the 50/50 lotteries $[x_1,x_c]$ and $[x_c,x_2]$ with corresponding expected utilities of 1/4 and 3/4, respectively. Further midpoints can be assessed in a similar manner and each comparison involves a bisection of a particular interval.

The chaining of responses might lead to serial dependence of measurements and a compounding of errors in measurement (Knowles 1984). Apart from chaining, range effects might occur because not only does the range of outcomes (that is the difference between the greater and lesser prize in the lottery) change throughout the series of lotteries, but also the range between the extremes of the interval of the first lottery is large (Krzystofowicz and Duckstein 1980; McCord and de Neufville 1986). Later on in this section it will be argued that this varying range of outcomes might also be considered an asset of the midpoint chaining technique.

A further effect specifically noted with the CE-technique is the dependence of the utility function on the probabilities specified in the binary lotteries. E.g., Van Dam (1973) and Karmarkar (1978) showed that 50/50 lotteries resulted in different utility functions than lotteries with 10/90 or 25/75 probabilities. McCord and de Neufville (1983) also report such an effect. In an experiment with 22 MIT-respondents, the average relative difference between, theoretically equal, certainty equivalents for different p-values ranged from 30% to 100%. Of course these results are not in line with expected utility theory. In the expected utility model the utility function is independent of the probability distribution that is evaluated (axiom of independence).

The dependence of the utility function on the probability used in the lotteries leads one to suggest conditional utility functions: u(x/p) instead of u(x) (e.g. see the lottery dependent utility theory of Becker and Sarin 1987). Van Dam (1973) suggested decision weights in line with Kahneman and Tversky's (1979) prospect theory to account for the effects. In actual measurements a preference exists for using $p = 1/2$ in the lotteries because it is thought to result in the least distortion.

In a number of studies the PE- and CE-technique were directly compared. In Officer and Halter (1968) the predictive validity of the CE-technique was superior. However, they surveyed only 5 farmers. In Hershey et al. (1982), in a critical review of the study of Fishburn and Kochenberger (1979), it was shown that the PE-technique tended to concave functions for losses and convex functions for gains, whereas the CE-technique tended towards convex-concave curves. Furthermore, they found that the CE-technique generally leads to more risk seeking than the PE-technique.

Further experiments which showed systematic differences between both techniques are reported in Hershey and Schoemaker (1985) and their results were elaborated upon by Johnson and Schkade (1989). In both studies the methods are compared in two-stage designs. Firstly, subjects have to provide a CE-judgment and they later provide an answer for a related lottery with a PE-technique (or vice versa). In case of procedure invariant measurement these judgments should coincide. To illustrate the two-stage procedure, consider a farmer who indicates a certainty equivalent of say 25 cts/kg for a 50/50 lottery with outcomes 10 and 70 cts/kg. Then e.g. a week later, confronted with a lottery with outcomes 10 and 70 cts/kg and the sure amount of 25 cts/kg, the same respondent should specify $p = 0.50$ as indifference probability in the lottery.

Experiments conducted in this manner with students as respondents showed serious inconsistencies between the techniques. The extent of discrepancy depends upon the respondent's initial risk attitude, the order of questioning (CE followed by PE or vice versa) and upon whether lotteries take place in the domain of gains or in the domain of losses. Several theoretical explanations have been provided to account for the experimental results (Hershey and Schoemaker 1985). The most important explanation seams to be *reframing*: in the PE-technique the sure amount serves as a reference point and the two outcomes are recoded into a gain and a loss. By reframing, a pure gain or a pure loss gamble is thus translated into a mixed gamble. Experimental evidence shows that in general respondents are more risk averse in mixed gambles than in either pure loss or pure gain gambles. Consequently the PE-version will result in more risk aversion. Other factors which probably contribute to the observed discrepancies are the anchoring and adjustment heuristic (in the CE-technique the expected value of the lottery might serve as an anchor from which the adjustment is insufficient in order to arrive at the true certainty equivalent) and random error (Hershey and Schoemaker 1985).

The large majority of research in establishing the biases of different assessment techniques concerns laboratory experiments.[3] Surprisingly little attention is devoted to the validity and reliability of utility measurement in survey research. In survey research typically only one assessment technique is applied in measuring risk attitudes. Taking into account the labile nature of the utility assessment, the validity of the measurements and conclusions in these studies are questionable.

Also, in survey research hardly any attention is paid to studying the reliability of the measurement. Exceptions are the test-retest measurements in Officer and Halter (1968) and Binswanger (1980, 1981). Both studies concern agricultural producers. For example, Binswanger showed that (lowly educated) farmers in India were more risk averse, less sensitive to interviewer variation and more stable in judgment when assessments were conducted with real money lotteries (a farmer could remain at the status quo or win up to a monthly income) than with lotteries with hypothetical outcomes. These differences in validity and reliability between real and hypothetical lotteries decreased after playing a number of real lotteries. In general, one might conclude that training the respondent seems to yield more valid and stable results. MacCrimmon and Wehrung (1986) repeated their measurements one year later with business executives as respondents. They found significant test-retest correlations but the magnitude of these correlations was fairly low.

Conclusion and choice of assessment technique

Since the PE- and CE-technique generally do not yield the same results, one might wonder which technique is best. According to Johnson and Schkade (1989, p. 423), after extensively reviewing the evidence: " ... it is not apparent which

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[3] It should be noted here that the external validity of the experimental results can be questioned. Typically, students are taken as subjects; the involvement of these subjects in providing answers may be low resulting in the fact that less time, attention and hard thought about their preferences is spent. Also, consistency tests are usually absent so that no feedback is provided to encourage further thought or revisions in opinions.

response mode better reflects a decision maker's true preferences". Not surprisingly, they recommend to use a multiple method approach to " ... guard against the sensitivity of assessments to response mode biases". For example, use could be made of the so-called hybrid models in which a combination of techniques is used alternately in one assessment task to arrive at a utility function. Farquhar (1984) suggests that such hybrid techniques would be less sensitive to bias than single techniques, without making it more difficult to the respondent.[4]

Von Winterfeldt and Edwards (1986) also recommend to use several techniques, the main part of which is to confront subjects with inconsistent answers thereby asking them to reconcile the measurements. In fact, in decision analysis consistency is induced explicitly. Differences between e.g. the CE- and PE-technique will therefore not show up.

From the review of the literature we conclude that a multiple method approach appears to be a key factor for a valid assessment of utility functions. This approach will therefore be applied in this study. Apart from using two certainty procedures in measuring the value function, two procedures incorporating risk will be applied to measure the utility function. The latter procedures concern the paired-gamble technique within a conjoint measurement approach and a standard-gamble approach using the midpoint chaining variant of the CE-technique.

Several reasons exist for choosing the CE-technique instead of the PE-technique. Firstly, most studies containing utility measurements with agricultural producers as respondents have been conducted with the CE-technique. Examples of studies applying the CE-technique are: Officer and Halter (1971), Halter and Dean (1971), Francisco and Anderson (1972), Hazell and Scandizzo (1977), Bond and Wonder (1980) and Hamal and Anderson (1982). Bond and Wonder and Hazell and Scandizzo used probabilities of 1/4 and 3/4 in their lotteries; all other studies used $p = 1/2$. Eliashberg (1980) applied the CE-technique to consumers and Swalm (1966) conducted one of the earliest empirical studies in utility assessment with business executives as respondents. In general, respondents show few difficulties in responding to the questions.

The main reason however, for preferring the CE-technique to the PE-technique, is the difference in ease with which the farmers in our study responded to both types of questions. In pilot interviews with 15 farmers both the CE- and the PE-technique were tested. In these pilot interviews it became clear that most farmers had difficulty in answering the PE-questions and in several cases no responses could be obtained at all. In particular, the farmers showed difficulties

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4 It is surprising that, to our best knowledge, no experimental research is performed to evaluate the hybrid measurements using an interactive computer device. Further research of this matter is especially relevant because decreasing costs of computers enable the use of computer controlled interactive utility assessments in survey research which until recently could be used only in decision analysis conditions.

in arriving at indifference by means of adjusting probabilities. To the farmers a difference in probabilities between e.g. p = 0.35 and p = 0.37 bears no vivid consequences. This caused reluctance to think more deeply about their preferences and often resulted in nice number probabilities like a half, a third, a quarter, etc. In sharp contrast with the PE-technique, in the CE-technique the attribute of adjustment concerns the price/kg which is interpreted fairly easily. To a farmer the difference in price between 23 or 24 cts/kg has a clear meaning and the consequences of the one cents difference are easily calculated and understood (i.e. about Dfl 500,= per ha.). Also the 50/50 chances in the lotteries can be easily interpreted.

Another main argument in favor of the CE-technique concerns the sequence of lotteries in the midpoint chaining technique leading to different ranges in the lotteries. These changing outcomes in the binary lotteries can be easily interpreted by the farmers. A lottery played on the lower part of the price interval, say between 10 and 25 cts/kg, can be interpreted as reflecting the decision problem a farmer faces in a year in which the overall market price is fairly low, whereas lotteries with high outcomes, say between 35 and 60 cts/kg, reflect the decision problem in a year with a high overall price level. These lotteries thus are much less artificial than either a PE-technique in which the outcomes of the interval remain fixed and the sure outcome is varied over the interval or a CE-variant in which the outcomes remain fixed and the probabilities are varied. The realism added to the midpoint chaining task might reduce the sensitivity to the varying range bias, suggested in the literature.

6.2.2 Implementation of the midpoint chaining technique

Specification of attribute range

The attribute for which the utility function is assessed is the price/kg. The outcomes in the lotteries are denoted in cts/kg or equivalently in Dfl/100 kg. The utility function is assessed on an interval ranging from 10 to 70 cts/kg. That is, the first lottery presented to the respondents concerns a 50/50 lottery with outcomes of 10 and 70 cts/kg. These boundaries are chosen in such a way that the whole probability distribution associated with a marketing strategy can be evaluated. We expect the minimum and maximum price of a marketing strategy to lie between 10 and 70 cts/kg on the following grounds.

The lowest price level of 10 cts/kg is more or less a natural bottom price of a marketing strategy. A farmer will at least receive the futter price of ware potatoes which is about 7 cts/kg at a minimum. Since, even in a year with very low prices, at least part of the total harvest of an individual farmer will be sold at higher prices than the futter price and well above 10 cts/kg, the marketing strategy will almost always result in a higher overall price than 10 cts/kg.

The upper boundary of the interval is more difficult to determine. In some extreme years, e.g. in 1976, prices at the end of the season were above 100 cts/kg; in 1983 they were up to 100 cts/kg. However, in both years, these prices were extremes but only for part of the total selling season. Very few farmers will have sold all or the largest part of their harvest at such high prices; typically they will have sold at lower prices earlier in the season or at lower contract prices. Therefore, the marketing strategy has resulted in a higher price than say 60 or 70 cts/kg for only a few farmers. To illustrate this phenomenon, in 1983 which was a year with high prices at the end of the season, the maximum prices farmers actually attained for marketing strategies ranged from 50 to 70 cts/kg. The boundary of 70 cts/kg is therefore a realistic maximum.

Sequence of assessments

The respondent is confronted with 10 lotteries on the specified interval. For each lottery the farmer has to assess the certainty equivalent. In all lotteries $p = 1/2$. The sequence of lotteries is described in Figure 6.2. The curves in this figure specify the outcomes in each lottery. The levels of expected utility corresponding to the assessed certainty equivalents are specified too in Figure 6.2 (the endpoints $u(x_L)$ and $u(x_H)$ are scaled 0 and 1, respectively). The first equivalent x_1 is assessed between x_L and x_H (the level of expected utility corresponding to this equivalent is 0.500). The second equivalent x_2 is assessed between x_L and x_1 (expected utility is 0.250) and the third equivalent x_3 is assessed between x_1 and x_H (expected utility is 0.750). The fourth equivalent x_4 is assessed between x_2 and x_3 (expected utility is 0.500), etc. In this manner 10 certainty equivalents are assessed.

If these ten certainty equivalents were plotted in a graph with the assessed certainty equivalents on the x-axis and the expected utilities on the y-axis, a function could be drawn or fitted through the points. In Figure 6.2 this would result in a concave utility function, implying risk aversion (e.g. notice that in Figure 6.1 the certainty equivalent x_1 is smaller than $(x_L + x_H)/2$ (the expected value of the lottery). Figure 6.2 further shows the variation in range of the lottery. The first lottery between $x_L = 10$ and $x_H = 70$ cts/kg is largest in range, whereas the ranges of lotteries 5 and 7 are very small, especially in case of strongly risk averse respondents.

Three of the 10 lotteries concern consistency measurements, namely: x_4, x_9 and x_{10}. For $u(x) = 0.500$ three measurements are obtained namely x_1, x_4 and x_{10}; the utility level $u(x) = 0.375$ is measured twice namely x_5 and x_9. Theoretically, the certainty equivalents for the same level of utility should be equal. Because of measurement error these measurements will not be exactly equal. However, in a reliable and valid measurement they will be close to one another.

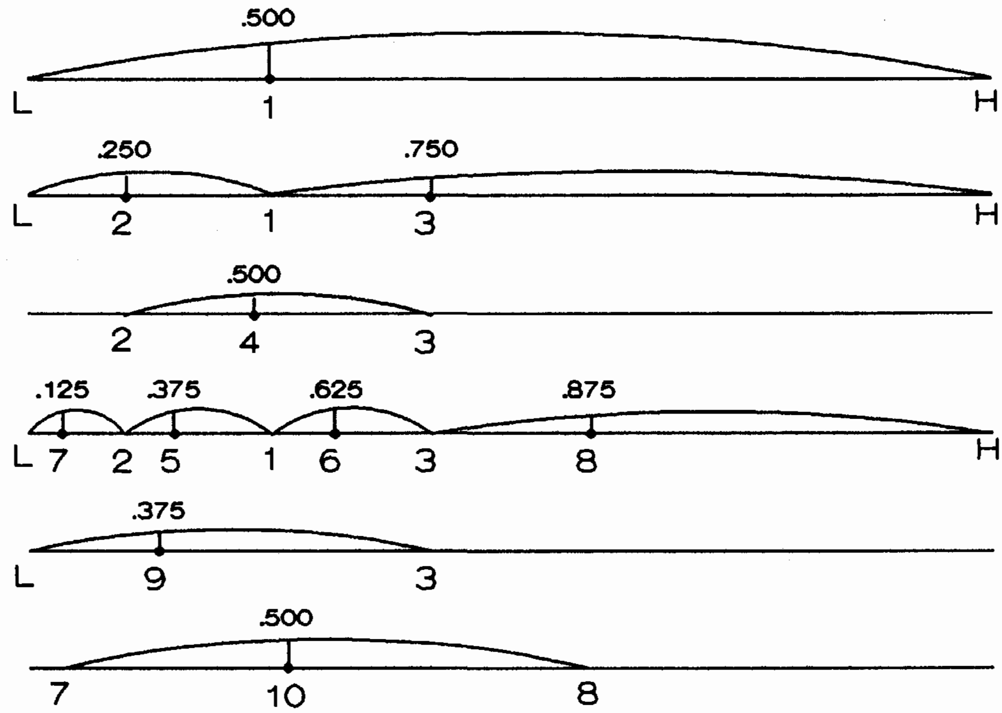

Figure 6.2 Sequence of assessment of 10 certainty equivalents by means of 50/50 lotteries in the midpoint chaining technique

The lotteries were presented to the respondents on paper. The lottery was described in a tree format. The interviewers were instructed to arrive at the indifference point by iteration. That is, the interviewer confronts the respondent with a sure price level that is alternately above and below the "expected" certainty equivalent. Such an iteration seems preferable to e.g. incrementing or decrementing systematically. The interviewers were extensively trained in the assessment procedure.

Before conducting the sequence of 10 lotteries the respondent received an elaborate explanation of the goals of measurement and some training in the assessment procedure by means of conducting four test lotteries. In the description of the decision context farmers were instructed to imagine selling the total harvest according to the lottery or the certain price. Prices were set for the variety Bintje at the farmer's usual moment of delivery and usual quality, size distribution and waste percentage of ware potatoes.

A number of farmers showed difficulty in responding to the questions. The interviewers were instructed to take ample time in explaining the purposes of the question and familiarizing the respondent with the questioning procedure. In case interviewers seriously doubted the respondents' understanding of the question or the seriousness in answering the question, the assessed data were not analysed.

6.2.3 Specification of utility functions and method of parameter estimation

Specification of utility functions

In the expected utility model the sole requirement of the utility function u(x) is that it is a monotonically decreasing or increasing function on the relevant interval. The particular shape of the function is left open. In this study both a negative exponential and a power function will be fitted to the ten assessed points. This choice is based on both theoretical and practical reasons which will be delineated below.

The concepts of absolute and proportional risk aversion, indicated by the Pratt-Arrow coefficients, provide one way of choosing suitable functions. Most attention in this respect has been given to wealth as attribute. Tsiang (1972) refers to Arrow (1975, 1971) in providing four conditions for a utility function for wealth in order to be acceptable:

1. *marginal utility of wealth is positive*

$$u'(x) > 0 \tag{6.2}$$

2. *marginal utility of wealth decreases with increasing wealth*

$$u''(x) < 0 \tag{6.3}$$

3. *marginal absolute risk aversion is constant or decreasing with increasing wealth*

$$\frac{d\left(-\frac{u''(x)}{u'(x)}\right)}{dx} \leq 0 \tag{6.4}$$

4. *marginal proportional risk aversion is constant or increasing with increasing wealth*

$$\frac{d\left(-x\,\frac{u''(x)}{u'(x)}\right)}{dx} \geq 0 \tag{6.5}$$

These conditions imply the following behavioral assumptions. Conditions 1 and 2 state that the utility function of wealth is increasing and that decision makers are risk averse towards wealth. Condition 3 implies that for equal absolute changes in wealth, say plus or minus Dfl 10.000, a decision maker is equally or less risk averse if he becomes wealthier. Finally, condition 4 implies that for proportional changes in wealth, say plus or minus 10% of his wealth, a decision maker is equally or more averse if he becomes wealthier.

In general the conditions 1, 2 and 3 are theoretically and empirically accepted (Tsiang 1972). With respect to condition 4, however, this is not generally the case. For example Rubinstein (1976, p. 553) states: "While the issue of the realistic sign of absolute risk aversion seems to be settled (decreasing absolute risk aversion), the direction of proportional risk aversion remains an open question". In studies with agricultural producers the assumption of a decreasing absolute risk attitude has been confirmed. For example, Hamal and Anderson (1982) found a decreasing absolute and a constant proportional wealth function for a majority of 60 farmers in Nepal; Hildreth and Knowles (1986) found a decreasing absolute risk aversion function with 13 farmers in Minnesota.

Three functions meet all four conditions mentioned above. These functions are a negative exponential, a power and a logarithm function.

1. *Negative exponential function*

$$u(x) = a + b\ e^{-c\ x} \tag{6.6}$$

$$r(x) = c \tag{6.7}$$

$$s(x) = x\ r(x) = x\ c \tag{6.8}$$

In Equation 6.7 r(x) is the Pratt-Arrow coefficient of absolute risk aversion and s(x) in Equation 6.8 is the Pratt-Arrow coefficient of proportional risk aversion (see Chapter 3).

In Equation 6.6 parameters a and b are scaling coefficients (u(x) is an interval scale). Parameter c concerns the risk attitude. If $c > 0$ the decision maker is risk averse, if $c < 0$ the decision maker is risk seeking. The Pratt-Arrow coefficients show that the negative exponential function implies a constant absolute risk attitude (referred to as CARA) and an increasing proportional risk attitude (IPRA).

2. *Power function*

$$u(x) = a + b\ x^{1-c} \tag{6.9}$$

$$r(x) = c/x \tag{6.10}$$

$$s(x) = x\ r(x) = c \tag{6.11}$$

Again parameters a and b in 6.9 are scaling coefficients and c indicates the risk attitude. If $0 < c < 1$ the decision maker is risk averse, if $c < 0$ the decision maker is risk seeking. The power function implies a decreasing absolute risk attitude (DARA) and a constant proportional risk attitude (CPRA).

3. *Logarithm function*

$$u(x) = a + b \ln (x+c) \tag{6.12}$$

$$r(x) = 1 / (x+c) \tag{6.13}$$

$$s(x) = x / (x+c) \tag{6.14}$$

The logarithm function implies DARA and: CPRA if $c = 0$, IPRA if $c > 0$ and DPRA if $c < 0$.

The conditions 1 to 4 of the function for wealth mentioned above are mainly based on plausibility and do not have a strong theoretical foundation. Sinn (1983, 1985) has tried to provide these foundations by combining von Neumann-Morgenstern utility functions and psychophysical theory. In psychophysics the relationship between the objective intensity of a stimulus and the subjective intensity of the sensation is studied. This relationship is extensively analyzed empirically for many different stimuli.

Two functions are suggested to describe the relationship: a logarithm function (put forward by Fechner) and a power function (brought up by Stevens). In the logarithm function, equal relative changes in stimulus intensity bring about equal absolute changes in sensation intensity. In the power function equal relative changes in stimulus intensity bring about equal relative changes in sensation intensity (Sinn 1983).

In Sinn (1983) an interesting discussion can be found concerning which of the two specifications is more plausible and more in line with empirical research. Sinn departs from the general standpoint in stating that Fechners logarithm law is most plausible. For his argumentation the reader is referred to the original source. What matters here is that both functions are founded in Weber's relativity law: equal relative changes are equally perceptible, equally intensive or equally significant (Sinn 1983, p. 145). The perception of such diverse stimuli like taste, sound, light, electricity etc. can be described accurately by Weber's law.

An interesting hypothesis therefore would be to extend Weber's law to the stimulus "wealth". Thus Sinn adds the so-called *Weak Relativity Axiom* to the axioms of von Neumann-Morgenstern: *equal relative changes in wealth are equally significant to the decision maker*. The sole functions which confirm this axiom are the power and logarithm function. The negative exponential function is excluded by this axiom.

The linking of psychophysics and utility theory is very interesting and needs further attention. Apart from Sinn (1983), Kahneman and Tversky (1979) refer to psychophysical theory in discussing the appropriate shape of their value function in Prospect Theory. However, they do not elaborate upon the issue like Sinn.

Notwithstanding the incompatibility of a negative exponential function and psychophysics, the negative exponential function is very often used in utility assessment. E.g. Keeney and Raiffa (1976) often refer to this function and applied the function to model e.g. the utility of response times of a fire department. Also a combination of exponential functions is used quite often in decision analysis: $u(x) = a - b\ e^{-cx} - d\ e^{-fx}$ (with c, d and $f > 0$). According to Eliashberg and Hauser (1985) the exponential (and power) function dominate in decision analysis and marketing. In a review of several studies, Fishburn and Kochenberger (1979) showed a good fit of the negative exponential function respectively above and below the reference point.

Conclusion

Both the power and negative exponential function are often applied in utility assessments. Theoretical arguments concerning absolute and proportional risk aversion suggest both functions to be suitable, although the power function is favorable from the standpoint of psychophysical theory. Both functions are easy to work with. After scaling the boundaries of the functions, the estimation of only one parameter suffices to characterize a decision maker's risk attitude. Since in this study a large number of functions have to be fitted, this practical aspect is very important.

The logarithm function will not be fitted to the data. For practical reasons the analysis has to be limited to fitting two functions. A choice therefore has to be made between the power and logarithm function since both share the same characteristics of DARA and CPRA. Considering that the power function is most often used in decision analysis we prefer the power function.

From a theoretical and practical viewpoint therefore, in this study both a negative exponential and a power function will be fitted for each respondent and their fit will be compared. The function specification that fits the data best will be chosen in subsequent analyses.

The following specifications of the functions result by scaling the functions; the utility of the lowest (x_L) and highest (x_H) value of the price interval are scaled 0 and 1, respectively.

1. *Negative exponential function*

$$u(x) = \frac{1 - e^{-c(x - x_L)}}{1 - e^{-c(x_H - x_L)}} \tag{6.15}$$

with:

$$x_L \leq x \leq x_H$$

$$0 \leq u(x) \leq 1$$

2. *Power function*

$$u(x) = \frac{(x - x_L)^{1-c}}{(x_H - x_L)^{1-c}} \tag{6.16}$$

with:

$$x_L \leq x \leq x_H$$

$$0 \leq u(x) \leq 1$$

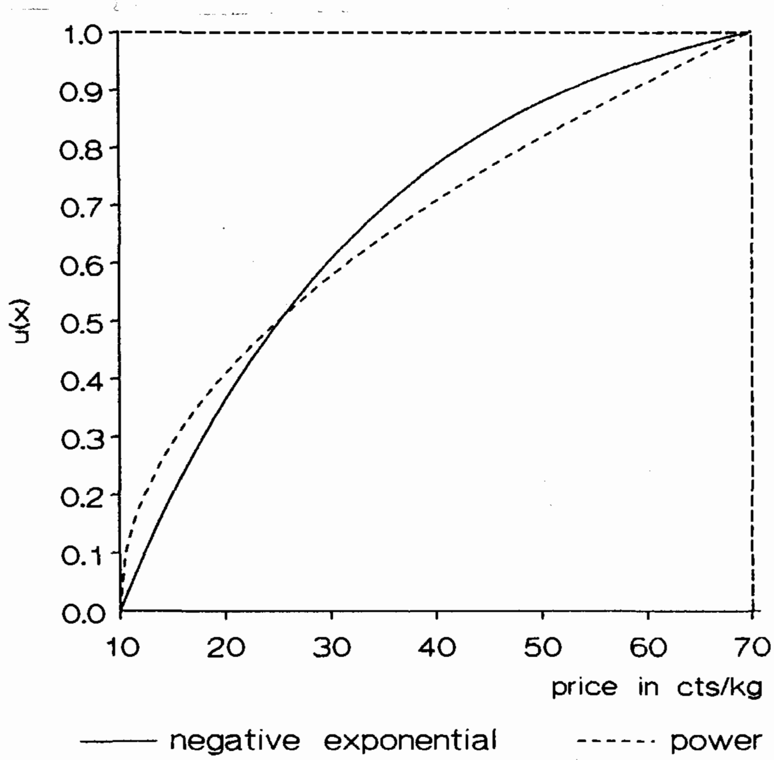

Figure 6.3 An example of a negative exponential and a power function

In Figure 6.3 an example of both functions is shown. For both functions in this figure the certainty equivalent of a 50/50 lottery between 10 and 70 cts/kg is 25 cts/kg. The figure shows that the power function is more concave than the negative exponential function for low price levels. For high price levels the negative exponential function is most concave.

Parameter estimation method

The sequence of 10 lotteries in the midpoint chaining technique results in 10 points of the utility function. In order to arrive at a classification of decision makers with respect to risk attitude and in order to be able to evaluate probability distributions, a smooth curve representing the utility function is needed. In case the number of datapoints is larger than the number of function parameters, the parameter can be estimated by means of statistical fitting procedures. Usually, a non-linear function is fitted by means of least-squares (see Eliashberg and Hauser (1985) for another approach in estimating the parameter). For example, Officer and Halter (1968) and Lin, Dean and Moore (1974) applied this procedure in assessments obtained from agricultural producers. Currim and Sarin (1983) applied the procedure to consumers.

Generally, $u(x_i)$ serves as the dependent and x_i as the independent variable. In most cases no distinction is made between $u(x_i)$ as the (error laden) response variable (e.g. in case of a PE-technique) or x_i as the response variable (in case of a CE-technique). In case of a CE-technique however, the inverse function should be estimated since the certainty equivalents and not the utility levels are measured with error. Here the following procedure is applied (Knowles 1984).

Assume

$$x_i = \tilde{x}_i + e_i \tag{6.17}$$

with:

$\tilde{x}_i =$ perfect response

$x_i =$ actual response

$e_i =$ error

If lotteries are constructed with p = 1/2 then:

$$u(\tilde{x}_i) = \tfrac{1}{2}\{u(x_j) + u(x_k)\} \tag{6.18}$$

with:

$$x_j < x_i < x_k$$

From 6.18 follows:

$$\tilde{x}_i = u^{-1}\left\{\tfrac{1}{2}\left(u\left(x_j\right) + u\left(x_k\right)\right)\right\} \tag{6.19}$$

Assume a negative exponential utility function:

$$u(x) = \frac{1 - e^{-cx}}{1 - e^{-c}} \tag{6.20}$$

scaled on the interval [0,1] with u(0) = 0 and u(1) = 1.

Then by substituting 6.20 and 6.17 in 6.18 and rearranging results in:

$$x_i = \frac{\ln\left\{\tfrac{1}{2}\left(e^{-cx_j} + e^{-cx_k}\right)\right\}}{-c} + e_i \tag{6.21}$$

In Equation 6.21 x_j and x_k respectively represent the low and high outcome in the 50/50 lottery and x_i stands for the assessed certainty equivalent. The respondent assesses x_i for a number of lotteries (10 in this study), with varying outcomes x_j and x_k.

If a power function is assumed instead of a negative exponential function:

$$u(x) = x^c \tag{6.22}$$

then Equation 6.23 results instead of 6.21:

$$x_i = \tfrac{1}{2}\left\{\left(x_j^c + x_k^c\right)^{\frac{1}{c}}\right\} + e_i \tag{6.23}$$

Generally stated, if x is not scaled on the interval [0,1] but on the interval $[x_L, x_H]$ with $u(x_L) = 0$ and $u(x_H) = 1$ (see Section 6.2.2), then Equation 6.21 does not change, but 6.23 becomes:

$$x_i = (x_H - x_L)\left\{\tfrac{1}{2}\left(\frac{x_j - x_L}{x_H - x_L}\right)^c + \left(\frac{x_k - x_L}{x_H - x_L}\right)^c\right\}^{\frac{1}{c}} + x_L + e_i \tag{6.24}$$

It is easy to see in 6.24 that if $x_L = 0$ and $x_H - x_L = 1$ then 6.24 reduces to 6.23.

Non-linear least-squares is used to estimate parameter c in Equations 6.21 and 6.24. If Equations 6.21 and 6.24 are written as:

$$x_i = f_i(c) + e_i \tag{6.25}$$

The parameter c in 6.25 is chosen so as to minimize (Maddala 1986):

$$SSE = \sum_{i=1}^{n} [x_i - f_i(c)]^2 \tag{6.26}$$

where SSE is the sum of squared errors.

If the respondent answered all lottery questions then n = 10.

The parameter c in 6.21 and in 6.24 is estimated by using routine ZXMIN from the IMSL-library of FORTRAN programs. In ZXMIN the least squares estimate is obtained by Fletcher's Quasi-Newton method (see the IMSL manual for further details). The algebraically calculated parameter of the first lottery (at u(x) = 0.5) provided the initial estimate of the parameter in ZXMIN.

If it is assumed that the residuals e_i are independently and identically distributed with mean 0 and variance (sigma)^2 and if c-hat is the final estimate of c, then (Maddala 1986, p.174):

$$\hat{\sigma}^2 = \frac{1}{n}\ SSE(\hat{c}) \tag{6.27}$$

and the nonlinear-least-squares estimator c-hat is approximately normally distributed with mean c and variance

$$\hat{\sigma}^2 \left[\sum_{i=1}^{n} \left(\frac{\delta f_i}{\delta c}\right)^2\right]^{-1} \tag{6.28}$$

The confidence interval calculated for the estimated parameter will be used entirely for descriptive purposes, namely to classify decision makers into the broad risk classes of risk averse, risk neutral and risk seeking. Because of the small number of assessments (n = 10) and the possibly serial dependence of errors in the midpoint chaining technique, the variance of the estimator will not be used for inferences.

6.3 Results of measuring risk attitude by means of lotteries

In this section the results of measuring the farmer's risk attitude by means of the lottery technique will be presented. An overview of the certainty equivalents measured for each expected utility level will be given first, followed by a discussion of the results of estimating the parameter in the negative exponential and in the power function. In comparing the results of 1984 and 1985, information about temporal shifts in risk attitude will be obtained.

Certainty equivalents measured in 1984 and 1985

At least three certainty equivalents could be assessed for a total of 225 respondents in 1984. Since the lottery question was asked in the second interview held in 1984 and 15 farmers refused cooperation altogether in the second interview, certainty equivalents could have been elicited for a maximum of 238 farmers. Of these 238 farmers, a total of 13 farmers did not respond to the question because they did not completely understand the lottery question or deemed the measurement procedure utterly unrealistic. This leads to a response to the question of 94.5% (225 out of 238), which is quite high. In 1985, at least three equivalents were measured for 191 out of 205 respondents, which results in a response percentage of 93.2%.

In Table 6.2 some descriptive statistics (mean, median and standard deviation) are shown concerning the certainty equivalents assessed in 1984 and 1985. The results in Table 6.2 are ordered by level of expected utility of the lotteries. The order in which the lotteries were presented to the respondent is indicated by the number in the first column of the table. The second column shows the outcomes used in each lottery. With the exception of the first lottery in which the outcomes are 10 and 70 cts/kg for all respondents, the outcomes of the lotteries depend upon the answers respondents have provided in former lotteries. As a consequence, the expected value of the lottery and range of the lottery for each level of expected utility vary between respondents. Table 6.2 therefore shows the average expected value and the average range of the lotteries for each level of expected utility.

Furthermore, in Table 6.2 the measurements are classified for each level of expected utility into risk averse, risk neutral and risk seeking responses. In theory only equivalents which are equal to the expected value of the lottery should be classified as risk neutral. Such an approach, however, would not take response errors into consideration. Equivalents which are close to the expected value of the lottery are therefore denoted as risk neutral, too. Specifically, certainty equivalents which deviate less than or equal to 5 percent of the range of the lottery from the expected value of the lottery, are classified as risk neutral (the level of 5 percent is subjectively chosen). For example, in a 50/50 lottery with outcomes 15 and 35 cts/kg the range of the lottery is 20 cts/kg and the expected value is 25 cts/kg. In this case, certainty equivalents in the interval with boundaries 24 and 26 cts/kg are denoted as risk neutral.

As Table 6.2 shows, the average certainty equivalent assessed in 1984 for the first lottery between 10 and 70 cts/kg is 27 cts/kg, with a median response of 25 cts/kg. Since the expected value of the lottery is 40 cts/kg these responses imply, of course, that most farmers are risk averse. In 1984, 89% of respondents gave risk averse responses in the first lottery whereas 6% provided equivalents which imply risk seeking behavior.

Table 6.2 ***Results of the assessment of certainty equivalents (in cts/kg) in 1984 and 1985, by means of the midpoint chaining technique (X_L and X_H are the outcomes in the 50/50 lotteries)***

MEASUREMENT	LOTTERY		EXP. UTILITY	CERTAINTY EQUIVALENT			RANGE OF LOTTERY	E(x) OF LOTTERY	PERCENTAGE RESPONDENTS		
X_i	X_L	X_H	E[u(x)]	mean	median	st.dev.	mean	mean	A	RN	S[a]
Year 1984 N = 225											
7	10	X_2	.125	16.03	15.0	5.34	9.44	14.72	15	25	60
2	10	X_1	.250	19.44	18.0	6.66	16.90	18.45	24	33	43
5	X_2	X_1	.375	23.11	22.0	7.84	7.46	23.17	32	37	31
9	10	X_3	.375	23.42	22.0	8.28	28.69	24.34	55	26	20
1	10	70	.500	26.99	25.0	9.03	60.00	40.00	89	5	6
4	X_2	X_3	.500	27.89	26.0	9.77	19.25	29.06	32	37	31
10	X_7	X_8	.500	28.61	28.0	9.86	32.54	32.30	74	18	8
6	X_1	X_3	.625	31.97	31.0	10.35	11.79	32.79	59	25	16
3	X_1	70	.750	38.69	38.0	11.54	43.10	48.45	84	8	8
8	X_3	70	.875	48.50	50.0	12.20	31.31	54.34	68	19	13
Year 1985 N = 191											
7	10	X_2	.125	17.21	16.0	5.24	11.84	15.92	18	24	58
2	10	X_1	.250	21.84	20.0	7.15	21.49	20.74	25	35	41
5	X_2	X_1	.375	26.53	25.0	8.48	9.70	26.68	43	33	24
1	10	70	.500	31.49	31.0	9.50	60.00	40.00	73	17	10
4	X_2	X_3	.500	31.05	30.0	10.00	21.13	32.40	59	25	16
6	X_1	X_3	.625	36.86	37.0	10.62	11.44	37.25	54	25	20
3	X_1	70	.750	42.97	44.0	11.42	38.51	50.74	77	15	8
8	X_3	70	.875	51.52	54.0	11.58	27.03	56.48	67	20	13

[a] A = risk averse, RN = risk neutral, S = risk seeking

The variation in equivalents between respondents is quite large in this first lottery. The 5th and 95th percentiles of the certainty equivalents assessed are, respectively, 15 and 44 cts/kg, the 10th and 90th percentile values are 16.5 and 37.5 cts/kg. These figures show that risk aversion varies largely between farmers. Both strongly risk averse and risk neutral or slightly risk seeking farmers are present in the sample.

The distribution of responses with respect to whether a respondent is risk averse, risk neutral, or risk seeking appears to be different between the lotteries. The percentage of risk neutral or risk seeking responses is high, especially for low levels of expected utility (0.125 and 0.25). This implies a utility function which is linear or even convex for low price levels (predominantly between 10 and 19 cts/kg). One explanation for this phenomenon might be a range effect as was mentioned in Section 6.2.1. In small-ranged lotteries, responses tend to be more often risk neutral or risk seeking than in large-ranged lotteries.

The analysis of the relationship in Table 6.2 between the percentage of risk averse responses and the average range of the lottery seems to support the hypothesis of a range effect. A higher percentage of risk averse responses goes together with a larger range of the lottery. Measurement 6, however, with an expected utility of 0.625, is an exception in this respect. Although the average range for this lottery is quite small (11.5 cts/kg), the percentage of risk averse responses is fairly large (59%). It therefore seems that, in our case, a small range of the lottery induces risk seeking responses *only* in case of a low expected value of the lottery. This might indicate that the range of the lottery is not the only reason for less risk averse responses associated with low levels of expected utility. A supplementary explanation is that farmers code the outcomes in lotteries played for low levels of price as losses and exhibit less risk aversion or even risk seeking preferences, as hypothesized in Prospect Theory (Kahneman and Tversky 1979). Findings in 1985 show a similar pattern concerning the relationship between range and risk aversion.

Three measurements are obtained in 1984 at $u(x) = 0.5$ and two measurements at $u(x) = 0.375$ in order to test the internal consistency of the assessments. If farmers respond in accordance with expected utility theory, the same certainty equivalents should result aside from random response error. Table 6.2 shows that average responses at $u(x) = 0.5$ are lowest for the first measurement and highest for the tenth measurement, with the fourth measurement in between. When tested, these differences are significant (ANOVA with repeated measurement, $p < 0.001$). The first measurement implies more risk aversion than the fourth and tenth measurement. Although significant, differences between the assessments are not substantial. The median absolute difference for all three pairwise comparisons is 2 cts/kg. For 90% of the respondents the absolute difference is smaller than 5 cts/kg and for 25% of the respondents perfectly consistent answers were obtained. Also, correlations between measurements are very high (Pearson correlations are all above 0.90). Taking into account the extreme range of the first lottery, which most likely made it a fairly difficult and error prone elicitation, these differences are small.

No significant difference is found between the measurements in 1984 for $u(x) = 0.375$ (pairwise t-test, $p = 0.195$). In 1985, only one consistency measurement was provided for at $u(x) = 0.5$. Although the average equivalent of the fourth measurement is again smaller than that of the first measurement (see Table 6.2), this difference is not significant ($p = 0.137$). It is therefore concluded that respondents assessed equivalents in an internally consistent manner. In general therefore, this finding implies that farmers responded in accordance with the expected utility model.

By comparing the results of 1984 with those of 1985, it becomes very clear that average risk aversion is less in 1985. For example, comparing the first elicitation in both years shows that the median certainty equivalent has increased by 6 cts/kg in 1985, namely from 25 to 31 cts/kg. Especially the percentage of risk neutral responses has increased for this lottery: from 5% in 1984 to 17% in 1985. Further comparisons and possible explanations for differences between the years will be made after estimating the parameters of the utility functions. We will now turn to this estimation.

Results of estimating the parameters in the negative exponential and power function

In Table 6.3 the descriptive statistics of parameter estimates are presented. It concerns the estimate of parameter c in 6.21 and 6.24, respectively. It is clear from this table that in 1984 the negative exponential function, implying constant absolute risk aversion, provides a much better fit than the power function. The average mean sum of squared errors (MSE) of the negative exponential function is 7.47 compared to 17.76 of the power function. Moreover, by comparing the MSE of the functions pairwise, the negative exponential function shows a better fit for all respondents.

Table 6.3 *Results of fitting per individual a power and a negative exponential function to the data points measured by means of the midpoint chaining technique*

		PARAMETER			MSE	N
FUNCTION		mean	median	st.dev.	mean	
Power	1984	.669	.571	.631	17.76	225
Negative exponential	1984	.043	.036	.042	7.47	225
Negative exponential	1985	.031	.022	.045	6.27	191

The reasons for this better fit of the negative exponential function are clear. It was already shown in Table 6.2 that farmers responded less risk averse to lotteries with low levels of expected utility, especially for u(x) = 0.125 and u(x) = 0.250, than to lotteries with high levels of expected utility. The certainty equivalents elicited for low levels of expected utility imply a less concave, or even a linear or convex, lower part of the curve. Since the power function is most concave in the lower part of the curve, (note that the power function describes *decreasing* absolute risk aversion) the function fits the data much worse than the negative exponential curve which describes *constant* absolute risk aversion (see also Figure 6.3).

The pattern of certainty equivalents in 1985 is similar to the one in 1984 (see Table 6.2). It was decided therefore to skip fitting the power function in 1985, since from the pattern it was clear that the power function would fit equally bad compared to the negative exponential function. The average fit of the negative exponential function is quite alike in both years.

By analyzing the residuals of the negative exponential function, insight can be gained into the quality of fit of this function. The function is fitted per individual so that there are only 10 residuals per individual. The analysis of residuals is therefore conducted by averaging residuals over individuals per level of expected utility. The residuals are measured along the x-axis (predicted x minus assessed x; see 6.21 and 6.22).

In both years, the median residual is positive for the two lowest levels of expected utility and approximately nil or slightly negative for higher levels of expected utility. Since deviations are measured along the x-axis, a positive residual implies that, in general, the function is located to the left of the assessed points for low levels of expected utility. The function is located somewhat to the right of the elicited points for high levels of expected utility. This pattern of residuals suggests an S-shaped pattern of assessed points which is approximated by a fully concave negative exponential function.

It should be stressed here that, although an S-shaped pattern is suggested by the residuals, the median residuals are close to zero. For example, for $u(x) = 0.25$ and $u(x) = 0.75$, the median residual is at a maximum, namely +1 and -1 cts/kg, respectively. Nevertheless, it is very interesting to speculate about possible reasons for such an S-shaped pattern. One reason is that, as has already been noted in the review of the literature in Section 6.2.1, the midpoint chaining technique shows a bias in producing convex-concave curves (Hershey et al. 1982). Our measurement seems to confirm this bias. The pattern would then be viewed as a response effect.

Alternatively, one might view the S-shaped pattern to represent the decision maker's true evaluation function. This might be the case when the farmer does not evaluate the price or gross margin he receives for his potatoes as a stream of income which contributes to his fixed costs, but as gains and losses with respect to a reference. Then, the farmer perceives a price which is *above* the reference price as a gain and, according to Prospect Theory (Kahneman and Tversky 1979), he will be risk averse, whereas a price *below* the reference price is perceived as a loss resulting in risk seeking choices. For example, the perceived direct costs of the crop might act as such a reference.

The analysis of whether farmers code prices with respect to a reference price and, if so, what price they take as a reference could be a subject for further inquiry. In such an inquiry, besides applying the midpoint chaining technique, some other techniques should be used in assessing utility functions in such a way as to enable a separation of response effects from reference point effects.

In this study the parameter of the negative exponential function will be taken to represent the risk attitude of farmers. An S-shaped function will not be fitted to the data. Firstly, as has been described, the deviations from the concave function are fairly small. Secondly, in case response effects cause the pattern, estimating such an S-shaped function would not be appropriate when compared to the theoretically more attractive negative exponential or power function. A third but nevertheless important reason concerns the convenience of the negative exponential function. In this function the risk attitude of a farmer can be uniquely described by only one parameter. In characterizing farmers, analyzing stability and convergent validity, studying relationships with personal and situational factors and in analyzing preferences, the use of only one parameter greatly simplifies work in these matters.

Shift in risk attitude from 1984 to 1985

Table 6.4 shows the percentiles of the parameter in the negative exponential function in both years. This parameter equals the Pratt-Arrow coefficient of absolute risk aversion. A positive parameter implies risk aversion (the larger the parameter, the more risk averse), a negative parameter indicates risk seeking. From this table it is clear that the average degree of risk aversion is less in 1985 (= 0.031) compared to 1984 (= 0.043). A risk parameter is obtained for 179 respondents in both years. Tested pairwise, both parametric and non-parametric, this difference is significant ($p < 0.001$). The parameter is larger in 1985 than in 1984 for 65% of the respondents. A shift towards risk seeking occurred between the years.

Table 6.4 *Distribution of the parameter of the negative exponential function in 1984 and 1985 (the coefficient of absolute risk aversion), as measured by means of the midpoint chaining technique (a larger positive parameter implies more risk aversion)*

	PARAMETER	
Percentile	1984	1985
05	-.0140	-.0277
10	.0017	-.0060
25	.0180	.0086
50	.0355	.0220
75	.0630	.0486
90	.0965	.0810
95	.1200	.1073
Mean	.043	.031
St.dev.	.042	.045
N	225	191

In 1984, 91.1% of the parameters is positive (implying risk aversion); in 1985, this percentage is 84.3%. These figures suggest that the percentage of risk seeking managers has increased from 8.9% to 15.7%. However, these percentages only discriminate between positive and negative coefficients, without taking the magnitude of the coefficient into consideration. No insight is gained into the percentage of risk neutral decision makers because a decision maker will be classified as risk neutral only in case a parameter is exactly zero which is an unlikely finding.

For this reason, the following procedure was used in classifying decision makers on the basis of the coefficient. If it is assumed that the residuals are independently and identically distributed per individual, then a standard error of the parameter can be estimated per individual (see Equations 6.27 and 6.28 in Section 6.2.3). If it is further assumed that the non-linear least-squares estimator is approximately normally distributed, then it is possible to test whether the parameter is significantly different from zero (= risk neutral) per individual. In this manner, the respondents can be classified into risk averse, risk neutral and risk seeking decision makers.

Because it is questionable whether the residuals per individual fit the assumptions, the analysis is performed here mainly for illustrative purposes. Table 6.5 shows the results. The parameters are tested with a significance level of 0.05 (two-tailed). In 1984, 12% and in 1985, 23% of parameters are not significantly different from zero. Those farmers are classified as risk neutral. The percentage of risk seeking farmers is low in both years, as expected.

Table 6.5 *Classification of respondents into three classes of risk attitude*

	1984	1985
Risk averse	82%	68%
Risk neutral	12%	23%
Risk seeking	6%	9%
	100%	100%
N	225	191

By comparing both years, it appears that especially the percentage of risk neutral farmers increased (from 12% in 1984 to 23% in 1985), whereas the percentage of risk seeking farmers only increased from 6% to 9%. One may therefore conclude that the risk attitude shifted from 1984 to 1985 towards risk neutrality, whereas only a small percentage became risk seeking in 1985. These findings are thus in sharp contrast with the conclusions which would be drawn if only the sign of the parameter were used when classifying decision makers into risk classes. The analysis therefore shows the value of taking the standard error of the parameter into account and this procedure should therefore be standard practice in utility assessment and classification of subjects into risk classes.

Figure 6.4 provides further insight into the magnitude of differences between farmers in risk aversion, both within each year and between the years. In this figure the utility functions corresponding to the 5th, 50th and 95th percentile are drawn for each year. For example, the curve located most to the left represents the negative exponential utility function with parameter c = 0.12: in 1984 only 5% of the farmers is more risk averse than this curve implies (see Table 6.4).

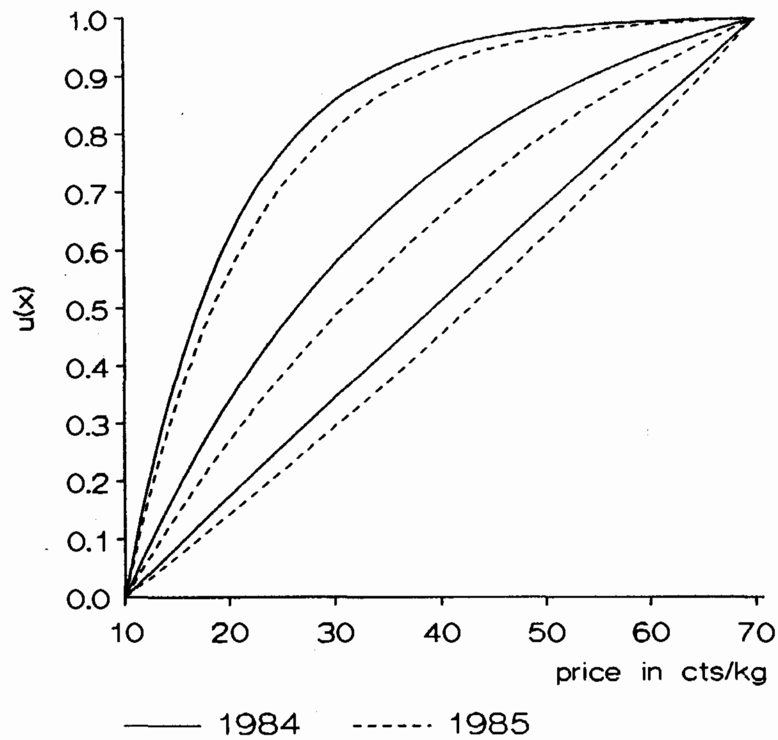

Figure 6.4 *Indication of degree of risk aversion by means of curves corresponding to 5th, 50th and 95th percentile (from right to left, respectively), in both years (negative exponential function; midpoint chaining technique; data shown in Table 6.4)*

As found above, farmers responded less risk averse in 1985 than in 1984. Before digressing upon possible explanations for this shift in risk aversion, it is necessary to study the stability of the measurement. Does the assessment in 1985 yield the same rank order of farmers in respect of risk attitude as the 1984 measurement? If it does, then risk aversion changed systematically in the sample which was probably caused by some common factor, e.g. an increase or decrease in wealth. If the correlation between both measurements is far from perfect, this might be due to a shift in risk attitude which differs in magnitude between respondents or to unstable measurement. In principle, as e.g. Heise (1969) has shown, it is not possible with only two measurements to differentiate between temporal stability and systematic change in risk attitude.

Computing the correlation between the risk attitudes of both years shows that this correlation is 0.45 ($n = 179$, $p < 0.001$) for both the Pearson and Spearman correlation coefficient. In evaluating the magnitude of this correlation it should be taken into account that the time span between the measurements is one year. This is an extremely long time interval for test-retest measurements. Usually, a period of two weeks between the measurements is advised. It is difficult to evaluate the magnitude of the stability, since comparable studies are scarce. To our knowledge only in the study of MacCrimmon and Wehrung (1986), which concerns the risk attitudes of 84 business executives, were measurements repeated with a year in between. They found a test-retest correlation of 0.35 ($p < 0.001$) for personal investments; the correlation was not significant for business investments. The stability in our study is good in comparison with their findings.

Noticing the reasonable stability of the measurement technique, interest is now focussed upon the possible reasons for the shift in risk attitude. Explanations for this temporal change in risk attitude towards less risk aversion are hard to give. On the contrary, the three plausible reasons for change in attitude described below suggest that, should attitudes have changed at all from 1984 to 1985, a shift towards risk aversion instead of risk seeking would have occurred.

The first explanation concerns the effect of wealth on risk attitude. A decreasing absolute risk aversion function is usually assumed for wealth (Arrow 1971). This implies that if a decision maker becomes more wealthy, he becomes less risk averse for absolute changes in wealth. In our study, this implies the following. At the moment of the first interview in 1984, farmers had experienced very high prices of ware potatoes in the former year (1983/84). Their wealth was therefore relatively high. Potato prices in 1984/85 were fairly low, so that the farmers' wealth must have decreased at the time of the interview in 1985. Farmers thus became less wealthy from 1984 to 1985. As a result, farmers should be more risk averse in 1985 compared to 1984 when assuming a decreasing absolute risk aversion for wealth. The data show a shift in the opposite direction, however. To accommodate such a shift, one would have to assume an increasing absolute risk aversion for wealth, which is rather implausible (Arrow 1971).

A second argument also leads to the hypothesis of an increasing absolute risk aversion for wealth. Possibly, farmers do not take their *current* wealth position as a reference point, but judge the lotteries on basis of their *expected* wealth position. Then, since farmers expected prices in 1985/86 to be lower than those in 1984/85 (see Chapter 5), they expect to be confronted with a decrease in wealth from 1984 to 1985. Again, this would imply more risk aversion in 1985 on part of the farmer in case of a decreasing absolute risk attitude.

A third argument concerns a possible biasing of the probabilities specified in the standard lotteries. Firstly, because farmers expected low prices in 1984/85 and secondly because they expected even lower prices in 1985 than in 1984, they may have biased the probability for the low outcome in the binary 50/50 lotteries as being larger than 50% (especially in 1985). If so, the certainty equivalents provided by the respondents correspond with a lower expected utility of the lottery. When the researcher processes the certainty equivalents as if the equivalents correspond to 50/50 lotteries, a higher expected utility than is intended by the respondent is matched to the equivalents. With such a perception bias, the utility function would be shifted to the left, implying more risk aversion. A shift to the right due to biasing of the probabilities could only result if farmers expected higher prices in 1985 than in 1984.

To summarize, the stability of the measurement is significantly positive and higher than that found in a reference study. Nevertheless the stability is not very high (0.45). If the measurement procedure were quite unreliable, one would expect the farmer's risk attitude to shift in a random manner. However, in the sample a systematic shift in attitude towards less risk aversion is found. This was contrary to the expectations: should the attitude change at all, one would expect it to shift towards more risk aversion.

Summary and conclusions of lottery measurement

An essential element in the expected utility model is the utility function. This function is predominantly assessed under risk by means of lotteries. In our review of the literature, a classification of techniques for assessing the function was presented and strengths and weaknesses were outlined. In general, the assessment appears to be susceptible to quite a range of judgmental biases and response mode effects. An overview of the most important biases and effects was given.

An important conclusion from this review was that studies in which risk attitudes are assessed for a large number of respondents in survey conditions and in which, at the same time, much attention is devoted to careful assessment of the function and stability of the measurement, are scarse. One purpose of this study was to gain more insight into the possibilities and problems of assessing risk attitudes on a large scale.

In this study, the so-called midpoint chaining technique was chosen for assessing the utility function. By means of ten binary lotteries, all 50/50 lotteries, chained in the appropriate manner, ten points of the function could be assessed. Two functions were fitted to these data: a negative exponential function, implying constant absolute risk aversion on the part of the decision maker, and a power function which characterizes a constant proportional risk averse decision maker. Very clearly, the negative exponential function fitted the data best. Some indications were found of an S-shaped utility function. It was suggested to attribute this shape to the response bias of the midpoint chaining technique (most likely caused by the varying range in the lotteries) probably in combination with an effect of a reference point, as is hypothesized in Prospect Theory.

Overall, farmers appeared to be risk averse. In 1984, 82% of the farmers were risk averse and 12% were risk neutral; in 1985, these percentages were 68% and 23%, respectively. The remaining farmers were slightly risk seeking. Farmers were somewhat less risk averse in 1985 compared to 1984, contrary to expectations.

If the true risk attitude is assumed to be fixed over the years, the stability of the risk attitude measurement is not very high (Pearson correlation 0.45), but still higher than the stability found in a reference study (0.35). However, as has been stated above, by measuring a concept only twice it is not possible to differentiate the stability of the measurement from the change in true score of the concept. In this study we had to limit ourselves to two moments of measurement. Longitudinal research, with more than two measurements in time, would provide information about the reliability of the risk attitude assessments and the temporal stability of risk attitude.

In determining whether the midpoint chaining technique is a suitable assessment technique in a survey, the following aspects should be taken into account. Overall, farmers responded fairly easily to the question. This is illustrated by the high response rate of the question (± 94%) and by the internal consistency in assessment. Presenting the question to farmers in the terminology of the actual decision-context, in contrast with the often rather hypothetical decision-contexts used in many experimental studies, probably motivated the decision makers to approach the question conscientiously and to think carefully about their preferences. Thus validity of the measurement has probably increased.

The largest threat to the realism of the question was experienced in the first lottery between 10 and 70 cts/kg, corresponding to an expected utility of 0.5 on the interval from 0 to 1. Because of this very large range, some farmers showed difficulty in providing the first certainty equivalent. This is probably one of the weakest aspects of the midpoint chaining technique. However, consistency checks for this first assessed point showed only small deviations, although respondents somewhat tended to assess less risk averse certainty equivalents in subsequent assessments for $E[u(\underline{x})] = 0.50$. A further indication of the fairly good first assessment is shown by the correlation between the parameter calculated algebraically for the first point assessed and the parameter estimated on basis of the complete assessment of ten lotteries. This Pearson correlation is 0.85.

Taking all findings together, it can be concluded that the midpoint chaining technique is a practically feasible technique for assessing utility functions in a valid manner in large scale survey research. On the basis of our experiences with the assessment technique in this study however, we believe that for assessing utility functions by means of lotteries for large numbers of respondents, interactive computer controlled assessment, e.g. the hybrid approach (Farquhar 1984), seems attractive for a number of reasons. Firstly, the paper and pencil approach used in this study makes it necessary for the interviewer to play a very important role in the assessment process. As with eliciting subjective probability distributions, iterating towards indifference assumes a skillful and extensively trained interviewer. In a computer controlled assessment, one is probably less dependent on the interviewer's competence. Such a finding would be beneficial for consumer survey research conducted by e.g. market research agencies.

A second argument for adaptive computer controlled assessment is the number of lotteries which the respondent has to answer. In survey conditions one would opt for assessing the utility function with as few assessments as possible. In our study, ten certainty equivalents were assessed for each farmer. As stated above, the correlation between the first assessment and the parameter estimated after ten assessments, was fairly high (0.85). With adaptive utility assessment, a sequential sampling approach could be used in which, after each assessment, it was checked whether more assessments would yield sufficiently new information for justifying the costs of this extra assessment. Thirdly, graphical display of the assessed function would probably motivate and stimulate the respondent even more to evaluate the adequacy of the assessment.

In the next section, attention will be directed towards the conjoint measurement technique in assessing risk attitude. This is followed by a comparison of the lottery and conjoint measurement technique (henceforth, the midpoint chaining technique will be referred to as lottery technique).

6.4 Measurement of risk attitude by means of conjoint measurement

6.4.1 Description of the method

In the former section, the standard method of measuring risk attitude was presented. Now, an alternative procedure is proposed, namely conjoint measurement. This technique is fairly popular in consumer research (see e.g. Green and Srinivasan (1978) for analyzing preferences of multiattribute choice alternatives). The basics of conjoint measurement were outlined by Tversky (1967) in his study of the expected utility model, specifically concerning the question of whether probabilities and utilities are combined multiplicatively and then added.[5] It is therefore quite remarkable that no empirical research exists to our knowledge in which risk attitudes are assessed using this technique. Wind (1982) and Corstjens and Weinstein (1982) suggested to apply conjoint analysis in this manner, but they presented no empirical research.

Since conjoint measurement is easy to handle in survey research and respondents feel comfortable with the technique as is shown by many consumer studies, this technique seems very suitable for assessing the risk attitude of decision makers in survey conditions. It should be noted here beforehand that conjoint measurement does have limitations in this respect. Specifically, no utility function for outcomes is obtained. At the end of this section this point will be elaborated

[5] Shanteau (1975) and Anderson and Shanteau (1970) replicated this study from the viewpoint of information integration.

upon. But first, the design of the conjoint measurement task and its results will be discussed.

Design of conjoint measurement task

In conjoint measurement the respondent has to rate or rank order, according to preference, a set of profiles describing the choice alternatives. Each profile consists of a combination of levels for a number of attributes. Then, by appropriate estimation techniques, the trade-off between levels of attributes can be obtained.

In this study, the attributes describing the alternatives are *expected value* and *standard deviation* of price. Thus, each profile specifies a certain level of expected price and standard deviation. By asking the respondent to rank order a set of profiles, which is systematically varied with respect to levels of expected value and standard deviation, the trade-off between both attributes can be estimated. Essentially, the trade-off between expected price and price risk (indicated by the standard deviation) provides a measure of the risk attitude of the decision maker. Highly risk averse decision makers have to be compensated more with respect to expected value than do less risk averse decision makers in order to prefer an alternative with a larger risk to an alternative with a smaller risk. For risk neutral decision makers no trade-off is made between expected value and price risk. They will order the set of profiles according to expected value irrespective of the risk associated with the profile.

The profiles can be described and presented to the respondent in two manners. In the *direct* manner, profiles are characterized by the levels of expected value and standard deviation. The profile is then described as e.g. expected value = 24 cts/kg and standard deviation = 7 cts/kg. In the *indirect* manner, the profiles consist of lotteries with probabilities and outcomes chosen in such a way as to represent the levels of expected value and standard deviation, e.g. a 50/50 lottery with outcomes 17 and 31 cts/kg representing an expected value of 24 cts/kg and a standard deviation of 7 cts/kg. In the direct manner, the description of the profiles is much more difficult to grasp and this method therefore seems possible only in case respondents are well trained in statistics. We therefore chose the indirect manner in this study.

To further simplify the respondent's task, *binary* lotteries with *50/50* probabilities were chosen. The conjoint measurement resembles the lottery technique in these respects. In fact, the respondents have to evaluate pairwise a series of binary 50/50 gambles and can thus be seen as the preference comparison version of the paired-gamble technique (see Table 6.1).

In this study, we limited the design of profiles to two attributes (expected value and standard deviation). As a consequence, respondents have had to choose only between symmetrical probability distributions. It is obvious that this design of the profiles is analogous to mean-variance analysis. Decision makers only have to take mean and variance of a distribution into account. Conjoint analysis needs not be constrained in this manner, however. It is perfectly possible to include in a profile a level of skewness, or even kurtosis, in order to detect preferences for skewness or kurtosis. Such a choice, however, would clearly increase the difficulty of the task for the respondent. In case of binary lotteries, taking skewness into account would imply refraining from 50/50 lotteries. Seen in the context of the whole interview, consisting of a fairly large number of elaborate and difficult questions, we deemed this more sophisticated design inappropriate.

The stimulus set

In constructing the profiles, six levels of price risk were chosen, namely 0, 2, 4, 7, 10 and 13 cts/kg and four levels of expected value: 23, 24, 25 and 26 cts/kg. In a full-factorial design this results in 24 combinations. Table 6.6 shows these combinations and the outcomes used in the binary lotteries. For example [18,32] concerns a lottery of receiving 18 cts/kg or 32 cts/kg with equal chances. The combinations were written down in a tree structure on separate cards and presented to the respondent. It should be noted that the range of the lottery is directly related to the level of risk of the lottery, since the standard deviation of the lottery equals half the range of the lottery.

In Table 6.6 the profile combinations in the lower right hand corner are not orthogonal profiles. In test interviews it became clear that the orthogonal profiles, namely [13,33] and [10,36] were consistently preferred least. As a consequence, these profiles did not provide information about the trade-off between expected value and risk. It was decided to replace these profiles by two riskless alternatives, namely 21 and 19 cts/kg, which can be traded-off against other profiles and which thus provide more information about the risk attitude of the decision maker. A small disadvantage of this replacement is that the main effects and interaction effects in such a non-orthogonal design cannot be estimated uncorrelated (Green and Srinivasan 1978).

Table 6.6 Set of profiles in conjoint measurement task

STANDARD DEVIATION	EXPECTED VALUE 26	25	24	23
0	26	25	24	23
2	24/28*	23/27	22/26	21/25
4	22/30	21/29	20/28	19/27
7	19/33	18/32	17/31	16/30
10	16/36	15/35	14/34	21
13	13/39	12/38	11/37	19

* 24/28 indicates a 50/50 lottery with outcomes 24 and 28 cts/kg; the expected value of this lottery is 26 and the standard deviation is 2.

A total of six combinations consist of riskless alternatives. These can be seen as representing the choice of a fixed-price contract and at the same time resembling the certainty equivalents in the lottery technique.

If the lotteries in Table 6.6 are compared within a row, then it turns out that lotteries located at the left dominate each lottery at the right. For a constant level of risk, the expected value decreases from left to right. Of course, it is assumed in this case that decision makers prefer high prices to low prices, that is, their utility function for price is increasing.

The ordering of lotteries is less obvious within each column. In this case the expected utility model will be contrasted with the hypothesis of an ideal risk level (Coombs 1975, Coombs and Huang 1976, Coombs and Avrunin 1977). Within a column, lotteries are compared with equal expected value but increasing risk. If a decision maker applies the expected utility model, a monotone rank order of lotteries will result. In case of a risk averse decision maker, preference for lotteries will be monotonically decreasing with risk, whereas for risk seeking decision makers preferences will be monotonically increasing with risk.

In contrast, the single-peaked preference theory of Coombs (1975) hypothesizes that decision makers prefer an ideal-level of risk instead of a monotone ordering of risk. In case of an ideal risk level, both alternatives with a smaller and alternatives with a larger risk than the ideal-level are less preferred. In this theory a decision maker could well prefer e.g. the lottery [22,30] to both [24,28] and [19,33]. Thus, the lottery with an intermediate level of risk is preferred, although the expected values of the lotteries are equal. In expected utility theory such an ideal-level of risk is impossible. It is interesting to study whether farmers choose according to the expected utility model or come up with an ideal-level of risk. MacCrimmon et al. (1980) performed a comparable analysis of this issue. Their results will be discussed below and compared to our findings.

The trade-off between expected value and risk follows from the preference order of lotteries in Table 6.6 which are not positioned on the same column or row. For example, a decision maker preferring e.g. lottery [20,28] to lottery [16,36] is less risk averse than one who prefers lottery [21,25] to lottery [16,36].

Data collection procedure

The profiles were described on separate cards. These were shuffled by the interviewer and handed over one by one to the respondent. The lottery on the card was pictured as a probability tree. The respondents were asked to provide a complete rank order of the profiles according to their preference. They were instructed to compare systematically each new card handed over to them, with each card already having been rank ordered. This ordering proved to be a relatively easy task to the respondents. In 1985 the conjoint measurement task was limited to a randomly selected third part of the total sample. As a consequence, data is available of two moments of measurements for only a part of the sample ($n = 61$).

Estimation procedure

In order to estimate the risk parameters, two models are specified; a mean-standard deviation model (referred to as MSD-model) and an ideal-point model (referred to as IP-model). The models are specified as follows:

MSD-model

$$P_i = a + b\ M_i + c\ SD_i + e_i \qquad (6.29)$$

IP-model

$$P_i = a + b\ M_i + c\ SD_i + d\ V_i + e_i \qquad (6.30)$$

with:

P_i = integer preference rank order of profile i (1 = least preferred)
M_i = expected value of profile i
SD_i = standard deviation of profile i
V_i = variance of profile i
e_i = random error
i = 1, 2, 3, ... , 24

In the MSD-model, a linear trade-off is assumed between expected value (mean) and risk (as indicated by the standard deviation). The IP-model makes a non-linear relationship between expected value and risk possible by means of including V_i ($= SD_i^2$). By testing whether parameter d is significantly different from zero it is tested whether a non-linear relationship between expected value and risk provides a better fit than a linear relationship.

In both models, one expects parameter b to be positive: a higher expected value goes together with a higher preference. In the MSD-model, parameter c is expected to be negative, implying risk aversion (a lower preference for higher risk), for most respondents. Parameter c will be positive for risk seeking respondents and zero for risk neutral farmers. In the IP-model an ideal-point for risk comes up at $SD = -c/2d$ ($c > 0$, $d < 0$). If d approaches 0 than the ideal-point goes to infinity. Consequently, the MSD-model can be seen as a special case of the ideal-point model, namely with an ideal-point at infinity (Carroll 1972).

Since the measurement of preferences for profiles consists of a rank order, a non-linear estimation method, like LINMAP (Srinivasan and Shocker 1973), is most appropriate. In case preferences are measured on an interval scale, ordinary least squares (OLS) is a suitable technique. When both techniques are compared, it shows that OLS has the advantage of providing standard errors for the estimated parameters and this enables testing statistically whether the IP-model fits the data better than the MSD-model. Furthermore, OLS is a much more convenient and less expensive technique than LINMAP, especially when taking into account that both the models have to be estimated in both years for each individual.

Although OLS seems inappropriate in view of the ordinal dependent variable, the simulation studies by Carmone et al. (1978) and Wittink and Cattin (1981) have found that OLS, when applied to an integer rank order, yields solutions that are very close, in terms of predictive validity, to those obtained by nonmetric algoritms like LINMAP. The empirical studies of e.g. Green and Srinivasan (1978) and Jain et al. (1979) too, showed only minor differences in predictive validity between estimation methods. We will therefore use OLS as a method of estimation. Of course, by employing ranks as the dependent variable, the usual standard errors and statistical tests are not strictly valid. Care should therefore be taken in this respect.

6.4.2 Results of conjoint measurement

Both the parameters of the MSD-model and those of the IP-model were estimated by means of OLS *per individual*. These estimates, averaged over individuals, are presented in Table 6.7. Estimates were obtained in 1984 for a total of 218 respondents (the question was asked in the second interview of 1984 with 238 farmers as respondents so the response percentage is very high: 91.6% (218/238)). Response in 1985 was even higher; estimates could be obtained for 66 out of 68 respondents (97.1%). The results of both years are available for a total of 61 respondents.

In Table 6.7 the average values of several statistics are shown. The significance of parameters is tested with significance level $p = 0.05$ (two-tailed). The percentages of significant parameters are presented in the table.

Both years yield comparable results. As the median R-squares show, the models fit fairly well. The signs of the coefficients are in the expected direction and mostly significant. For four respondents in 1984 parameter b is not significantly positive. This implies that for these respondents a higher expected value of the lottery does not yield a higher preference, which is not very plausible. These four respondents will be removed in further analyses.

In the MSD-model, parameter c is not significantly different from zero for 4% (1985) to 7.8% (1984) of the respondents, implying risk neutral farmers (the standard deviation of the profile does not influence preference). The number of cases in which parameter c is significantly positive (= risk seeking decision makers) is negligible.

Table 6.7 Conjoint analysis of risk preference models: results of OLS per individual

MODEL	1984 MSD	1984 IP	1985 MSD	1985 IP
Mean R^2	.846	.881	.863	.889
Mean R^2(adj.)	.831	.863	.850	.872
Median R^2	.904	.929	.924	.932
Minimum R^2	.188	.292	.362	.421
Maximum R^2	.987	.991	.985	.991
St.dev. of R^2	.155	.121	.142	.120
N	218	218	66	66
Regression coefficients				
Mean b	2.800	2.717	2.765	2.689
Mean c	-1.235	-.726	-1.337	-.874
Mean d	--	-.041	--	-.037
Significance in % ($p < 0.05$, two-tailed)				
Parameter b				
Positive, not significant	1.8	1.8	--	--
Positive, significant	98.2	98.2	100.0	100.0
Parameter c				
Positive, not significant	2.8	9.6	2.0	11.0
Positive, significant	2.8	18.3	2.0	5.0
Negative, not significant	5.0	25.2	2.0	15.0
Negative, significant	89.4	56.9	95.0	70.0
Parameter d				
Positive, not significant	--	14.7	--	15.0
Positive, significant	--	9.2	--	8.0
Negative, not significant	--	34.4	--	33.0
Negative, significant	--	41.7	--	44.0

Models

MSD-model $P_i = a + b\,M_i + c\,SD_i$

IP-model $P_i = a + b\,M_i + c\,SD_i + d\,V_i$

As is shown by the mean and median R^2, the IP-model fits the data somewhat better than the MSD-model. The differences are small, however. By means of the F-test on the change in R^2 due to the inclusion of V_i, it is tested *per individual* whether the IP-model fits significantly better (that is, if the F-value is larger than 4.35 ($F(1,20) = 4.35$, $p = 0.025$). In 1984, the fit of the IP-model is significantly better than the MSD-model for 38% of the respondents. In 1985, this percentage is 33%. Because of the ordinal dependent variable, these figures should be interpreted carefully.

Using the estimates of parameters c and d in the IP-model, the ideal-point can be calculated. In 1984, this ideal-point is located between the minimum and maximum level of risk for 22.6% of the respondents (minimum and maximum levels of risk (= standard deviation) are 0 and 13, respectively). In 1985, this percentage is 16.7%. In both years these percentages are lower than the percentage of respondents for which the IP-model fits better than the MSD-model. The percentages thus show that a significantly larger fit of the IP-model does not necessarily imply an ideal-point for risk in the relevant range of the attribute.[6]

In order to gain more insight into the role of the ideal-point in ordering the profiles, in Table 6.8 the rank order data of 1984 are split into *monotone*, *ideal-point* and *other* rank orders, for each level of expected value (26, 25 and 24, respectively). Monotone rank orders are in accordance with the expected utility model and can imply risk aversion or risk seeking. Ideal-point rank orders are incompatible with expected utility theory but consistent with Coombs's (1975) single-peaked preference theory (only unimodal rank orders are classified as ideal-point orders). Furthermore in Table 6.8 the location of the ideal point is specified (at small, medium or large risk, respectively). Monotone and ideal-point orders taken together form the total of unimodal or single-peaked rank orders.

To elucidate the classification, consider the 6 profiles in the first column of Table 6.6. Suppose these profiles are denoted A, B, C, ... , F (in decreasing order). If a respondent makes the rank order A, B, ... , F (with decreasing preference), he is classified as *monotonically risk averse*: in each pairwise comparison the profile with the smaller risk is preferred. The rank order F, E, ..., B, A is classified as *monotonically risk seeking*.

A rank order of B, A, C, D, ... , F (with decreasing preference) is classified as an *ideal-point* rank order with the ideal-point at *small* risk; a rank order of C, B, D, A, E, F is classified as an ideal-point rank order with the ideal-point at the *medium* risk, etc. Ideal-points of B and E are denoted as such at small and large risk respectively; ideal-points of C and D are classified as medium levels of risk. A rank order of e.g. A, C, B, F, D, E is classified as "other rank order" because it is not unimodal.

In classifying rank orders, a further differentiation is made with respect to whether the certain profile is included or excluded. For example, a rank order in which the profiles are ordered monotonically with respect to risk, but where the certain profile is placed somewhere in-between the order, excluding the certain

6 In case the ideal-point is located further to the endpoints of the risk scale, the IP-model approximates the MSD-model to a larger extent (Carroll 1972).

profile will change the classification of the order from ideal-point to monotone, e.g. the ideal-point rank order B, A, C, D, ... , F becomes the monotone rank order B, C, D, ... , F if A (the certain profile) is excluded.

Table 6.8 shows that the percentage of monotone rank orders is 45% (certain profile included). These 45% of the farmers rank order the profiles in accordance with expected utility theory. Almost all farmers are monotonically risk averse (43.7%), the percentage of monotonically risk seeking farmers is low (1.2%).

The percentage of ideal-point orders is 28.7%. Monotone and ideal-point order taken together results in a total percentage of unimodal orders of 73.7% (certain profile included), with a higher percentage for a lower expected value (from 69.5% to 80.7%). Also, by removing the certain profile, the percentage of unimodal orders increases from 73.3% to 84.4%. The removal of the certain profile especially lowers the percentage of ideal-point and "other" orders in favor of monotone rankorders (the percentage of ideal-point order decreases from 28.7% to 19.3% and the percentage of monotone orders increases from 45% to 65%).

Table 6.8 *Classification of preference rank order of risk profiles into monotone, ideal-point and other orders, for each expected value, in 1984, in % (percentages are computed vertically)*

	CERTAIN PROFILE INCLUDED					CERTAIN PROFILE EXCLUDED				
RANK ORDER OF PROFILES	26	25	24	Total	Mc[1]	26	25	24	Total	Mc[1]
Monotone	**37.6**	**43.6**	**53.7**	**45.0**	**19.2**	**56.0**	**65.1**	**74.3**	**65.1**	**57.5**
- Averse	36.7	42.2	52.3	43.7	12.5	54.1	63.8	72.8	63.5	44.2
- Seeking	.9	1.4	1.4	1.2	6.7	1.8	1.4	1.8	1.7	13.3
Ideal point	**31.7**	**27.5**	**27.1**	**28.7**	**60.0**	**25.7**	**17.4**	**14.7**	**19.3**	**40.0**
- at small risk	17.4	21.6	20.2	19.7	31.7	20.6	12.8	11.9	15.1	-
- at medium risk	13.8	5.5	6.9	8.7	17.5	3.2	3.7	2.8	3.2	40.0
- at large risk	.5	.5	-	.3	10.8	1.8	.9	-	.9	-
Unimodal orders*	**69.3**	**71.1**	**80.7**	**73.7**	**79.2**	**81.7**	**82.7**	**89.0**	**84.4**	**97.5**
Other rank orders	**30.7**	**28.9**	**19.3**	**26.3**	**20.8**	**18.3**	**17.4**	**11.0**	**15.6**	**2.5**
N	218	218	218	654	120	218	218	218	654	120

* Unimodal orders consist of the sum of monotone and ideal point orders

1 MacCrimmon, K.A. et al (1980): Real money lotteries: a study of ideal risk, context effects and simple processes.

When looking at the *location* of the ideal-point, it shows that respondents prefer a profile with a small risk to a profile with either no risk or a medium to large risk. For example, with an expected value of 26 cts/kg, about 17.4% of the farmers prefer profile [24,28] to the certain profile of 26 cts/kg, but they prefer 26 cts/kg to profiles [22,30], [19,33], ... [13,39]. Analogous preferences are exhibited for expected values of 25 and 24 cts/kg.

Our results contrast to a large extent with the findings of MacCrimmon et al. (1980) who, in a comparable design, have found a much higher percentage of respondents with an ideal-level of risk. As is shown in Table 6.8, they found in their study about 60% of all rank orders to be of the ideal-point type, we found only 29%. They therefore concluded that (p.172): "Our data provides evidence that motivated real decision makers playing for significant amounts of real money exhibit an ideal-level of risk", thus confirming Coomb's hypothesis. In this study, much less support for the hypothesis of Coombs is found.

They further found that the percentage of monotone rank orders increases dramatically from 19.2% to 57.5% (see Table 6.8) if the certain profile is excluded. Based on their findings MacCrimmon et al. conclude that (p.172): " ... if a sure prospect creates a different mental set from uncertain alternatives, we must be cautious about theories that value uncertain prospects according to their certainty equivalent". Although in this study also the inclusion of the certain profile seems to invoke some respondents to consider ideal-levels of risk and thus depart from expected utility theory, removing the certain profile increased the percentage of monotone rank orders in our study to a much smaller extent than in the study of MacCrimmon et al. In our data, measurements appear to be much less sensitive to the inclusion of the certain profile. Their conclusion thus is only partly supported by our findings.

It should be noted here that the finding that the majority of the ideal-point orders concerns an ideal-point at small risk due to the inclusion of the certain profile, is not in accordance with the certainty effect as labelled by Kahneman and Tversky (1979). The certainty effect concerns the effect that a sure prospect is evaluated more favorably compared to a prospect that is merely probable (see also Section 6.2). Consequently, on the basis of the certainty effect, one expects the certain profile to be preferred to an uncertain profile with the same expected value. Actually, the reversed effect shows up in the study of MacCrimmon et al. and in this study. Farmers prefer a profile with a small risk to the certain profile. It is concluded therefore that the certainty effect is not supported in this study. Perhaps the utility for gaming (see 6.2) can explain the finding: farmers prefer a profile with an insignificant amount of risk to the 'dull' certain profile, solely due to the expected pleasure of 'playing' the lottery.

It is concluded that, in the conjoint measurement task, only a limited percentage of decision makers exhibited preferences which are not in accordance with the expected utility model. That is, for only about 15% to 20% of the respondents, preferences can be described somewhat better by assuming an ideal-point for risk in the relevant range of risk. Moreover, exclusion of the certain profile even lowers this percentage. In further analyses concerning the risk attitude the parameter estimates of the MSD-model will therefore be used. This model accurately explains preferences among risky profiles of most farmers.

Distribution and stability of the risk attitude measured by means of conjoint measurement

In the MSD-model, the trade-off between expected value and standard deviation on the iso-utility curve is taken to be the risk parameter. This parameter will be referred to as RC indicating the risk parameter (= R) measured by means of conjoint measurement (= C). This parameter is defined as:

$$RC \equiv \left.\frac{dM}{dSD}\right|_{U=U^*} = -\frac{\partial U/\partial SD}{\partial U/\partial M} = -\frac{c}{b} \tag{6.31}$$

In case of the MSD-model (see Equation 6.29) this parameter RC = -c/b. Since b > 0 because of the increasing utility function of price, and c < 0 in case of risk aversion (higher risk goes together with a lower preference) RC > 0 in case of a risk averse decision maker. If c > 0 it follows that RC < 0, which implies a risk seeking attitude. In case of risk neutrality c = 0 and thus RC = 0.

Table 6.9 shows the distribution of RC in both years. The value of the median risk parameter in both years is about 0.50. This value indicates that in order to prefer two alternatives equally, an increase of e.g. 2 cts/kg in standard deviation should be compensated by an increase of 1 ct/kg in expected value. The table further shows that in 1984 about 5% of the farmers was risk neutral to slightly risk seeking (RC ± 0).

The average risk parameter is somewhat higher in 1985 than in 1984 (0.49 versus 0.46, respectively), suggesting an *increase* in degree of risk aversion. However, a pairwise test, both parametric and non-parametric, shows no clear significant difference in risk attitude between both years ($t(61) = 1.68$, $p < 0.099$). This finding is in contrast with that of the lottery technique which showed a significant *decrease* in risk aversion from 1984 to 1985.

The stability of the RC-parameter is fairly low. Only the Spearman correlation is significant, namely 0.30 ($p < 0.01$, one-tailed). The Pearson correlation is 0.20 and not significant ($p = 0.12$). A different measure of stability is the correlation between the rank order of profiles in both years. Such a correlation can be computed per individual over the 24 profiles. The median Spearman correlation is 0.44; the 10th and 90th percentile are 0.18 and 0.78, respectively. When tested with $p = 0.025$ (one-tailed), 60% of the correlations is positive and significant; with $p = 0.05$ (one-tailed) this percentage increases to 70%. Of course, it should be taken into account that measurements took place with a year in between. It is therefore very difficult to compare these stability correlations with those of other studies. For example Acito (1977), McCullough and Best (1979) and Segal (1982) found test-retest correlations of respectively 0.89, 0.93 and 0.94 between preference rank orders of 27 profiles, measured with respectively 6, 2 and 10 days in between.

Table 6.9 *Distribution of the parameter RC in 1984 and 1985, measured by means of conjoint measurement (a larger positive parameter implies more risk aversion)*

	1984	1985
MODEL	MSD	MSD
Percentile		
05	-.02	.12
10	.17	.28
25	.35	.39
50	.51	.53
75	.61	.64
90	.73	.76
95	.78	.81
Mean	.463	.494
St.dev.	.277	.256
N	214	66

Summary and conclusion

An important advantage of conjoint measurement is the simplicity of the task for the respondent. Instead of having to provide indifference judgments as with the lottery technique, in conjoint measurement a preference statement between lotteries suffices. Indications of the ease with which the respondents completed this task are the high response percentage and the short time needed to complete the task, which ranged between 5 and 10 minutes. Conjoint measurement therefore proves to be a suitable technique for measuring risk attitudes in survey conditions.

The major findings will now be summarized. The mean-standard deviation model, implying a linear trade-off between the expected value and the risk (standard deviation) of a lottery, appears to be describing the preference structure of at least 80% of the respondents very well. For less than a fifth of the respondents, Coombs' (1975) hypothesis of an ideal-point for risk provided a better fit than the mean-standard deviation model. For most of these respondents, the fit improved only slightly, although statistically significantly. Such an ideal-point is incompatible with expected utility theory. Furthermore, findings suggest that the inclusion of certain profiles in the design induce respondents towards an ideal-point model for risk. The effect, however, was much less than found by MacCrimmon et al. (1980). Taking into account the small percentage of farmers for which the ideal-point model fits significantly better in combination with the minor increase in fit of this model, it is therefore concluded that most of the exhibited preferences of respondents in this conjoint measurement task are in accordance with expected utility theory.

Findings show that risk attitude did not shift between both years, but that stability seems fairly low. However, no studies exist with which to compare our stabilities because of the long annual time interval between test and retest.

Conjoint measurement is a promising method for an easy assessment of risk attitude and is especially suitable for survey research. The flexibility of the technique (in principle, the form of the evaluation function is totally free) and the ease of the task for the respondent are certainly strengths compared to other techniques of assessing risk attitude. A weakness is the low stability of the measurement found in this study. Another weakness is that in the usual procedure of conjoint measurement no utility function for outcomes is obtained which can be incorporated in the expected utility model. One remedy to this problem might be to assume e.g. a negative exponential function and estimate the parameter in this function in a LINMAP-like procedure with the pairwise preferences between profiles as dependent variable. One difficulty in such a procedure would be to develop criteria to select the appropriate specification of the function.

The assessment of risk attitude by means of conjoint measurement deserves more empirical research in order to further delineate strengths and weaknesses of this technique. For example, research could be directed towards assessing the influence of different experimental designs on the measurement of risk attitude, analyzing the effect of incorporating skewness as an attribute and towards developing procedures for improving the stability of the measurement.

6.5 Stability and convergent validity of measuring risk attitude

The previous sections provided the two measurements of the variable risk attitude. These indicators were obtained in both years. In this section, the convergent validity of these indicators will be studied together with the stability of the latent variable risk attitude.

A suitable technique to study these aspects is LISREL (Jöreskog and Sörbom 1976, 1977, 1983; Olsson and Bergman 1977). Figure 6.5 shows the specifications of the model. Risk attitude is conceived as a latent variable measured by two indicators, analogous to the common factor model. Arrows are therefore drawn from the latent variable towards the indicators.

The regression coefficient Beta in Figure 6.5 measures the stability of this latent variable and specifies the extent that the measurements in both years are linearly related. When the solution is standardized, Beta represents the standardized regression coefficient (= correlation coefficient) between the risk attitude in 1984 and that in 1985. A systematic shift in attitude is allowed in the model and will not influence parameter Beta.

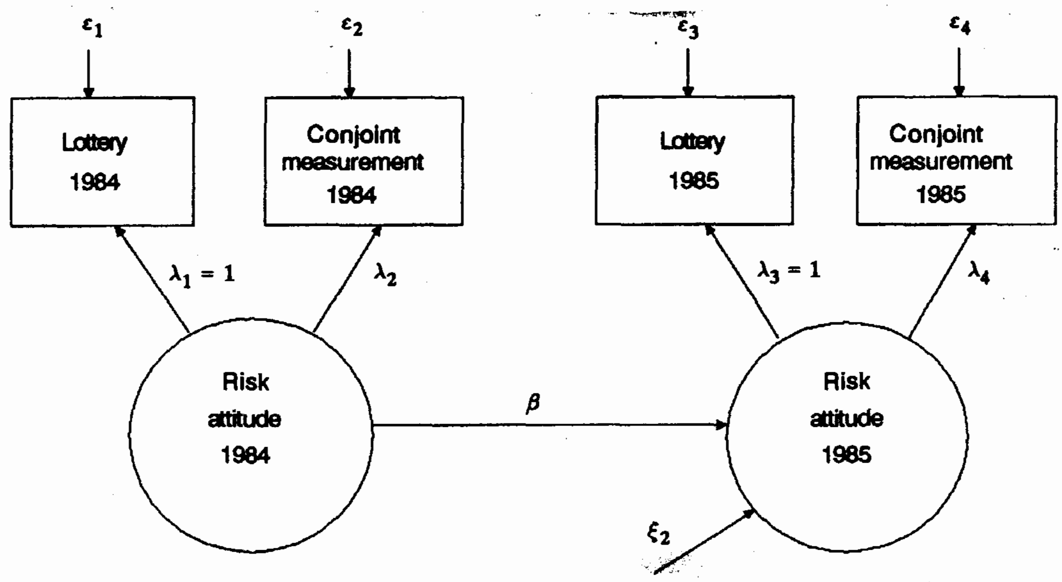

Figure 6.5 Model applied to estimate the stability of risk attitude, in LISREL-notation

The epsilons in Figure 6.5 indicate the measurement error of each indicator. In terms of the common factor model, the variance of the epsilons represents the unique part of each variable $(1 - h^2)$. Lambdas represent regression coefficients in the unstandardized solution of the LISREL model and beta-weights in the standardized solution. The input of LISREL is a correlation or covariance matrix. The parameters in the model are usually estimated by means of maximum likelihood. In this method standard errors are obtained which enables the testing of the significance of the parameters. To this end, it is assumed that the joint distribution of variables is multivariate normal. This assumption is difficult to meet, especially for small samples.

Table 6.10 provides the Pearson and Spearman correlations between the indicators, both with pairwise and listwise deletion of missing cases. Because the conjoint measurement task was repeated in 1985 for only a fifth of the total sample, listwise deletion of missing cases leads to only $n = 59$ respondents for which all four measurements are available. With pairwise deletion, the number of cases ranges from 59 to 214. The removal of outliers did not alter the correlations.

All correlations are positive and significant, with the exception of stability of the conjoint measurement (Pearson correlation). By comparing Spearman and Pearson correlations, no large differences show up. As expected, listwise deletion generally results in higher correlation coefficients.

Table 6.10 Pearson and Spearman correlation matrices of indicators of risk attitude

below diagonal: pairwise deletion of missing data
above diagonal: listwise deletion (n = 59)

		RL84	RC84	RL85	RC85
Pearson correlations					
Lottery	RL84	--	*50*^{d}	**59**^{d}	28^{d}
Conjoint	RC84	*49*^{d}	--	37^{c}	**21**
Lottery	RL85	**44**^{d}	23^{d}	--	*31*^{c}
Conjoint	RC85	27^{b}	**20**	*34*^{c}	--
Spearman correlations					
Lottery	RL84	--	*45*^{d}	**43**^{d}	37^{c}
Conjoint	RC84	*49*^{d}	--	27^{b}	**32**^{c}
Lottery	RL85	**45**^{d}	23^{d}	--	*36*^{c}
Conjoint	RC85	37^{c}	**30**^{c}	*40*^{d}	--

Bold stability
Italics convergent validity

a $p < .05$ (one-tailed)
b $p < .025$ (one-tailed)
c $p < .01$ (one-tailed)
d $p < .001$ (one-tailed)

The Pearson correlation between the lottery and conjoint measurement is 0.50 in 1984 and 0.31 in 1985. Spearman correlations are 0.45 and 0.36, respectively. These correlations concern the convergent validity of the measurement of risk attitude. Since they are significantly positive in both years, this is an indication that both techniques measure the same concept.

The Pearson correlation matrix of Table 6.10 was the input in the LISREL-VI version of SPSS-x. Table 6.11 shows the estimates of the parameters (standardized values). Replacing the correlation matrix by the covariance matrix did not alter conclusions. For ease of interpretation therefore, the results of the correlation matrix are presented here.

With one degree of freedom and listwise deletion the model provides a good fit of the data, as is shown by Chi-square (p = 0.76) and the goodness of fit index which is near to the maximum value of 1.

The estimate of stability, Beta, is 0.82 which is significant (t-value = 3.51) and high. The most reliable indicators of risk attitude are the lottery measurements as is shown by the lambda's 1 and 3. However, also the conjoint measurement indicators contribute significantly to the stability of the concept (t-values of 3.30 and

2.24, respectively). The stability of 0.82 is, of course, higher than for each technique separately (the stability of the lottery technique is 0.59 and that of the conjoint measurement is 0.21). It illustrates the increase in reliability that is obtained when measuring concepts by more than one method.

Table 6.11 Stability of risk attitude, estimated separately for pairwise and listwise deletion of missing values (standardized LISREL solution, maximum likelihood estimates)

	LISTWISE[a]		PAIRWISE	
Parameter	Coefficient	t-value	Coefficient	t-value[b]
λ_1	0.894[c]		0.924[c]	
λ_2	0.564	3.30	0.526	2.25
λ_3	0.803[c]		0.731[c]	
λ_4	0.381	2.24	0.467	2.15
β	0.824	3.51	0.643	2.17
Var. ξ_2	0.207	0.78	0.586	1.24
$\theta_{\varepsilon 1}$	0.202	1.02	0.147	0.43
$\theta_{\varepsilon 2}$	0.682	4.59	0.723	4.17
$\theta_{\varepsilon 3}$	0.356	1.40	0.466	1.86
$\theta_{\varepsilon 4}$	0.855	5.08	0.782	4.50
χ^2 (d.f=1)	0.10		0.65	
p	0.76		0.25	
Goodness of fit index	0.999		0.998	

a n = 59
b Standard errors and t-values are computed for n = 59
c Fixed to 1 in the unstandardized solution

As was already clear from the smaller correlations in Table 6.10, pairwise deletion results in a lower estimate of stability, namely Beta = 0.64, which is still significant (t-value = 2.17). It should be noted here that, because of the different number of cases for each correlation, the standard errors and thus the t-values are calculated for n = 59 which represents the minimum number of cases a correlation is based on. As a result, the t-values presented are on the safe side. Important differences between the manners in which missing values are handled do not show up further.

It is concluded that risk attitude can be successfully represented by a latent variable which is indicated by measurements from both a standard lottery questioning procedure and conjoint measurement. This results in a stable measurement of risk attitude, with the lottery technique yielding the most reliable measurement. The contribution of conjoint measurement is less than the lottery technique but statistically significant. It is shown that LISREL provides an excellent framework to gain insight into relationships between measurements. Explicitly conceiving risk attitude as a latent variable which is indicated by multiple indicators, provides avenues for further research into the risk attitude concept.

6.6 Measurement of strength of preference

This section concerns itself with the assessment of the evaluation function under certainty: the strength of preference or value function v(x). First, a number of measurement procedures for assessing value functions will be reviewed, followed by a description of the implementation of the techniques in this study. The results of the assessments obtained by each technique will be presented in Section 6.6.2. In Section 6.6.3 then the correspondence in assessment is dealt with.

6.6.1 The midvalue splitting and rating technique in assessing value functions

Defining strength of preference

The value function is often called a strength of preference function. Strength of preference refers to the intensity of a decision maker's preference for an alternative or consequence. The value function is used to order the *differences* in the *strength of preference* between pairs of alternatives. It thus provides ordered value differences (Fishburn 1970, Hauser and Shugan 1980). Several alternative axiom systems exist for value functions, see e.g. Krantz et al. (1971). These axioms imply that there exists a real-valued function v on X (X denotes the set of all possible consequences) so that for all w, x, y, z from X the difference in the strength of preference between w and x exceeds the difference between y and z, iff.:

$$v(w) - v(x) > v(y) - v(z). \tag{6.32}$$

This function v is unique up to positive linear transformations, so it provides an interval scale of measurement like the utility function u.

Review of assessment techniques

In Fishburn (1967) a number of techniques for assessing single and multiattribute value functions are presented. For *multiattribute* decision problems conjoint measurement is an appropriate and often used technique in consumer and marketing research to assess the value functions (see e.g. Green and Srinivasan 1978). For assessing *single* attribute value functions three sets of techniques can be distinguished: *direct rating*, *equisection* and *ordered metric*.

The *direct rating* technique is one of the most well-known and used measurement technique in the social sciences. Many different question formats exist like 5 or 7-point category scales, graphic scales, constant sum scales etc. In psychophysics, functions are assessed by means of magnitude estimation (Stevens 1985) in which the respondent has to express the intensity of a particular stimulus in comparison with a reference stimulus. Magnitude estimation results in interval or even ratio scale measurement (see Chapter 5). Another variant of the rating technique that arrives at an interval level of measurement involves fixing the boundaries of the scale at e.g. 0 and 100 and then asking the respondent to express the intensity (e.g. strength of preference) of a stimulus by assigning a number between 0 and 100. Such a procedure is applied in this study and further on in this study this variant will be denoted as rating technique. This technique has been applied in studies of Huber (1974) and Eliashberg (1980) in assessing strength of preference.

A second technique to measure value functions is *equisection* (Torgerson 1958). In this technique the boundaries of the interval are fixed. The respondent is asked to distribute n-1 stimuli over the interval such that n intervals result which are equal in subjective value (say strength of preference). In case n=2 this method is called the *bisection* or *midvalue splitting* technique (referred to as MVS-technique). In the assessment task the respondent has to specify whether a change from x_i to x_j equals in value a change from x_i to x_k ($x_i < x_j < x_k$). By iteration a value of x_j can be found so that the respondent is indifferent between both changes; then the first midvalue has been assessed. This midvalue point is also referred to as equal difference point (Dyer and Sarin 1982) or value equivalent. Like the midpoint chaining technique concerning lotteries, a sequence of successive bisections results in a number of points of the value function. It is clear that the assessment procedure in the midvalue splitting technique corresponds directly to the definition and meaning of a value function (ordered value differences). Empirical studies which used the midvalue splitting technique in assessing a value function are e.g. Pliskin and Beck (1976) and Eliashberg (1980).

According to Torgerson (1958) the midvalue splitting technique is one of the most simple scaling techniques since an ordinal judgment of the respondent suffices. By comparing two intervals the respondent solely has to state whether one interval is larger in subjective value than the other interval. Contrariwise, with the rating scale a respondent has to place *selected* stimuli on a scale. He has to state whether a stimulus is larger/smaller in value than another stimulus and if so, how much larger/smaller. Torgerson thus prefers the midvalue splitting technique. Eliashberg (1980) on the other hand points out that the successive bisections in the midvalue splitting technique might result in a compounding of errors (like in the midpoint chaining technique). He thus expects more measurement error and inconsistencies with the midvalue splitting technique than with a rating scale.

In a direct comparison of both techniques concerning a two attribute decision problem (student housing locations with attributes: rent and distance to campus), Eliashberg (1980) showed that indeed the predictive validity of the rating technique was higher than that of the midvalue splitting technique. However, the differences in predictive validity were relatively small. To our best knowledge no other empirical comparisons between both techniques have been carried out to confirm this result.

A third technique reviewed by Fishburn (1967) concerns the *ordered metric* technique. In this technique the respondent is given two intervals and he has to specify whether one interval is larger in value than the other interval, that is whether $[v(w) - v(x)]$ R $[v(y) - v(z)]$ (the respondent specifies R: $<$, $>$ or $=$). A number of such intervals are compared pairwise. Each comparison yields a restriction in a linear programming program (e.g. LINMAP) used to calculate the scale values. This task is fairly easy to the respondent. However, a main disadvantage of this technique is the large number of pairwise comparisons the respondent has to make before the value function can be assessed accurately. For example, for assessing 7 points of the function (excluding the boundaries), according to Dyer et al. (1973) at least 50 pairwise comparisons are necessary. Such a large number of comparisons makes this technique unattractive to apply.

In conclusion, the rating and midvalue splitting technique will be applied in measuring the value function. The application of two techniques enables one to study the convergent validity. In both techniques a number of points of the value function will be assessed. Like in the utility assessment, both a negative exponential and power function will be fitted to the assessed points. The theoretical and practical arguments for fitting these function specifications which were mentioned in respect of utility functions are also valid for value functions. Fitting the same function specifications furthermore facilitates the direct comparison and analysis of the relationship between the value and utility function.

Implementation of the midvalue splitting technique

The procedure used in the midvalue splitting technique resembles the lottery (midpoint chaining) technique to a very large extent. The same boundaries (10 and 70 cts/kg) and sequence of successive bisections are chosen. See Figure 6.3 for this sequence. The consistency measurements 4, 9 and 10 in Figure 6.3 are left out in the assessment of the value function. Because of limited interviewing time these measurements were replaced with only one consistency measurement assessed at $v(x) = 0.375$ (between $v(x) = 0.125$ and $v(x) = 0.625$). In this manner a total of 8 assessments is obtained: 7 points of the curve and one consistency measurement.

In the interview, the respondent was presented with two situations: one concerning a change in price from A to B and one concerning such a change from B to C (in which A < B < C). These situations were written down on paper. Subsequently, the farmer was asked to indicate which change in price he deemed more valuable: the change in price from A to B or the change from B to C. By adjusting the value C, the interviewer iterated towards the equal difference point.

The question format was: "Consider that the market price of ware potatoes is 10 cts/kg. Suddenly a large demand for potatoes causes prices to rise to 15 cts/kg. Instead of 10 cts/kg you receive 15 cts/kg. Of course you will be pleased with this 5 cts/kg rise in price. Now consider yourself in the situation of a 15 cts/kg market price; suddenly prices rise to 20 cts/kg. Again you will be pleased with this 5 cts/kg rise in price. The question now is which 5 cts/kg rise in price you value most: from 10 to 15 or from 15 to 20 cts/kg?". By choosing prices close to the boundaries in the initial questions, say 12 cts/kg instead of 15 cts/kg in the above question, choices are made easy to the respondent. The rapid rise in price was made plausible by referring to the unexpected upward price movement in 1976 caused by a sudden demand for ware potatoes from the GDR.

In a number of test questions the respondent was made familiar with the questioning procedure. Familiarizing the respondent with the goal and meaning of the measurement by means of test questions facilitated the first assessment greatly, even considering the extreme boundaries of 10 and 70. In the test assessments "regret" formulations have also been used, that is in the above example the respondent is asked the valuation of a sudden 5 cts/kg price fall: from 20 to 15 compared to that from 15 to 10 cts/kg. According to the axioms of ordered value differences this "regret" formulation should result in the same midvalue as the "joy" formulation. This has not been tested explicitly. By confronting the respondent with both types of questions during the training task it is tried to induce such consistency.

In 1984, the midvalue splitting question was asked in the first of the two interviews held with each farmer. The measurement of the value function therefore most likely did not interfere with the utility assessment, since the lottery question was asked in the second interview in 1984, at least one week after the first interview. In order to achieve independent measurements in 1985, the midvalue splitting and lottery technique were maximally separated in the interview. The lottery technique was set in the first part of the interview, the midvalue splitting technique was situated at the end of the interview. In 1985 the midvalue splitting task was given to a third of the respondents, randomly selected.

In estimating the parameter of the negative exponential and power function, the same procedure will be followed as with the lottery measurement. This procedure was described extensively in Section 6.2.3.

Implementation of the rating technique

In the rating technique, ten price levels are presented to the respondent in random order. The respondent is asked to value each price level on a scale between 0 (corresponding to price level 10 cts/kg) and 10 (price level 70 cts/kg). Apart from round scale numbers the respondent can specify the fractions 0.25, 0.50 and 0.75, analogous to the scoring system used in schools to rate performances. The respondents are familiar with this scoring system and showed no difficulty in answering the questions. Only a few minutes were needed to complete the rating task.

The following price levels are rated: 14, 17, 20, 23, 25, 30, 35, 40, 50 and 60 cts/kg. These price levels are chosen so as to get approximately equal value intervals for the majority of respondents. Since in test interviews it was shown that for many respondents prices around 25 cts/kg corresponded to $v(x) = 0.5$ (implying a concave curve), it was tried to get an equal number of assessments below and above +/-25 cts/kg. Such a distribution of assessments enables an accurate estimation of the value function. As a consequence, differences between the stimulus price levels below 25 cts/kg are smaller than those above 25 cts/kg.

The rating question was situated in the last part of the second interview in 1984 in order to avoid effects of the utility measurement in the lottery question (situated in the first part of the interview). In 1985, the rating task was situated between the lottery and midvalue splitting task in the middle of the interview.

Since the ten price levels are presented to the respondent in random order one can view these measurements as independent. The parameters in the negative exponential and power function (see specifications 6.15 and 6.16) can therefore be estimated in a straightforward manner. Non-linear least squares estimates are obtained with the ratings on the 10-point scale as dependent and the stimulus price levels as independent variable.

In both techniques described above the decision context of the assessment equals that of the lottery technique. That is, the farmer has to imagine selling his total harvest at the assessed prices. In evaluating prices, respondents were instructed to assume a potato produce of usual quality, waste percentage and size distribution.

6.6.2 Results of midvalue splitting and rating technique

Results of the midvalue splitting technique

Since the midvalue splitting technique was applied in the first interview of 1984, a maximum of 253 respondents could answer the question. The percentage of respondents for which at least three equivalents were obtained is 87.7% (222 out of 253). In 1985, 86.7% (58 out of 67) responded to the question. These response percentages are somewhat lower than those for the lottery technique, which at least partly might be due to the fact that in both years, the question was situated in the final part of the interview, whereas the lottery technique was situated in the first part.

In Table 6.12 descriptive statistics of the value equivalents measured by means of the midvalue splitting technique are shown, ordered with respect to increasing value of v(x). In the same manner as with the lottery technique, for each level of v(x) the equivalents are classified into value averse, value neutral and value seeking. It should be noted here again that to ease presentation and discussion of results, a terminology analogous to that used with the utility function is introduced. As a consequence, a decision maker with a concave value function, implying decreasing marginal value, will be referred to as a *value averse* decision maker. In the same manner, *value seeking* of course implies a convex value function of increasing marginal value of price. Constant marginal value is referred to as *value neutral*.

As is shown in Table 6.12 the mean value equivalent at v(x) = 0.50 is 25.5 cts/kg in both years. This means that an increase from 10 to 25.5 cts/kg is deemed equally valuable as an increase from 25.5 to 70 cts/kg. In the same manner, an increase from 10 to 17.5 cts/kg (from v(x) = 0 to v(x) = 0.25) equals in value an increase from 17.5 to 25.5 cts/kg (from v(x) = 0.25 to v(x) = 0.50) etc.

Table 6.12 *Results of the measurement of the value equivalents (in cts/kg) in 1984 and 1985, obtained by the midvalue splitting technique (X_L and X_H are the boundaries in the assessment of the value equivalent)*

MEASUREMENT	OUTCOMES			VALUE EQUIVALENT			PERCENTAGE OF RESPONDENTS		
X_i	X_L	X_H	V(x)	mean	median	st.dev.	D	C	I[a]
Year 1984	**N = 222**								
4	10	X_2	0.125	14.21	13.0	3.92	33	30	37
2	10	X_1	0.250	17.55	17.0	5.18	42	33	25
5	X_2	X_1	0.375	21.03	20.0	6.56	54	29	17
8	10	X_3	0.375	21.12	20.0	6.84	64	25	11
1	10	70	0.500	25.50	25.0	7.80	91	7	2
6	X_1	X_3	0.625	30.86	30.0	9.15	60	30	10
3	X_1	70	0.750	37.73	39.0	11.04	84	12	4
7	X_3	70	0.875	47.81	52.0	11.88	70	24	6
Year 1985	**N = 58**								
4	10	X_2	0.125	13.87	14.0	1.83	24	42	34
2	10	X_1	0.250	17.20	17.5	3.01	41	28	31
5	X_2	X_1	0.375	20.90	20.0	4.51	49	42	9
8	10	X_3	0.375	20.86	21.0	4.72	63	25	12
1	10	70	0.500	25.52	26.5	6.97	95	5	-
6	X_1	X_3	0.625	30.35	31.0	8.37	60	28	12
3	X_1	70	0.750	37.00	38.0	10.73	87	10	3
7	X_3	70	0.875	46.53	48.0	11.45	82	16	2

[a] D = decreasing marginal value ('value averse'), C = constant marginal value ('value neutral'), I = increasing marginal value ('value seeking')

Almost all the respondents provided 'value averse' equivalents in the first assessment between 10 and 70 cts/kg (in 1984 only 2% of the equivalents implies 'value seeking'.[7] By and large therefore, farmers are value averse. Farmers, of course, differ amongst themselves with respect to the degree of value aversion. For example, in 1984 the value equivalents at the 5th and 95th percentile of the first measurement between 10 and 70 cts/kg were 15 and 37.5 cts/kg, respectively. In both years a consistency assessment was made at v(x) = 0.375. There are no significant differences in the assessments in both years.

In Table 6.12, the data shows a pattern similar to that found with the lottery technique (compare with Table 6.2). That is, the percentage of value seeking responses increases with lower levels of v(x). However, the percentages of value seeking responses are lower than those of the lottery technique. For example, at v(x) = 0.125 about 35% of responses with the midvalue splitting technique can be classified as value seeking, whereas with the lottery technique 60% is classified as risk seeking (at u(x) = 0.125).

In contrast to the risk seeking responses with lotteries, value seeking responses, implying increasing marginal value, are not very plausible if farmers evaluate prices as a stream of income. Value seeking responses should therefore most likely be attributed to response effects, due to the varying range in the sequence of assessment. Such an effect has already been suggested and described with the lottery technique (see Section 6.3). Another explanation is to attribute the effect to a reference point, as is assumed in Prospect Theory. In that case a convex value function could result if respondents perceived the prices between 10 and ± 21 cts/kg as losses and prices above 21 cts/kg as gains. The price of ± 21 cts/kg would then be considered the reference price.

There is a clear resemblance of lottery and midvalue splitting techniques. In both techniques, iteration takes place towards indifference, binary outcomes are used, assessments are chained, and the range between outcomes depends on responses of the subject and the utility/value level. Therefore similar response effects can be expected. Our finding of lower percentages of value seeking responses with the midvalue splitting technique than with the lottery technique shows that respondents, notwithstanding the resemblance in questioning technique, do perceive a difference in concept measured. In the lottery technique risk is introduced, inducing respondents to provide more risk seeking equivalents than in the midvalue splitting technique where riskless evaluations are made, inducing respondents towards the theoretically more plausible value averse responses.

[7] Henceforth, for reasons of comparison with the measurement of the utility function, decreasing/increasing marginal value responses will be referred to as value averse/seeking.

Parameter estimates of the negative exponential and the power function

A negative exponential and a power function were fitted to the data. Table 6.13 presents the results of the estimation per individual. The average MSE (= mean sum of squared errors) in 1984 shows that the negative exponential function fits the data much better than does the power function. This finding as well as its explanation are in perfect agreement with those of the lottery technique (see Section 6.3): for low levels of v(x) farmers provide less value averse equivalents than for higher levels of v(x), so that the power function is too steep for low levels of v(x).

As with the lottery technique the median residuals suggest an S-shaped value function. This finding and its explanation will be elaborated upon in Section 6.6.3 when comparing the midvalue splitting and rating technique.

Table 6.13 Results of fitting per individual a power and a negative exponential function to the data points measured by means of the midvalue splitting technique

		PARAMETER			MSE	N
FUNCTION		mean	median	st.dev.	mean	
Power	1984	.553	.495	.380	16.80	222
Negative exponential	1984	.051	.039	.042	4.88	222
Negative exponential	1985	.053	.041	.046	3.12	58

The average parameter of the negative exponential function is, in both years, slightly above 0.50, with a median value of approximately 0.40 (see Table 6.14). When tested pairwise, no significant difference shows up between the years ($t(56) = 0.041$, $p < 0.68$). This means that no systematic shift in strength of preference occurred between the years. Figure 6.6 shows the value functions corresponding to three percentiles (5, 50 and 95) in both years. Clearly, the differences between 1984 and 1985 are small.

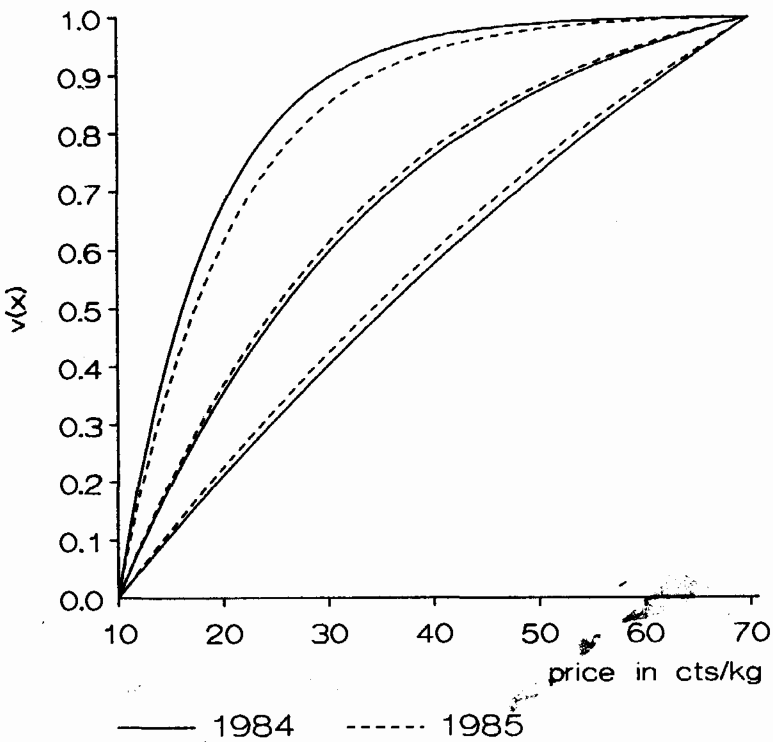

Figure 6.6 *Indication of degree of strength of preference by means of curves corresponding to 5th, 50th and 95th percentile (from right to left, respectively), in both years (negative exponential function; midvalue splitting technique; parameters shown in Table 6.14)*

Although positive and significant, the stability of the parameter is fairly small. The Pearson correlation is 0.35 ($p < 0.007$) (after removing two outliers, i.e. two extreme value averse individuals, the correlation is 0.24 ($p < 0.05$)). The Spearman correlation is 0.29 ($p < 0.014$) (after removing two outliers 0.23 ($p < 0.05$)). The influence of outliers is relatively large because of the small number of observations ($n = 57$).

Table 6.14 Distribution of the parameter of the negative exponential function in 1984 and 1985, as measured by means of the midvalue splitting technique (a larger positive parameter implies a more concave function)

	PARAMETER	
Percentile	1984	1985
05	.0044	.0117
10	.0101	.0131
25	.0244	.0225
50	.0385	.0410
75	.0650	.0670
90	.1121	.0938
95	.1377	.1299
Mean	.051	.053
St.dev.	.042	.046
N	222	58

Results of the rating technique

Response percentages of this rating task were extremely high. In 1984, 236 out of 238 farmers completed the question (99.2%); in 1985, this percentage is 99.0% (203 out of 205). These figures show the great ease with which farmers responded to the question.

Descriptive statistics of the responses to the rating technique are presented in Table 6.15. The responses are ordered with respect to increasing price level. In order to facilitate interpretation of the assessments consider the following implications of the data presented in Table 6.15. Taking into consideration that v(x) = 0.5 corresponds to the rating of 5 on a scale ranging from 0 to 10, Table 6.15 shows that 20 cts/kg is conceived by an average farmer as half way in value between 10 and 70 cts/kg (mean rating of 20 cts/kg is 5.15). Stated otherwise, a change in price from 10 to 20 cts/kg equals in value a change from 20 to 70 cts/kg!

Likewise, the value of 7.5 (v(x) = 0.75) corresponds to 35 cts/kg. This means that farmers consider a change in price from 20 cts/kg (v(x) = 0.50) to 35 cts/kg (an increase of 15 cts/kg) equally valuable as a change from 35 to 70 cts/kg (an increase of 35 cts/kg). Furthermore, since a rating of 6 corresponds to "sufficient" in school performance terms, farmers in general consider 23 to 25 cts/kg a "sufficient" price (see also in Table 2.2 that this sufficient price is the average market price for ware potatoes).

Table 6.15 Results of the measurement of the value function by means of the rating technique

	RATING[a]					
PRICE IN	1984 (N = 236)			1985 (N = 203)		
(CTS/KG)	mean	median	st.dev.	mean	median	st.dev.
14	3.00	2.99	1.11	3.26	3.07	1.15
17	4.23	4.44	1.19	4.69	4.94	1.05
20	5.15	5.12	1.12	5.55	5.89	1.12
23	5.78	5.98	1.21	6.20	6.11	1.07
25	6.26	6.45	1.20	6.61	6.86	1.09
30	7.02	7.03	1.15	7.32	7.39	1.03
35	7.53	7.54	1.07	7.81	7.91	.97
40	8.09	8.02	.93	8.26	8.08	.86
50	8.69	8.66	.77	8.79	8.94	.78
60	9.25	9.05	.55	9.31	9.42	.59

[a] Ratings on a scale of 0 to 10

The mean ratings that correspond to the price levels indicate that in general the value function is fairly steep for low price levels. Notice that the rating of 2.5 ($v(x) = 0.25$) is even below 14 cts/kg, which leads to the conclusion that a change of less than 4 cts/kg, namely from 10 to 14 cts/kg, represents a quarter in value!

Fitting a negative exponential and a power function to the data (Equations 6.15 and 6.16, respectively), confirms the notion of a very steep lower part of the function. The average MSE of the power function is smaller in both years than the average MSE of the negative exponential function (Table 6.16). Pairwise tested, parametric and non-parametric, this difference is largely significant ($p < 0.01$). The rating technique therefore implicates that farmers exhibit decreasing absolute risk aversion and constant proportional risk aversion. This finding contrasts with those of the lottery and midvalue splitting technique, in which the power function showed a worse fit than the negative exponential function.

Reviewing these findings one might suspect a response effect on part of the rating technique which could clarify the relatively high valuation of low price levels. Using a rating scale between 0 and 10 and making reference, although only minorly, to the scoring system used in schools, may have induced some respondents to consider all ratings below, say 3 or 4, as "very bad". In this case respondents may use only ratings between, say 4 and 10, to evaluate the price levels on the interval [10,70]. They may not have considered ratings below 4 as relevant. If such a response effect indeed is present, this would probably have been smaller if a rating scale between 0 and 100 had been used.

Table 6.16 Results of fitting per individual a negative exponential and a power function to the data points measured by means of the rating technique

		PARAMETER			MSE	N
FUNCTION		mean	median	st.dev.	mean	
Negative exponential	1984	.065	.066	.025	5.058	236
Negative exponential	1985	.074	.074	.025	5.994	203
Power	1984	.384	.354	.131	4.382	236
Power	1985	.341	.327	.103	4.957	203

Table 6.15 shows that the average and median ratings per level of price are somewhat higher in 1985 than in 1984. This finding can also be drawn from the smaller average parameter of the power function in 1985 (and the larger average parameter of the negative exponential function) (see Table 6.16).[8]

A total of 67% of the parameters is smaller in 1985 than in 1984. By testing the parameters of the power function pairwise between the years, a significant difference is found ($t(196) = 4.24$, $p < 0.01$). Since a smaller parameter in the power function implies a more concave function, this means that farmers became more value averse in 1985. The value function is shifted to the left: the same price level is valued higher in 1985 than in 1984. Apparently, farmers are more pleased with a price of e.g. 20 cts/kg in 1985 than in 1984. Table 6.17 and Figure 6.7 further illustrate this shift from 1984 to 1985 towards value aversion.

This shift of the value function is in accordance with a decreasing absolute risk aversion function for wealth. As was described in Section 6.3 a farmer's wealth decreased from 1984 to 1985. Consequently, he will value an increase in price more in 1985 than in 1984. It should be noted however, that this finding is not supported by assessments of the midvalue splitting technique, since no shift in strength of preference was found with that technique.

[8] Note that a larger parameter in the power function implies a less concave curve, whereas a larger parameter in the negative exponential function implies a more concave curve (see Equations 6.15 and 6.16).

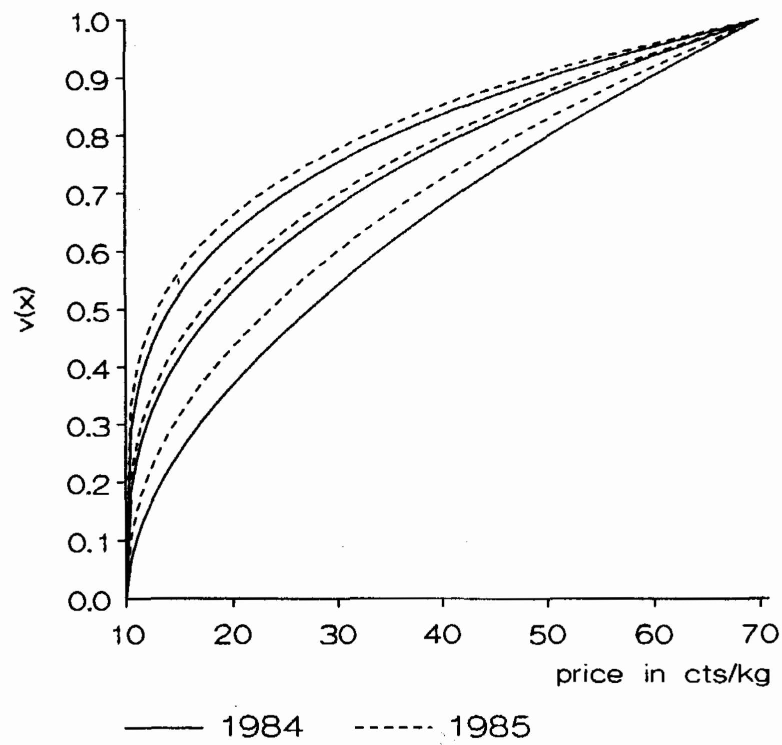

Figure 6.7 *Indication of degree of strength of preference by means of curves corresponding to 5th, 50th and 95th percentile (from left to right, respectively), in both years (power function; rating technique; data shown in Table 6.17)*

The stability of the assessment by the rating technique is fairly small, although correlations are positive and significant. The Pearson correlation is 0.15 ($p < 0.025$) and the Spearman correlation is 0.19 ($p < 0.01$). These correlations are of the same magnitude as those found with the midvalue value splitting technique. However, since with the rating technique the correlations are computed for a larger number of respondents ($n = 203$ compared to $n = 57$) the correlations here are statistically significant. The low correlations, although statistically significant, show that ratings shifted on average between the years but not for all individuals by the same amount or in the same direction, thus causing a fairly different rank order of respondents with respect to strength of preference.

Table 6.17 Distribution of the parameter of the power function in 1984 and 1985, as measured by means of the rating technique (a larger positive parameter implies a less concave function)

	PARAMETER	
Percentile	1984	1985
05	.226	.205
10	.259	.231
25	.301	.268
50	.354	.327
75	.447	.399
90	.558	.466
95	.640	.545
Mean	.384	.341
St.dev.	.131	.103
N	236	203

6.6.3 Stability and convergent validity of strength of preference measurement

In this section convergent validity and stability of the strength of preference will be analyzed in the same manner as was done with respect to the risk attitude. That is, strength of preference is conceived as a latent variable indicated by the assessments of rating and midvalue splitting technique.

First, the mutual location of the functions will be analyzed. Figures 6.8 and 6.9 show the functions corresponding to respectively the 10th, 50th and 90th percentile, for both techniques and both years. The figures clearly show the differences in function form between a negative exponential and a power function. For low values of x the negative exponential curve (MVS-technique) is located below the power function (rating technique); for high values of x it is located above the power function. In both years, the curve corresponding to the median parameter in the negative exponential function is located below the power function up to 45 cts/kg.

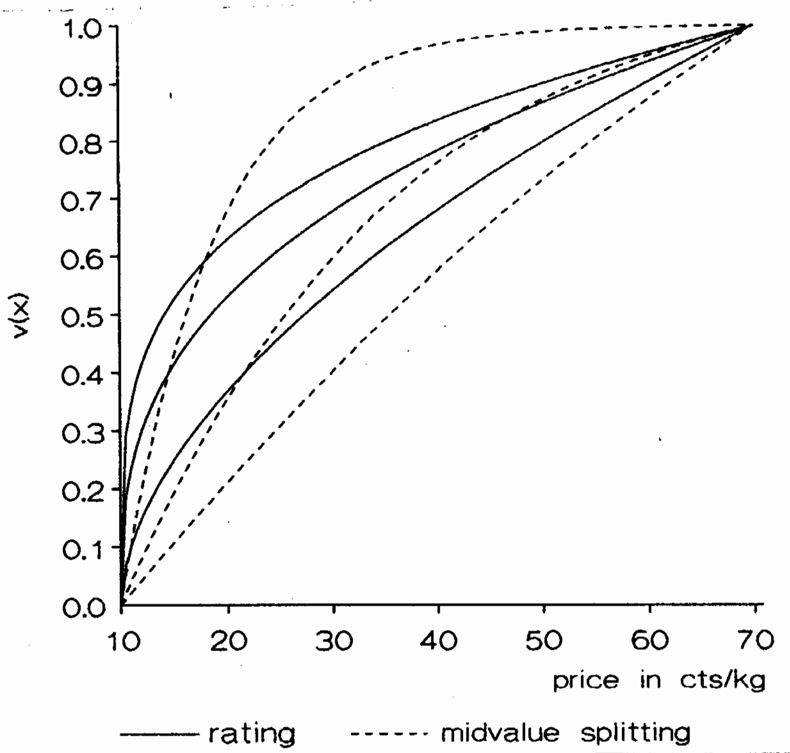

Figure 6.8 ***Comparison of midvalue splitting and rating technique by means of curves corresponding to the 10th, 50th and 90th percentile, in 1984***

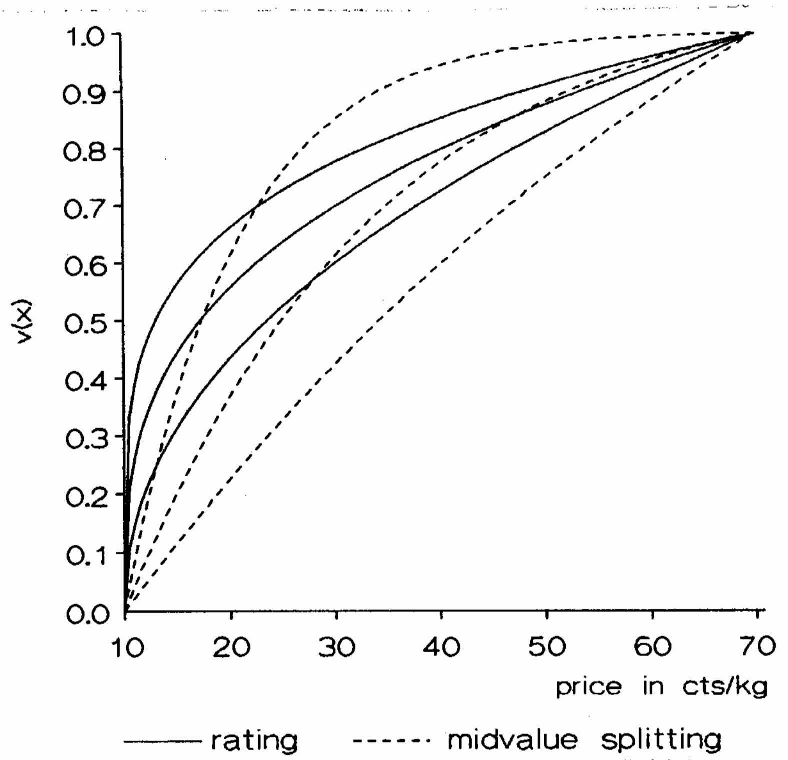

Figure 6.9 ***Comparison of midvalue splitting and rating technique by means of curves corresponding to the 10th, 50th and 90th percentile, in 1985***

In Table 6.18 the correlations between the parameters obtained by the respective measurements are presented. In order to interpret the correlations correctly, it should be noted here that high risk aversion implies a large positive coefficient in the negative exponential function and a small positive coefficient in the power function. Thus, convergent validity between the measurements would be established if the correlation between the coefficient obtained by the midvalue splitting technique would correlate highly negatively with the coefficient obtained by the rating technique. To simplify the analysis, the coefficients in the power function obtained by the rating technique are recoded into negative values. As a consequence, the correlation should be positive to indicate convergent validity.[9]

Table 6.18 *Pearson and Spearman correlation matrices of indicators of strength of preference (after removing two outliers)*

below diagonal: pairwise deletion of missing data
above diagonal: listwise deletion (n = 55)

		VM84	VR84	VM85	VR85
Pearson correlations					
MVS	VM84	--	*21*	**27**[b]	19
Rating	VR84	*14*[b]	--	08	**47**[d]
MVS	VM85	**24**[a]	08	--	*30*[b]
Rating	VR85	07	**15**[b]	*29*[b]	--
Spearman correlations					
MVS	VM84	--	*18*	**24**[a]	17
Rating	VR84	*15*[b]	--	15	**39**[d]
MVS	VM85	**23**[a]	15	--	*32*[c]
Rating	VR85	10	**19**[c]	*33*[c]	--

Bold stability
Italics convergent validity

[a] $p < .05$ (one-tailed)
[b] $p < .025$ (one-tailed)
[c] $p < .01$ (one-tailed)
[d] $p < .001$ (one-tailed)

[9] Although the power function showed a better fit than the negative exponential function, which makes the parameter in this function the best indicator of risk attitude, the correlations between the parameters of these two functions are very high (Pearson = 0.94 and Spearman = 0.99). As a consequence, the correlations between the rating technique and midvalue splitting technique as well as the stability of the rating technique hardly change when the risk parameter of the negative exponential function is taken instead of the parameter of the power function.

Table 6.18 shows that with listwise deletion of missing values, only n = 55 cases remain. The fairly low convergent validity correlations are most striking in Table 6.18. The Pearson correlation between midvalue splitting and rating technique is 0.14 in 1984 and 0.29 in 1985 (pairwise). Both correlations are significant ($p < 0.025$). Listwise, the correlations are 0.21 ($p < 0.10$) in 1984 and 0.30 ($p < 0.025$) in 1985. The Spearman correlations are of comparable size as the Pearson correlations.

Differences between pairwise and listwise handling of missing cases show only slightly higher listwise correlations. A notable exception in this respect is the stability of the rating technique. Pairwise, the stability is 0.15 (Pearson, $p < 0.025$) and 0.19 (Spearman, $p < 0.01$), listwise the stability is 0.47 ($p < 0.001$) and 0.39 ($p < 0.001$), respectively. These latter stabilities are fairly high.

When reviewing the fairly low correlations between respective measurements in combination with the small number of observations, it should not be surprising that the LISREL estimate of stability is not significant. A model analogous to the one in Figure 6.5 is estimated. The estimated correlation (Beta) between the strength of preference of 1984 with that of 1985 is 0.61 (t-value 1.26 (n = 55)) in case of listwise correlations and 0.50 (t-value 0.692 (standard error calculated with n = 55)) in case of pairwise correlations. With respect to the risk attitude, the stability estimates were 0.82 and 0.64, respectively. In contrast with the risk attitude, the strength of preference thus appears to be less stable.

Summary and conclusion

Two techniques for measuring the value function were presented. For both the midvalue splitting and the rating technique, respondents showed no difficulties in answering the questions. The rating technique was judged the easiest one of the techniques and took less interviewing time.

The findings show that respondents exhibit decreasing marginal value, as was expected. No respondents exhibit increasing marginal value. No difference in this respect shows up between the techniques.

With respect to the temporal stability of the techniques, the midvalue splitting technique did not show a change in strength of preference, whereas with the rating technique a shift towards more value aversion from 1984 to 1985 could be seen. The stability correlation is positive and statistically significant for both techniques but fairly low. Convergent validity between the measurements is low, too. The parameters measured by means of the midvalue splitting and rating technique are hardly correlated (the correlations are positive and statistically significant, though). Consequently, strength of preference conceived as a latent variable which is indicated by the assessments obtained by the midvalue splitting and rating technique could not be proven to be significantly stable. This may be partly due to the small number of observations available in testing the stability (n = 55).

The most important difference between both techniques concerns the valuation of low price levels. In the rating technique, low price levels are more highly valuated than in the midvalue splitting technique. As a consequence, the power function fitted best for the rating technique, whereas the negative exponential function fitted the data best for the midvalue splitting technique. Furthermore, the negative exponential function, fitted for the midvalue splitting technique, is located to the left of the points assessed for low levels of the value function v(x), and located somewhat to the right of the points assessed for medium and high levels of v(x). Again, as with the lottery technique, this suggests an S-shaped evaluation function, although smaller differences show up with the midvalue splitting technique than with the lottery technique. In contrast, the power function, fitted for the rating technique, on average even underestimates the points assessed for low levels of v(x). For none of the respondents do the data obtained by the rating technique suggest an S-shaped evaluation function.

For a possible explanation of these differences between the techniques, one has to point out the differences between the respondent's assessment task in association with both techniques. Note that an essential difference between the techniques concerns the manner in which the respondents have to provide their valuation of a price level.

In the midvalue splitting technique, two outcomes are presented to the respondent who has to provide the equal difference price. As a result, his valuation of a specific price level is implicit in the procedure. That is, the respondent specifies a price corresponding to the value implicit in the question. The measurement process of the midvalue splitting technique is in this respect analogous to the one used with the lottery technique. In the rating technique on the other hand, the respondent is presented with an explicit price level and he has to specify his valuation of this level directly. So, in contrast with the midvalue splitting technique, he provides a value that corresponds to the price level specified in the question. Moreover, although the endpoints of the price scale are set beforehand, they are less prominently present in the assessment task than the endpoints in the midvalue splitting technique.

The specific task in the MVS-technique of finding the equal difference point between two endpoints (analogous to specifying the certainty equivalent in the lottery technique) might induce respondents to use the anchoring and (insufficient) adjustment heuristic (Kahneman and Tversky 1982) (notice, however, that by using an appropriate iterating questioning procedure, it has been attempted to minimize anchoring effects). The expected value of the lottery and, equivalently, the price half way in-between the endpoints in the midvalue splitting task, might serve as an anchor on the basis of which respondents have to adjust. It seems that especially when evaluating prices for low levels of the function and when ranges between the outcomes in the task are small, respondents adjust insufficiently. This response effect thus leads to a less concave curve for low price levels, or it might even lead to an S-shape evaluation function. Such an anchoring and adjustment effect is unlikely in the rating technique.

It is concluded here that the tendency towards an S-shape of the points assessed can be viewed as resulting from a response effect of the midvalue splitting technique (and lottery technique). Alternatively, one might hypothesize a true S-shaped value function underlying the preferences. However, not only would such a function be questionable from a theoretical point of view, on the basis of the results from the rating technique a response effect on the part of the midvalue splitting technique is most likely. With the rating technique low prices are valued extremely high in comparison with the midvalue splitting technique and no indication whatsoever is found which suggests an S-shaped value function.

6.7 Testing the concept of relative risk attitude

This section deals with the correspondence between the assessments of risk attitude and strength of preference. Firstly, in 6.7.1, the correlations between the respective assessments will be analyzed. Secondly, the functional relationship between the utility and value function will be dealt with in 6.7.2.

6.7.1 Correlations between assessments of risk attitude and strength of preference

For each respondent, the lottery, midvalue splitting and rating technique all yield a curve representing risk attitude and strength of preference, respectively. Table 6.19 illustrates the differences between the techniques. In this table the mean and standard deviation of the equivalents, computed for value/utility levels of 0.10, 0.25, 0.50, 0.75 and 0.90, are shown.

The figures in the table show that for most levels of value/utility the curves of midvalue splitting and lottery technique are closer to one another than those of midvalue splitting and rating technique. For example, in 1984, the mean price corresponding to the value level of 0.50 is 25.66 cts/kg for the midvalue splitting technique (VM84) and 19.69 cts/kg for the rating technique (VR84). This is a 6 cts/kg difference, with the curve of the rating technique located to the left of the curve of the midvalue splitting technique. The mean certainty equivalent corresponding to the utility level of 0.50 is 27.42 cts/kg for the lottery technique (RL84). The difference with VM84 is therefore only 1.76 cts/kg.

The results in 1985 confirm the findings in 1984. The average difference between VM85 and VR85 is 7.24 cts/kg (25.12 - 17.88) for $v(x) = 0.5$, whereas the average difference between VM85 and RL85 is 5.79 cts/kg (25.12 - 30.91). The latter average has increased in comparison with 1984, but it is still less than the difference between rating and midvalue splitting technique.

Table 6.19 ***Mean and standard deviation of value equivalents and certainty equivalents for five levels of the value and utility function, and for three measurement techniques, in 1984 and 1985 (in cts/kg)***

	UTILITY/VALUE LEVEL									
	0.10		0.25		0.50		0.75		0.90	
MEASURE-MENT	mean	st.dev.	mean	st.dev.	mean	st.dev.	mean	st.dev.	mean	st.dev.
VM84[a]	12.70	2.05	17.02	4.09	25.66	7.26	37.86	10.31	49.63	11.43
VR84[b]	10.35	.71	12.05	2.32	19.69	5.38	37.10	6.47	54.53	4.08
RL84[c]	13.55	4.64	18.36	6.75	27.42	9.37	39.61	11.31	51.06	11.29
RL85	14.36	4.15	20.35	7.02	30.91	9.99	43.89	11.58	54.81	10.98
VM85	12.48	1.17	16.62	3.01	25.12	6.35	37.35	9.85	49.27	11.30
VR85	10.35	.37	11.37	1.55	17.88	4.46	34.82	6.08	53.11	4.02

[a] Midvalue splitting technique
[b] Rating technique
[c] Lottery technique

Figures 6.10 and 6.11 show, for each year separately, the functions corresponding to the 5th, 50th and 95th parameter percentiles for the lottery and midvalue splitting technique (in Figures 6.8 and 6.9 the differences between rating and midvalue splitting technique were already shown).

The findings show that two techniques which are supposed to measure the same concept, namely the midvalue splitting and rating technique both measuring the value function, are located further away from one another than two techniques which are supposed to measure different concepts, namely midvalue splitting and lottery technique measuring, respectively, value and utility function. The findings are in agreement with those of McCord and De Neufville (1983), who also found larger differences between theoretically equivalent functions than between theoretically different functions.

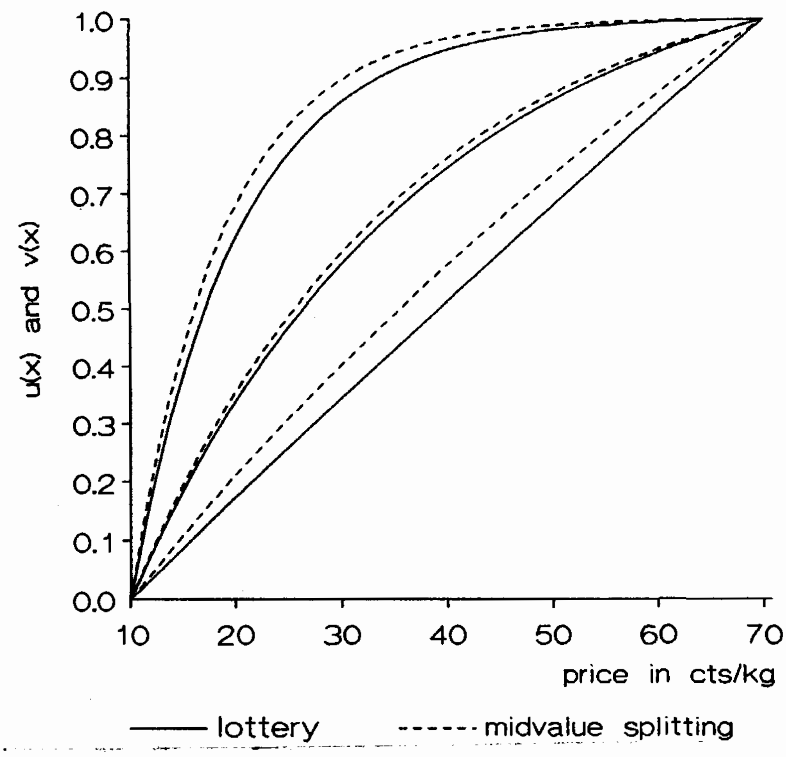

Figure 6.10 *Curves obtained by the lottery and midvalue splitting technique in 1984 (curves correspond to the 5th, 50th and 95th percentile (from right to left, respectively)*

Now attention is directed towards the correlations between the parameters (Pratt-Arrow coefficients of risk aversion) obtained with each technique. Even if the location of the function differs with different techniques, the correlations between the techniques can be high. Table 6.20 shows both Pearson and Spearman correlations between the respective measurements. Missing cases are handled pairwise; the number of cases on the basis of which the correlations are calculated therefore varies. The stability of each measurement is presented on the diagonal (printed in bold): the parameter in 1984 is correlated with the parameter in 1985 for the same technique. Data of 1984 are shown below the diagonal, data of 1985 are shown above the diagonal. Removing outliers did not effect the correlations, except for VM85, for which two outliers were therefore removed. Practically all correlations have the right sign (positive) and almost all are statistically significant for at least $p < 0.05$ (one-tailed).

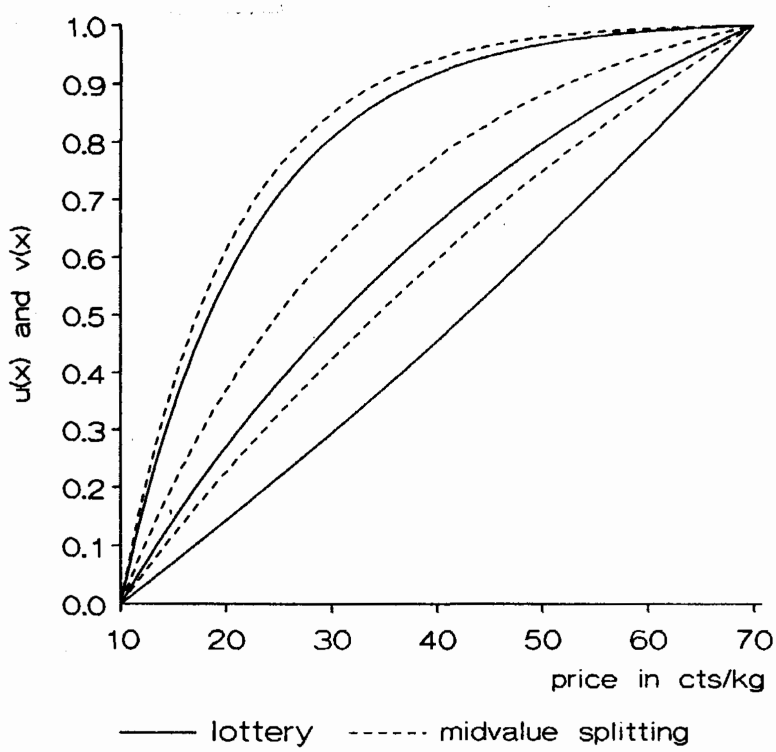

Figure 6.11 *Curves obtained by the lottery and midvalue splitting technique in 1985 (curves correspond to the 5th, 50th and 95th percentile (from right to left, respectively)*

With respect to the stability of the assessments the following can be said. In Table 6.20, it is shown that the lottery technique correlates the highest (Pearson = 0.44) between the years in comparison with other techniques, followed by the midvalue splitting technique (0.24). The stability of the conjoint (0.20) and rating technique (0.15) is smaller. The Spearman correlation of conjoint measurement is substantially higher than the Pearson correlation, though. Although differences are small, the correlations suggest that a technique which is evaluated by the respondents as easy (conjoint and rating technique) results in somewhat less stable measurements than a technique which the respondents perceive as more difficult (lottery and midvalue splitting technique). The difficulty of the questioning procedure perhaps induces respondents to think hard about their preferences and consequently the assessments might be more consistent and stable.

Again, it should be stressed here that the assessments took place with a year in between, implying that one should be extremely cautious to conclude from the fairly low stability correlations that the assessments are unreliable. Indeed, a change in attitude and unreliability of the assessment cannot be separated with only two moments of measurement. If attitudes did actually change, and if respondents differed with respect to the amount or the direction of change, then even a perfectly reliable measurement instrument would yield low "stability" cor-

relations. With less than perfect reliable measurement techniques, stability correlations will be attenuated. It can therefore be concluded that the estimated stabilities, which are positive and significant for all four techniques, are the lower boundaries of the test-retest reliability of each technique.

It is thus not possible to simply state that the lottery technique is e.g. more stable than the midvalue splitting technique because the stability correlation is higher. On the contrary, it might be the other way around. That is, it is possible that the true risk attitude did not change, so that the correlation concerns just stability. On the other hand, a low stability for the midvalue splitting technique may be attributed to a change in true strength of preference notwithstanding the fact that the midvalue splitting technique might be highly reliable.

Taking this into account two conclusions can be drawn from our findings. Firstly, attitudes did not change randomly from one year to the next, because then no statistically significant positive correlation between the years would have been obtained, whether the technique were reliable or not. Secondly, the techniques are not totally unreliable, because if they were, no significant correlations would have been obtained, whether the attitudes changed randomly or not at all.

Now attention is directed towards the correspondence between the techniques. Are risk attitude and strength of preference one and the same concept/construct? In the terminology of factor analysis one construct means that there is one common factor measured by means of four indicators (the assessments obtained by four techniques). The hypothesis of a relative risk attitude implies that risk attitude and strength of preference are different concepts. This hypothesis therefore means that there are two common factors and that each factor is indicated by two techniques (a low correlation between latent variables risk attitude and strength of preference is thus an indication of a relative risk attitude (see note 1 in Section 6.1)).

Table 6.20 shows the correlations between the different techniques for each year separately. The convergent correlation (Pearson) between the lottery and conjoint technique in 1984 is 0.49 and 0.14 between the midvalue splitting and rating technique. In 1985, these correlations are 0.34 and 0.29, respectively. The Spearman correlations are somewhat higher. In both years, these correlations are positive and clearly significant. Taking into account that unreliability of the measurement technique attenuates the correlation between the measures, it can be concluded that the measures for each concept converge in both years.

However, to confirm that risk attitude and strength of preference are two different concepts, the correlation between measures which are intended to measure a different theoretical concept should be low or at least lower than convergent correlation. This is only partly confirmed, as is shown in Table 6.20. The confirmation stems from the rating and conjoint measurement technique. The rating technique appears to correlate less with the lottery and conjoint technique than with the midvalue splitting technique, in both years. With respect to the conjoint measurement technique, an analogous conclusion can be drawn: correlations are higher with the lottery technique than with both of the other techniques. The midvalue splitting technique, however, in both years correlates higher with the lottery technique than with the theoretically equivalent rating technique. Furthermore, the correlation between midvalue splitting technique and the conjoint measurement is comparable to the one with the rating technique (0.14) (data to calculate a correlation between midvalue splitting technique and conjoint measurement are only available in 1984).

Table 6.20 *Correlations between indicators of risk attitude (lottery and conjoint) and strength of preference (MVS and rating) at two moments of measurement (pairwise deletion of missing values)*

diagonal: stabilities
below diagonal: data 1984
above diagonal: data 1985

		LOTTERY RL	CONJOINT RC	MVS VM	RATING VR
Pearson correlations					
Lottery	RL	**44**[e]	*34*[d]	33[d]	20[d]
Conjoint	RC	*49*[e]	**20**[a]	*	17[a]
MVS	VM	22[e]	14[c]	**24**[b]	*29*[c]
Rating	VR	04	-07	*14*[c]	**15**[c]
Spearman correlations					
Lottery	RL	**45**[e]	*40*[e]	40[e]	21[d]
Conjoint	RC	*49*[e]	**30**[d]	*	29[d]
MVS	VM	26[e]	15[c]	**23**[b]	*31*[d]
Rating	VR	02	-04	*15*[c]	**19**[d]

Bold stability
Italics convergent validity
* no data available

a p < .10
b p < .05
c p < .025
d p < .01
e p < .001 (all one-tailed)

An exploratory factor analysis is performed on the correlation matrix in 1984 mainly for illustrative purposes. In this manner further insight is gained into the mutual relationship between the variables. This analysis was performed only for

1984 since in 1985 the correlation between conjoint measurement and midvalue splitting technique is not available, thus reducing the number of variables in a factor analysis to only three. The estimates of the common factor model are obtained by means of generalized least squares. Two factors with eigenvalue larger than one resulted (1.60 and 1.10, respectively), explaining a total of 67.7% of the variance. These two factors indicate that the hypothesis of one common factor cannot be accepted. The correlation matrix is reproduced perfectly by two factors.

The lottery (0.74) and conjoint measurement (0.67) load highest on one factor, whereas the rating technique does so on the other factor (0.52) (between brackets the factor loadings are given; Varimax rotation). The midvalue splitting technique loads on both factors: (0.24) on the first and (0.29) on the second. An oblique rotation yields a correlation between the factors of only 0.16 which indicates that a weak relationship between strength of preference and risk attitude exists, which is mainly due to the correlation of the midvalue splitting technique with the lottery technique.

The findings show that the correlations between the respective measurements are too small to conclude that strength of preference and risk attitude are one and the same concept. This study indicates that risk attitude and strength of preference are different constructs. However, the latent variables are not independent, either, which is specifically indicated by the correlation between the midvalue splitting and the lottery technique. The assessments obtained by the rating scale are dissimilar to those of the other two measurement techniques. Not only does this technique yield a different function form, also correlations with the other measurements are fairly few.

The latent variable approach thus confirms the concept of a relative risk attitude. This means that no linear relationship exists between u(x) and v(x). In the next section the specific relationship between the functions will be tested.

6.7.2 The relationship between u(x) and v(x)

Attention will now be directed towards the relationship w between the value function v(x) and utility function u(x) in: $u(x) = w(v(x))$. More specifically, it will be tested whether both functions are related linearly or not. As has been discussed in Chapter 3, Allais (1979) is one of the proponents of a linear relationship. Bell and Raiffa (1980), Dyer and Sarin (1982) and Sinn (1983) hypothesize a negative exponential relationship between the utility function and the value function. This negative exponential function implies a *constant absolute* and an *increasing proportional* relative risk attitude.

The relationship can be specified in the following manner:

$$u(x) = a + b\, e^{-c\, v(x)} \qquad \text{for } c < 0 \text{ or } c > 0, \qquad (6.33a)$$

$$u(x) = a + b\, v(x) \qquad \text{for } c = 0. \qquad (6.33b)$$

The parameter c in this relationship (6.33a) between v(x) and u(x), specifies the relative risk attitude. For $c > 0$ the decision maker is relatively risk averse, if $c < 0$ he is relatively risk seeking. With v(x) taken as the x-axis and u(x) as the y-axis, a concave curve describes the relationship for $c > 0$. A convex curve results if $c < 0$.

In Figure 6.12 an example of four relative risk attitudes is given. The negative exponential function describing the relationship between v(x) and u(x) is shown for four parameters. One function implies a relatively risk averse decision maker ($c = 2.3$); all others imply relatively risk seeking decision makers.[10]

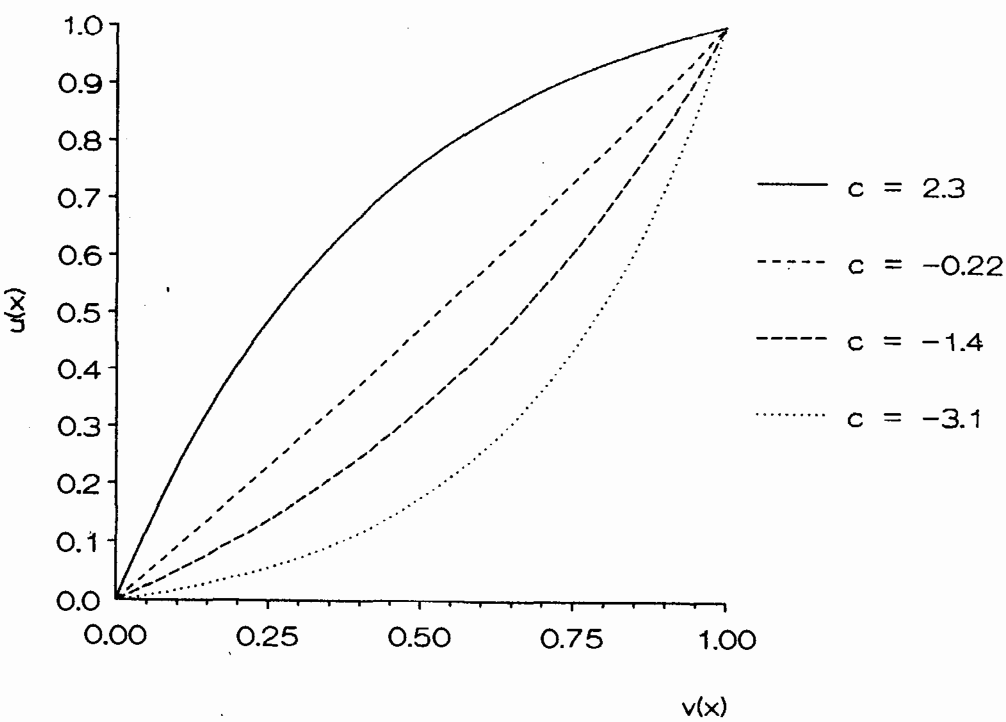

Figure 6.12 Relative risk attitudes for four different parameter values in the negative exponential function

To illustrate the concept of relative risk attitude further (see also Chapter 3), assume that a 50/50 lottery is presented to the decision maker with *values* taken as the outcomes, e.g. $v_1(x) = 0.10$ and $v_2(x) = 0.60$. The decision maker is asked

10 The parameters of the functions in this example correspond to, respectively, the 10th, 25th, 50th and 90th percentile of the measured relative risk attitude in 1984 (see Table 6.21 below).

to specify the certainty equivalent. The expected value of the lottery is $E[v(\underline{x})] = 0.35$. If therefore the decision maker specifies a certainty equivalent of $v_c(x) = 0.35$, then this decision maker is said to be relatively risk *neutral*. If the decision maker specifies a certainty equivalent of less than 0.35, say $v_c(x) = 0.25$, this decision maker is said to be relatively risk *averse*. That is so because, when he is *certain* of outcomes, a change from $v(x) = 0.10$ to 0.35 equals in value a change from 0.35 to 0.60; under *risk*, a change from 0.10 to 0.25 equals in utility a change from 0.25 to 0.60. The relative risk attitude thus describes the true effect of risk on the decision maker's valuation of outcomes, since the confounding effect of v(x) is controlled for.

Estimation procedure

Since it is not possible to directly measure the relative risk attitude by means of presenting respondents with lotteries with values as outcomes (as was done in the example above), an indirect way has to be sought. Firstly, both u(x) and v(x) are measured for the attribute x. Subsequently, u(x) and v(x) are related statistically. See also Krzystofowicz (1983) for such an analysis.

The relationship between u(x) and v(x) will be studied here for the lottery technique (assessment of u(x)) and the midvalue splitting technique (assessment of v(x)). The v(x) function, assessed by means of the rating technique, will not be taken as a comparison. The main reason for this choice is that differences between the lottery and rating technique are larger than the differences between the lottery and midvalue technique (see e.g. Table 6.19). If the hypothesis of a linear relationship between u(x) and v(x) will be rejected for the midvalue splitting and lottery technique, then this hypothesis will be rejected for the rating technique, too.

In order to estimate the relationship in Equation 6.33, the assessed equivalents will be used. For the lottery and midvalue splitting technique, 7 points (certainty equivalents for u(x) and value equivalents for v(x)) are available for each respondent. These 7 points correspond pairwise with respect to level of utility/value. For example, for $u(x) = v(x) = 0.25$ a certainty equivalent, say 25 cts/kg, and a value equivalent, say 30 cts/kg, have been assessed. For the remaining six utility/value levels these equivalents also have been measured. Subsequently, the relationship between these two series of equivalents is analyzed. The value/utility levels associated with these points are spread evenly over the interval between 0 and 1, namely: 0.125, 0.250, 0.375, ... , 0.750, 0.875.

As stated above, the negative exponential function seems most appropriate theoretically (see also Chapter 3) in describing the relationship between the value and utility function. However, it is possible that some other non-linear function provides a better fit.

For reasons of comparison, therefore, the fit of the negative exponential function will be compared to that of the power function, implying a *decreasing absolute* and *constant proportional* relative risk attitude:

$$u(x) = a + b\, v(x)^c \tag{6.34}$$

Specifically, the following specifications will be estimated by means of non-linear least-squares. The program ZXMIN will be used to estimate the parameters (see Section 6.2.3) For the negative exponential function, parameter d will be estimated in:

$$y_i = \frac{1 - e^{-dz_i}}{1 - e^{-d}} + e_i \tag{6.35}$$

For the power function, parameter d will be estimated in:

$$y_i = z_i^{\,d} + e_i \tag{6.36}$$

where:

- z_i = an element of the vector of value equivalents corresponding to value levels of 0.125, 0.25, 0.375, 0.50, 0.625, 0.75 and 0.875, assessed by means of the midvalue splitting technique
- y_i = an element of the vector of certainty equivalents corresponding to utility levels of 0.125, 0.25, 0.375, 0.50, 0.625, 0.75 and 0.875, assessed by means of the lottery technique,
- e_i = random error
- i = 1, 2, ... , 7.

The assessed equivalents concern points on the interval with boundaries 10 and 70 cts/kg. In Equations 6.35 and 6.36 these original equivalents are translated into points on the interval with boundaries 0 (corresponding to 10 cts/kg) and 1 (70 cts/kg), so $0 \leq z \leq 1$ and $0 \leq y \leq 1$.

Equations 6.35 and 6.36 concern the relationship between the assessed equivalents. It should be noted here that by using the equivalents in estimating the relative risk attitude, parameter d in 6.35 is related to parameter c in 6.33 by c = -d. Likewise, parameter d in 6.36 is related to parameter c in the power function (6.34) by c = 1/d.[11]

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[11] This can be seen as follows. By definition, a decision maker is said to be relatively risk averse if his certainty equivalent is smaller than his value equivalent (the utility function is located to the left of the value function; parameter $c > 0$ in 6.33a). Consequently, a convex relationship results between the value equivalents (z_i) on the x-axis and the certainty equivalents (y_i) on the y-axis, yielding a negative parameter d in 6.35 ($d < 0$) and $d > 1$ in 6.36. In an analogous manner, a concave relationship is found between z_i and y_i for a relatively risk seeking decision maker: $d > 0$ in 6.35 and $0 < d < 1$ in 6.36.

Results of estimating the relative risk attitude

Descriptive statistics of the estimates of the relative risk attitude are shown in Table 6.21. For 188 farmers data are available to estimate the relative risk attitude in 1984, in 1985 for 53 farmers data are available.

Table 6.21 Results of estimating per individual the relative risk attitude, in 1984 and 1985

	1984		1985	
	Negative exponential	Power	Negative exponential	Power
Mean d *	-.266	1.176	-1.199	1.470
Median d	-.220	1.072	-.832	1.276
St.dev. d	2.110	.592	1.989	.708
Mean |d|	1.598		1.711	
Median |d|	1.164		1.035	
St.dev. |d|	1.398		1.561	
N	188	188	53	53
Mean MSE	.004	.006	.003	.005
Median MSE	.002	.003	.002	.002
Percentile of parameter				
10	-3.101	.498	-4.041	.729
25	-1.420	.747	-2.513	1.010
75	1.005	1.503	-.0224	1.802
90	2.289	1.963	1.053	2.442
Percentage of respondents				
Relatively risk averse	43%	42%	20%	19%
Relatively risk neutral	07%	05%	04%	06%
Relatively risk seeking	51%	53%	76%	75%
	100%	100%	100%	100%

* Parameter d in Equation 6.35

The adequacy of fit of each function fitted to the data is indicated by the mean sum of squared errors (MSE). Notice from mean and median MSE in Table 6.21 that the negative exponential function fits the data better than the power function.[12] Tested pairwise, parametric and non-parametric, this difference is

12 Both functions fit the data much better than the linear function. Mean MSE for the linear function is 0.031 in 1984 and 0.039 in 1985. For all respondents the linear function fits worse than the negative exponential or power function.

thesis of a normal distribution of the parameter at the one-tailed significance level of $p = 0.10$ ($p = 0.64$ in 1984 and $p = 0.104$ in 1985).

The major findings can be summarized as follows. Our findings support the hypothesis of the relative risk attitude. The hypothesis of a linear relationship between utility and value function is clearly rejected in favor of a negative exponential relationship. This finding implies that farmers exhibit a constant absolute relative risk attitude. As a group, farmers are relatively risk seeking.
It is found that farmers tend to shift towards more relatively risk seeking behavior in 1985 compared to 1984. This shift is solely due to a change in the utility function towards less risk aversion. In Section 6.3, no satisfactory explanation for the direction of the shift in the utility function could be given. Therefore, the change in relative risk attitude is difficult to explain, too.

6.7.3 Conclusions

Reviewing the findings concerning the concepts of risk attitude, strength of preference and relative risk attitude leads to the following conclusions.

The assessment of each concept by means of different techniques in general showed a significantly positive convergence between techniques intended to measure the same theoretical construct; this implies convergent validity. However, since the convergent validity of the techniques is not very high, differences between the assessments can be substantial. It is therefore concluded that in modeling decision making, whether under certainty or under risk, it is fairly risky to rely on only one technique in measuring strength of preference and risk attitude. Despite this possible dependence of results upon the measurement technique chosen, the large majority of studies in applied contexts, especially in the agricultural economics literature on decision making under risk, relied and still rely on only one assessment technique. Conclusions from these studies should therefore be interpreted carefully. Of course, it is stressed here that the predictive validity of the techniques has not yet been studied. In Chapter 7, the sensitivity of predictive validity with respect to the specific measurement technique used will be analyzed.

It is concluded further that conceiving strength of preference and risk attitude as latent variables, each latent variable being indicated by a number of measurements, is very useful in analyzing validity and reliability issues. This framework provides ample opportunities, especially if one is interested in characterising a large sample of decision makers with respect to e.g. risk attitude.

Conceiving the concepts of risk attitude and strength of preference as latent variables shows that the concepts are only slightly positively related. This indicates that risk attitude and strength of preference are two different constructs; a confirmation of the concept of relative risk attitude. Preferences and choice behavior change when going from certainty (riskless measurement of strength of preference) to risk (measurement of risk attitude). The introduction of risk generally induces respondents to choose differently between lotteries than could be expected solely on the basis of their strength of preference.

If attention is directed towards the specific relationship between the utility and value function, the following can be concluded. Our findings indicate that the hypothesis of a linear relationship between the utility and value function is rejected in favor of the theoretically expected negative exponential relationship, implying a constant absolute relative risk attitude. Moreover, the hypothesized negative exponential function also fitted the data better than the power function.

The majority of the farmers showed a tendency towards relatively risk seeking behavior. In the classical interpretation of risk attitude in the expected utility model, only a small percentage of farmers was classified as slightly risk seeking in our study. By removing the confounding effect of the value function, a high percentage of farmers is classified as relatively risk seeking. These findings clearly illustrate the difference between risk attitude and relative risk attitude.

It should be noted that it is difficult to indicate how much of the difference between utility and value is due to measurement error (random error and/or systematic response effects) and how much of the difference is due to the effect of introducing risk into the measurement procedure. In this respect it is instructive to consider our finding that the differences between two techniques measuring a value function (i.e. the midvalue splitting and rating technique) were on average larger than the differences between the value function and the utility function, indicated by respectively the midvalue splitting and lottery technique. On the other hand, the clear resemblance of the questioning procedure in the lottery and midvalue splitting technique, uncertainty or certainty in the assessment being the sole important difference between the techniques, suggests that these two techniques might be considered most appropriate for assessing whether or not v(x) and u(x) differ. Clearly, even for these techniques a significant difference between the functions showed up in both years.

To evaluate the concepts further, it is interesting to study the relationship between on the one hand the several estimates of risk attitude, strength of preference and relative risk attitude and on the other hand characteristics of the farmer and his farming situation. These aspects will be dealt with in the following section.

6.8 Relationship between risk attitude and background variables of the farmer

In the conceptual model presented in Chapter 2 a relationship was hypothesized between the risk attitude and personal and situational variables. This analysis will be conducted in this section by means of regression analysis. In each year there are five dependent variables. Risk attitude is indicated by the lottery and conjoint measurement; strength of preference is indicated by the midvalue splitting and rating technique and the fifth variable concerns the relative risk attitude. Consequently, a total of ten dependent variables results.

The following set of variables was used as predictor variables. Personal characteristics of the farmer are: age, level of education, number of years of farming experience and the ancestors' region of descent (see Chapter 2). Situational variables selected are: arable land (in ha.), ware potato cultivation intensity (in %), number of ha. allocated to ware potatoes and whether or not onions are grown (like ware potatoes, onions is a risky crop). Another interesting variable is the farmer's solvency. However, due to a relatively high percentage of non-response (19%) which would constrain the analysis to a subset of farmers, this variable is not included in the regression analyses. Finally, the effect of the interviewer will be tested (data were collected with 14 interviewers in 1984 and 9 in 1985). All assessment techniques required an active role of the interviewer. Consequently, systematic effects might have been introduced.

Regression analysis is applied as the method of analysis. For each dependent variable, a series of analyses were conducted with different subsets of variables. A combination of subjective and stepwise selection was used in order to arrive at the final solution. Care was taken to preclude high multicollinearity. For example, the variables arable land, growing intensity and number of ha. allocated to potatoes are not included at the same time since, of course, a perfect linear relationship exists between these variables. Aside from arable land and number of ha. of ware potatoes grown, all predictor variables were recoded into dummy variables.

The main results of the analyses are summarized in Table 6.22. In this table the significant variables are indicated by x ($p < 0.10$, two-tailed). For ease of presentation no regression coefficients or t-values are shown. Adjusted R-squares are shown before and after inclusion of the interviewer effects. Some of the variables are only significant after inclusion of the interviewer dummy variables. The results in Table 6.22 clearly show that the indicators of risk attitude and strength of preference are only slightly associated with background variables. Prior to including the interviewer effects, all R-squares are very low. Only a few variables are significant for only some indicators. Moreover, these effects are not consistent over the years.

The region of descent most often shows an effect; it is significantly associated with four indicators. However, the results are not consistent even for this variable. That is, for two indicators a northern region of descent differs significantly from the other regions, whereas with respect to the remaining two indicators this concerns a south-west and a southern region. The intensity and cultivation of onions are associated with two indicators: the lottery measurement and the relative risk attitude in 1985. Farmers who cultivate potatoes with high intensity and farmers who cultivate onions are somewhat less risk averse and less relatively risk averse.

Table 6.22 Significant effects of background variables and interviewer on indicators of risk attitude, strength of preference and relative risk attitude

	LOTTERY		CONJOINT		MIDVALUE		RATING		RELATIVE RISK	
	1984	1985	1984	1985	1984	1985	1984	1985	1984	1985
Age	-	-	-	-	-	-	x	-	-	-
Education	-	-	-	-	-	-	x	-	-	-
Descent	x	x	-	-	x	-	-	x	-	-
Region	x	-	x	-	-	-	-	-	-	-
Arable land	-	-	x	-	-	-	x	-	-	-
Intensity	-	x	-	-	-	-	-	-	-	x
Onions	-	x	-	-	-	-	-	-	-	x
R^2-adjusted[a]	.03	.05	.02	-	.02	-	.05	.06	-	.06
R^2-adjusted[b]	.06	.08	.10	-	.05	-	.12	.15	.04	.12
Signif.[c]	.09	.06	.001	-	.05	-	.003	.000	.09	.18

x Significant variable ($p < 0.10$, two-tailed)

a Before inclusion of the interviewer dummy-variables

b After inclusion of the interviewer dummy-variables

c Significance of increase in R-square due to interviewer (F-test on change in R-square)

In general, we conclude that neither a consistent nor a strong relationship exist between personal and situational factors and indicators of risk attitude and strength of preference. The results suggest that the indicators of risk attitude and strength of preference are strongly linked to the specific decision problem the farmer is confronted with (the marketing of ware potatoes), so that the farmer's general characteristics are hardly relevant for these context specific preferences and choices. We think that it is quite possible for the same farmer to be very risk averse when marketing ware potatoes and to be only slightly risk averse with respect to e.g. pest management or choosing his crop rotation plan. Our findings therefore indicate the necessity of assessing risk attitude and strength of preference for each context separately. The relative risk attitude is hypothesized to be less context specific (Bell and Raiffa 1982). One would thus expect more consistent relationships with background variables. However, in this study no confirmation for this hypothesis is found.

In contrast to the personal and situational factors, the interviewer shows clear effects for three of the ten indicators: the conjoint measurement in 1984 and the rating technique in both years (see Table 6.22). Especially the rating task seems susceptible to interviewer influence. The differences in assessments between interviewers are not particularly large, however. For 1984 the mean parameter assessed by the three most extreme interviewers is 15% above or below the overall mean parameter. For the year 1985 differences are smaller (9% above or below overall mean). A reason for the effect of the interviewer in the rating task is probably a difference in emphasizing the endpoints of the scaling interval. More about this will be said in the next section. In contrast to the rating technique and conjoint measurement, the assessments with the lottery and midvalue splitting technique seem less easily affected by the interviewer.

The effect of the interviewer on the assessments should not be exaggerated; for only three of the ten measurements a significant effect shows up. Moreover, the effects of the interviewer are not consistent over the indicators. That is, there is not a group of interviewers who assesses systematically high or low values. Stated otherwise, for each indicator other interviewers are most extreme in their assessments. Nevertheless, the results show some sensitivity of the assessments to the interviewer. It would be interesting to study whether these effects are smaller when, instead of paper and pencil, use is made of an interactive computer device in the assessments.

Finally, it was analyzed whether there are any differences in risk attitude between cooperative and private farmers. It is hypothesized that no differences in risk attitude will exist between both groups, since the choice of the type of wholesale company is mainly based on non-price attributes. When tested, indeed no significant differences were found between cooperative and private farmers. However, within the group of cooperative farmers one expects that cooperative farmers who choose the 100% pooling strategy are more risk averse than those choosing the 50% pooling, 50% spot market strategy, since the former strategy is perceived as less risky than the latter. Indeed, in both years the farmers choosing the 100% pooling strategy were most risk averse for both the conjoint and lottery technique. However, this difference was only significant for the conjoint measurement. With respect to the conjoint measurement, the mean parameter in 1984 is 0.55 (100% pooling farmers) compared to 0.42 (50% pooling farmers) ($t = 2.17$, $p < .02$, one-tailed); in 1985 these figures are 0.57 and 0.42, respectively ($t = 2.86$, $p < .004$). There are no significant differences between the groups with respect to strength of preference or relative risk attitude.

6.9 Major findings and conclusions

In this chapter the concepts of risk attitude and strength of preference were extensively analyzed. In the introduction to this chapter four main purposes have been formulated: a) to measure an evaluation function which can be used to rank order probability distributions; b) to provide a characterization of a sample of farmers with respect to risk attitude and to study the relationship of this concept with the farmer's characteristics or his farming situation; c) to test the concept of relative risk attitude and d) to study in survey research the validity, reliability and practical feasibility of measurement procedures of both risk attitude and strength of preference. This section summarizes the major findings, especially with respect to c) and d).

A review of the literature showed that the measurement of risk attitude is susceptible to a range of biases and response mode effects. In general therefore, it is recommended to apply a multiple indicator approach in assessing risk attitude (von Winterfeldt and Edwards 1986; Johnson and Schkade 1989). Survey research in which such a multiple indicator approach is applied to study the validity and reliability of procedures in assessing risk attitude is sparse. In this study, explicit attention has been given to these aspects; four measurements procedures were applied: conjoint measurement, the lottery, the midvalue splitting and the rating technique. Of these four techniques the lottery technique is predominantly used in risk attitude assessment.

The concept of relative risk attitude made it necessary to differentiate between risky (conjoint measurement and lottery technique) and riskless measurement techniques (midvalue splitting and rating technique). If risk attitude and strength of preference are one and the same construct, we will have four indicators for risk attitude at our disposal. If risk attitude and strength of preference are two constructs, then there are two indicators of each concept, which enables an analysis of the relationship between the concepts.

In Table 6.23 the major findings of each measurement technique are summarized. The response percentages of all techniques are high. The midvalue splitting technique shows the lowest response percentages. Most likely this is mainly due to the fact that in both years this assessment was done at the end of the interview which may have made some respondents less motivated to complete the question.

When compared to the other techniques, the rating task is judged to be the easiest to both the respondent and the interviewer. This task was completed quickly. The midvalue splitting technique is seen as the most difficult, even somewhat more difficult than the lottery technique. For respondents it seems fairly difficult to judge *changes* in attribute levels. Contrariwise, in the lottery technique respondents are asked to compare a fixed amount to a lottery. This task is to some extent familiar to a farmer since in actual decision making farmers have to choose between fixed-price contracts (no risk involved) and other strategies of selling (all involving risk). The conjoint measurement task is judged to be somewhat easier than the lottery technique because respondents only have to rank order lotteries instead of having to provide indifference judgments.

Table 6.23 A summary of major findings with each assessment technique

CONSTRUCT	RISK ATTITUDE		STRENGTH OF PREFERENCE	
Technique	Conjoint measurement	Lottery	Midvalue splitting	Rating
Respondent's task	rank order 24 50/50 lotteries	assess certainty equivalents of 10 50/50 lotteries	assess 10 midvalues	rate 10 price levels on a 0 to 10 scale
Response % in 1984	95%	95%	88%	99%
Response % in 1985	93%	97%	87%	99%
Ease of task to the:				
- respondent	+	0	0/-	+ + +
- interviewer	+ +	0	0	+ + +
Internal consistency of assessment	high	high	high	high
Type of risk attitude	linear trade-off between mean and standard deviation	constant absolute risk aversion (negative exponential function)	constant absolute risk aversion (negative exponential function)	decreasing absolute risk aversion (power function)
Percentage of respondents:	1984 / 1985	1984 / 1985	1984 / 1985	1984 / 1985
- averse	89% / 95%	82% / 68%	91% / 95%	100% / 100%
- neutral	8% / 4%	12% / 23%	7% / 5%	-- / --
- seeking	3% / 1%	6% / 9%	2% / --	-- / --
Stability				
- temporal shift (from 1984 to 1985)	no sign. difference	less risk averse in 1985	no sign. difference	more value averse in 1985
- stability correlation	0.30 ($p < 0.01$)	0.45 ($p < 0.001$)	0.23 ($p < 0.05$)	0.19 ($p < 0.01$)
- stability of latent variable	0.82 ($p < 0.001$)		0.61 (not sign., $n = 55$)	
Convergent validity	in 1984: 0.49 ($p < 0.001$) in 1985: 0.40 ($p < 0.001$)		in 1984: 0.15 ($p < 0.025$) in 1985: 0.31 ($p < 0.01$)	
Response effects	inclusion of certain profile induced ideal points, but less than expected	more risk seeking responses for lotteries low in expected utility and small in range (tendency to S-shaped function)	same effect as with lottery technique, but smaller	- scaling of interval boundaries is probably not taken fully into account - no indication of an S-shaped function
Further findings	- expected utility model confirmed for at least 80% of respondents; Coombs' ideal-point model rejected - certainty effect rejected	in test interviews certainty equivalence technique clearly preferred to probability equivalence technique		most susceptible to interviewer effects

utility and with a small range in lottery outcomes, respondents tended to give risk neutral or risk seeking responses. Further research in which special attention is given to the effect of a reference point should clarify whether these responses are to be attributed to a method effect or to a respondent's coding of price levels into gains and losses as hypothesized in Prospect Theory (Kahneman and Tversky 1979).

In contrast with the lottery and midvalue splitting technique, no indications of an S-shaped evaluation function is found with the rating technique. On the contrary, the assessments show a very steep increase in value for low price levels (the power function therefore fitted best for the rating technique). This large difference between the techniques might be due to the explicitness of the interval boundaries in the measurement process. In contrast with the lottery and midvalue splitting technique where the boundaries of each assessment are on the forefront and the respondent is asked to assess a midpoint, the boundaries in the rating technique are less dominant in the assessment. The respondent is asked to rate price levels relative to the endpoints 0 = 10 cts/kg and 10 = 70 cts/kg. In this rating task it is possible that respondents use only ratings between, say, 4 and 10 to evaluate price levels on the interval [10,70]; ratings between 0 and 4 in this example are all perceived as "very bad" and so there is no need to differentiate between e.g. 3 and 4. Such an effect would probably have been smaller if a rating scale between 0 and 100 had been used.

Finally, the rating task seems most susceptible to interviewer effects. Conjoint measurement is sensitive in this respect, too. However, no consistent interviewer effects showed up, which means that there was not a particular group of interviewers who systematically assessed extreme values.

With respect to the relationship between personal and situational factors of the farmers and the indicators of risk attitude it is concluded that in this study no substantial or noteworthy relationships turn up. It is thought that the assessments of risk attitude and strength of preference are too context specific.

Overall, evidence in this study shows that for all the techniques that were applied, consistent and plausible assessments were obtained. The lottery technique proves to be best in these respects, followed by the conjoint measurement and midvalue splitting technique. The rating task is judged as the least reliable and valid method of assessment.

However, our findings also show that the measurements do not converge highly enough to warrant the supposition of having established a valid and stable measurement of either the risk attitude or the strength of preference (it should be noted in this respect that predictive validity of the assessments still has to be analyzed (see the next chapter)). Although stability and convergent correlations are positive and significant, their magnitude is fairly small. These rather low correlations indicate the danger of relying on only one measurement procedure in a study and thus prove the necessity to apply a multiple indicator approach.

Furthermore, it signals that more research into the concepts and their measurement has to be conducted in order to develop superior procedures.

The relative risk attitude

With respect to the construct of relative risk attitude the not-substantial correlations between risky techniques on the one hand and riskless techniques on the other hand indicate that the hypothesis of a relative risk attitude cannot be dismissed. Indeed, the specific test of the relationship between the utility function and the value function indicated a non-linear relationship. This means that the assessments in this study show that risk attitude and strength of preference are two distinctive concepts.

It was shown that the negative exponential function provided a better fit between utility and value function than a linear or power function. In this way respondents can be characterized by a constant absolute relative risk attitude.

As a group, the respondents exhibit a slight tendency towards relatively risk seeking behavior. However, the number of relatively risk averse respondents almost matched the number of relatively risk seeking respondents. The findings show that, in general, the introduction of risk into the decision making process induces decision makers to choose differently. Some will exhibit less conservative preferences in the presence of risk, whereas others will exhibit more conservative preferences.

In testing the hypothesis of the relative risk attitude, the assessments of the lottery technique and the midvalue splitting technique were used. The questioning procedure in these two techniques is very similar. The sole fundamental difference in assessment is whether or not risk is involved in the assessment. The significant difference in assessment that is found proves to a very large extent that respondents react differently under certainty than under risk. We therefore do not attribute the difference between the techniques in assessment to method variance.

As this study confirms the existence of the relative risk attitude, it is interesting to digress upon some consequences of this finding. Firstly, it implies that modeling decision making under risk as if it is a decision under certainty, will generally result in incorrect assessments. Consequently, one expects that the predictive validity of these models under certainty will not be high for decisions under risk. However, it is not yet clear how large the differences in predictive validity are between certainty and uncertainty models. This is one of the topics of Chapter 7.

Secondly, it should be noted that the concept of relative risk attitude is very specifically tied to the difference between a utility and a value function. It can only be assessed indirectly, not directly. This is definitely an unattractive feature of the concept. One consequence is that measurement error is introduced from two sources, namely the utility and the value function. Another consequence of the indirect assessment is that it is difficult to communicate the contents of the concept.

Thirdly, it is relevant to consider the question whether the concept of relative risk attitude is really theoretically compelling. That is, is it attractive to consider a quantal effect between certainty and uncertainty in such a way that the evaluation function shifts dramatically when moving from certainty to uncertainty? Von Winterfeldt and Edwards (1986) conclude negatively. They refute the idea of relative risk attitude and as a consequence allow no inconsistencies between risky and riskless measurements. Decision makers are urged to resolve their inconsistenties. We are less convinced that the concept of relative risk attitude is theoretically unattractive. To us, indeed a quantal effect between certainty and risk is plausible. The psychological state of uncertainty is of a different nature than that of certainty. Uncertainty, of course, is the general state.

In our view, the concept of relative risk attitude bridges the gap between Bernoulli's model and his explanation of risk aversion and the von Neumann-Morgenstern model. In the Bernoulli model strength of preference (i.e. decreasing marginal value) is the sole explanation for risk aversion. In contrast, in the original theory of von Neumann-Morgenstern no explanation is provided for risk aversion. Their theory rests on the fundamental assumption that decision makers do arrive at indifference probabilities or certainty equivalents, one way or another. The theory does not require that a reference is made to strength of preference, in this respect. However, when actually considering lotteries and when urged to state how one arrives at a particular certainty equivalent, strength of preference notions easily come to mind. Although these notions are important, we think, and our empirical study confirms this idea, that strength of preference alone is not enough to explain decisions.

We suggest a two-stage process. A decision under risk is governed by value comparisons of outcomes under certainty *plus* either the displeasure originating from nervousness about the risk of ending up with an unfavorable subjective value (relative risk aversion) or the pleasure derived from the chance of ending up with a favorable subjective value (relative risk seeking). The relative risk attitude, or the true risk attitude of a decision maker, thus is the net result of hope (greed) and fear, approach and avoidance concerning subjective values.

Of course, in some sense we are back to where we started: why is one person more 'nervous' about the chances of an unfavorable subjective value than another person? Should the relative risk attitude be seen as a personality trait and, if so, how does this trait develop? The real benefit of the concept still has to be confirmed. It has to be shown that it describes the true risk attitude of a decision maker better and more stable, and that it is less dependent than the conventional measure of risk attitude upon both the attribute under consideration and the decision context. Further empirical research is therefore surely needed to prove the worth of the concept. But at this moment in time we think it is too early to refute the idea of a relative risk attitude as e.g. von Winterfeldt and Edwards (1987) do.

Further conclusions concerning the differences between risky and riskless procedures will be drawn in the analysis of the predictive validity of the utility and value assessment and in the test of the subjective expected utility model. In the next chapter these issues will be dealt with.

CHAPTER SEVEN

ANALYSIS OF PREFERENCE FOR MARKETING STRATEGIES AND TEST OF THE EXPECTED UTILITY MODEL

7.1 Introduction

In this chapter we will focus on explaining and predicting the farmer's preference for a marketing strategy. The model of preference formation for a marketing strategy, described and presented in Chapter 3, will be tested. In this model the preference is hypothesized to be dependent upon two attributes: the *price* farmers expect to receive with a certain marketing strategy and the *type of wholesale company*. Within this two-attribute model, the effect of the price attribute on preferences is modelled according to the expected utility model.

This chapter deals with four issues. The central issue in this chapter will be the capability of this *expected utility model* to explain preferences. That is, what is the predictive validity of the expected utility model? In the expected utility model the subjective probability distribution of price of a marketing strategy (the primary subject of Chapter 5) is combined with the utility function (risk attitude) of the farmer (analyzed in Chapter 6) to arrive at the expected utility of a marketing strategy. The model furthermore assumes that decision makers will form a preference ranking of strategies in accordance with the rank order of expected utility.

In order to test and evaluate the predictive validity of the expected utility model, the model will be contrasted with a benchmark model. This benchmark model is the *expected value model*. In the expected value model, price risk of a strategy and risk attitude of the decision maker are not taken into account. That is, a linear utility function of the decision maker is assumed (a risk neutral decision maker) so that only the expected value of the subjective probability distribution governs preferences. Thus, it is assumed that the preference rank order of strategies in the expected value model equals the rank order of expected value of the strategies.

Essentially then, the issue of the capability of the expected utility model to explain preferences boils down to the question whether the expected utility model performs better than the expected value model in explaining preferences. Beforehand, one would expect that the predictive validity of the expected utility model will be higher than that of the expected value model. This expectation follows directly from the findings in the previous two chapters. The analysis in Chapter 5 showed that farmers perceive a substantial amount of price risk associated with each marketing strategy and in Chapter 6 it was shown that the majority of the farmers is risk averse. In this chapter then, it will be empirically assessed whether the expectation is correct. Are the perceived price risk and the risk aversion of farmers indeed influential variables in the formation of preference and secondly, how influential are these variables? Section 7.3.1 will deal with these issues.

The second issue in this chapter concerns the effects on the predictive validity of the expected utility model if the *utility function* is substituted by a *value function*. In the standard version of the expected utility model a utility function is assumed. This utility function is measured under risk by means of lotteries. The value function, on the other hand, is measured by means of riskless techniques. In this study the midvalue splitting and rating technique are used to measure the value function. The analysis in Chapter 6 has shown that significant differences exist between the utility and value function.

Since risk is introduced only in the lottery technique and not in the other two techniques, one would expect a higher predictive validity of the expected utility model when using the utility function than when using the value function. This expectation will be checked in this chapter. That is, is the predictive validity of the expected utility model indeed higher when using the function measured under *risk* than when using the function measured under *certainty*? Stated differently, does the relative risk attitude of a farmer influence preferences? The findings will be dealt with in Section 7.3.2.

A third subject of this chapter concerns an evaluation of the expected utility model from the viewpoint of efficiency in the explanation of preference. This concerns the question whether a more simple model than the sophisticated expected utility model would explain preferences equally well. The reason for searching for a more simple model is that, as was shown in Chapters 5 and 6, a number of elaborate measurements are necessary if one wants to use the expected utility model. A subjective probability distribution must be elicited for each choice alternative and the decision maker's risk attitude has to be assessed. Both measurements are fairly difficult and time consuming on the part of the respondent, which can become problematic when conducting research with a large number of respondents. Furthermore, incorporating the measurements in an analysis of preference requires a great deal of effort and time on part of the analyst.

Solely seen from the viewpoint of explaining preference, one can therefore put forward the question whether the expected utility model would result in a substantially better explanation of preference than a more pragmatic model of preference formation. The latter model uses measurements which are obtained more easily and quicker than the measurements needed in the expected utility model. In this study it is possible to make an explicit comparison of the expected utility model and such a pragmatic model. The farmer's perception of marketing strategies has not only been assessed by means of subjective probability distributions but also by means of a number of straightforward questions. The mean price of a strategy was asked directly and price risk was measured by means of magnitude

estimation. In Section 7.3.3 the predictive validity of a pragmatic model using these measurements will be analyzed.
In the analyses of Sections 7.3.1 to 7.3.3 the attention is primarily directed towards within-subject analyses. That is, models are tested which predict why a decision maker prefers marketing strategy A to B and B to C etc. In contrast, in Section 7.4 a number of between-subject analyses will be conducted. This means that the following question is raised (the fourth topic in this chapter): which farmers have a high preference for a particular marketing strategy and which farmers evaluate that strategy negatively? An attempt is made to explain the attitude towards a marketing strategy by the farmer's characteristics like risk attitude, age, level of education and so on. In a different manner than in the within-subject analyses the effect of risk attitude on preferences can thus be assessed.

Before presenting the results of the analyses mentioned above, first a number of general observations will be discussed in the next section. The section contains the descriptive statistics of the preference measurement, it describes the effect of the type of wholesale company on preference and, finally, it presents findings concerning the stability of preferences.

7.2 Measurement of preference: some general aspects

Data collection procedure

The farmers evaluated the marketing strategies on a seven-point rating scale: 13 strategies in 1984 and 18 in 1985 (see Chapter 4). The question they had to answer read: *When I consider all advantages and disadvantages of choosing this strategy this year, my judgment of this strategy is: very negative* (rating = 1) to *very positive* (rating = 7). To simplify the task, all strategies were displayed on cards and presented to the farmer. He was then asked to put each card in one of seven categories displayed on a large sheet. The question mentioned above was written at the top of the sheet. The farmers were told that they were allowed to put more than one strategy in a category. This procedure resulted in a number of piles of strategies. Having completed the task so far, the farmer was asked to reconsider the strategies in each pile and order them according to his preference. In this manner a complete rank order of the strategies was obtained. Both the category rating and the rank order were recorded. The farmers showed no difficulties in completing the task.

In both years, the measurement of preference for marketing strategies was situated in the first part of the questionnaire, amply before the measurements of risk perception and risk attitude in order to reduce the possibility of interference of measurements.

Main results

Table 7.1 shows descriptive statistics of the preference measurement in both years. From this table some primary remarks can be made.

The strategies consisting of a combination of a fixed-price contract and some other way of selling are evaluated very positively. See the high mean preference score of Strategies 9, 12 and 13. Apparently, in both years the fixed-price contract is very attractive to farmers, especially when it is combined with a chance of profiting from high market prices by means of selling at the spot market.

Table 7.1 *Descriptive statistics of preference measured on a seven-point rating scale (1 = very negative, 7 = very positive) in 1984 (N = 230) and 1985 (N = 200)*

	MEAN		MEDIAN		ST.DEV.	
STRATEGY	1984	1985	1984	1985	1984	1985
1. 100% Pc	4.27	3.73	4.38	3.40	1.98	2.18
2. 100% Bp	4.21	4.08	4.39	4.28	1.40	1.57
3. 100% Fp1	4.52	4.10	4.75	4.19	1.69	1.56
4. 100% Sm1	3.37	2.99	2.99	2.45	1.89	1.77
5. 100% Pp	4.10	3.69	4.21	3.62	1.66	1.88
6. 100% Sm2	4.06	3.43	4.08	3.31	1.61	1.70
7. 50% Pc /50% Sm1	4.49	4.05	4.68	4.03	1.54	1.72
8. 50% Bp /50% Sm1	4.41	4.16	4.47	4.16	1.32	1.44
9. 50% Fp1/50% Sm1	5.03	4.84	5.32	4.92	1.34	1.30
10. 50% Pp /50% Sm1	4.47	4.12	4.62	4.08	1.36	1.54
11. 50% Pc /50% Sm2	4.50	3.77	4.69	3.77	1.43	1.69
12. 50% Fp1/50% Sm2	5.07	4.46	5.32	4.68	1.27	1.46
13. 50% Fp1/40% Bp/10% Sm1	4.62	4.57	4.81	4.75	1.47	1.41
14. 100% Fp3	--	3.96	--	4.10	--	1.61
15. 50% Fp3/50% Sm1	--	4.39	--	4.55	--	1.45
16. 50% Pp/50% Sm2	--	3.92	--	3.97	--	1.39
17. 25% Pp/25% Fp1/50% Sm1	--	4.09	--	4.11	--	1.53
18. 25% Pp/25% Fp1/50% Sm2	--	4.03	--	3.98	--	1.45

Pc = pooling contract, cooperative company
Pp = pooling contract, private company
Bp = bottom-price contract, private company
Fp = fixed-price contract, private company (1 or 3 years fixed)
Sm1 = selling at the spot market, selling at one moment
Sm2 = selling at the spot market, selling at two moments

In contrast, selling the total harvest at spot market prices is evaluated negatively, as can be seen from the mean preference for Strategies 4 and 6, which are lowest in both years. Of these two strategies, Strategy 6 (selling at two moments at the spot market) is evaluated more positively than Strategy 4 (selling at one moment at the spot market) in both years (pairwise test, $p < .001$). Perhaps this preference for selling twice at the spot market is caused by the farmers' risk aversion. Since, according to the farmers (see Chapter 5), selling twice at the spot market results in a smaller risk than selling only once, risk averse farmers would opt for selling twice.

In both years, the farmers' opinions on 100% pooling at a cooperative company (Strategy 1) varies largely; more so than their opinions on other strategies. This can be concluded from the high standard deviation of the ratings. Farmers also largely differ in their evaluation of Strategy 4. In Section 7.4 it will be analyzed which characteristics of farmers can explain the differences in preference between farmers for both these strategies.

A comparison of the results of 1984 with those of 1985 shows that the mean evaluation for all marketing strategies is lower in 1985 than in 1984. Tested pairwise, the difference between both years is significant for all marketing strategies. It indicates that farmers evaluated all strategies fairly negative, which is most likely due to the low prices they expected in 1985 irrespective of the specific strategy (see Chapter 5). Another reason for this difference between the years might be that five strategies were added to the preference measurement in 1985 compared to 1984 (13 strategies were used in 1984; in 1985 this was extended to 18 strategies). These extra strategies may have induced farmers to lower their mean evaluation score of the other 13 strategies due to a change in reference. However, since further analyses are performed within each year, this difference in scale rating between both years is not a severe problem.

Effect of type of wholesale company farmers actually deal with

In Table 7.1 the preference ratings averaged over all farmers were displayed. In Table 7.2 the ratings are broken down by type of wholesale company the farmers actually deal with. In the remainder of this chapter a farmer selling his potatoes to a cooperative company will be referred to as a 'cooperative farmer', whereas a farmer dealing with a private company will be referred to as a 'private farmer'.

Table 7.2 clearly shows the differences in both years in the evaluation of marketing strategies between the two groups of farmers. Cooperative farmers evaluate strategies implying selling to a cooperative company (Strategies 1, 7 and 11) more positively than do private farmers. Private farmers evaluate strategies implying selling to a private company more positively than do cooperative farmers. Each group of farmers thus dislikes strategies supplied by the competing wholesale company.

There is, however, one notable and interesting exception in the pattern mentioned above. As Table 7.2 shows, cooperative farmers evaluate in both years 100% pooling at a private company (Strategy 5) more positively than do private farmers ($p < .001$). Apparently, cooperative farmers are much more fond of pooling than private farmers, irrespective of the type of wholesale company they have to deal with.

Table 7.2 Mean preference ratings in 1984 and 1985, separately for cooperative and private farmers (1 = very negative, 7 = very positive)

STRATEGY	1984 Coope-rative	1984 Private	1985 Coope-rative	1985 Private
1. 100% Pc	5.6	3.3	5.4	2.7
2. 100% Bp	4.2	4.2	3.8	4.3
3. 100% Fp1	4.7	4.4	4.2	4.1
4. 100% Sm1	2.9	3.7	2.7	3.2
5. 100% Pp	4.5	3.8	4.3	3.3
6. 100% Sm2	3.6	4.4	3.0	3.7
7. 50% Pc/50% Sm1	5.3	3.9	5.1	3.4
8. 50% Bp/50% Sm1	4.1	4.6	3.7	4.4
9. 50% Fp1/50% Sm1	4.8	5.2	4.4	5.1
10. 50% Pp/50% Sm1	4.4	4.5	4.1	4.1
11. 50% Pc/50% Sm2	5.3	4.0	4.7	3.2
12. 50% Fp1/50% Sm2	5.0	5.1	4.1	4.7
13. 50% Fp1/40% Bp/10% Sm1	4.4	4.8	4.2	4.8
14. 100% Fp3	--	--	4.2	3.8
15. 50% Fp3/50% Sm1	--	--	4.1	4.6
16. 50% Pp/50% Sm2	--	--	3.9	4.0
17. 25% Pp/25% Fp1/50% Sm1	--	--	3.5	4.5
18. 25% Pp/25% Fp1/50% Sm2	--	--	3.5	4.4

The effect of the type of wholesale company can be studied further by taking a closer look at a number of pairwise combinations of strategies, namely: a comparison of Strategy 1 with 5, Strategy 7 with 10 and Strategy 11 with 16. The strategies concern the 100% pooling strategies (Strategies 1 and 5) and the strategies in which 50% pooling is combined with 50% spot market sales (Strategies 7, 10, 11, and 16). These marketing strategies are selected because in each pairwise combination the strategies are similar except with respect to type of wholesale company. As a consequence, these combinations enable one to analyse differences between cooperative and private farmers more clearly. Table 7.3 shows the mean preference ratings for the five pairwise combinations. Data are presented for the total group of farmers and for cooperative and private farmers separately.

When testing the differences between the corresponding strategies by means of the pairwise t-test, it turns out that for the total group no significant differences between these strategies exist. For example, 100% pooling at a cooperative company is evaluated equally positive as 100% pooling at a private company. However, testing the pairwise differences separately for each group of farmers, the differences are significant and substantial for all five comparisons. If they can choose similar strategies with each type of wholesale company, each group of farmers clearly prefers the strategy implying the type of wholesale company he actually deals with.[1] The findings in Table 7.3 further show that although private farmers like 100% pooling less than do cooperative farmers (see above), if they have to choose between a) 100% pooling and selling to a cooperative company (Strategy 1) or b) 100% pooling and selling to a private company (Strategy 5), they will prefer the latter. (see also Section 7.3.1).

Table 7.3 Testing the effect of type of wholesale company on preferences for five pairwise combinations of marketing strategies (mean preference ratings), for all farmers and separately for cooperative and private farmers

		1984			1985		
STRATEGY		All	Cooperative	Private	All	Cooperative	Private
1.	100% Pc (coop.)	4.27	5.59	3.34	3.73	5.35	2.71
5.	100% Pp (priv.)	4.10	4.48	3.83	3.69	4.31	3.29
	Difference (1-5)	.17	1.11	-.49	.04	1.04	-.58
	Significance	-	**	**	-	**	**
7.	50% Pc/50% Sm1 (coop.)	4.49	5.33	3.90	4.05	5.12	3.38
10.	50% Pp/50% Sm1 (priv.)	4.47	4.37	4.54	4.12	4.14	4.11
	Difference (7-10)	.02	.96	-.63	-.07	.98	-.73
	Significance	-	**	**	-	**	**
11.	50% Pc/50% Sm2 (coop.)	--	--	--	3.77	4.71	3.17
16.	50% Pp/50% Sm2 (priv.)	--	--	--	3.92	3.86	3.97
	Difference (11-16)				-.16	.86	-.79
	Significance				-	**	**

** = $p < 0.001$ (one-tailed)
- = not significant

The preference formation model, hypothesized and presented in Chapter 3, provides two explanations for the differences between cooperative and private farmers in the evaluation of marketing strategies. Firstly, a difference between the groups in price risk perception of a strategy; secondly, a difference due to other attributes of the strategy.

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[1] Another effect of the wholesale company shows up in Table 7.1. The standard deviation of the rating is larger for cooperative strategies than for similar private strategies (compare Strategy 1 and 5, 7 and 10, 11 and 16). Apparently farmers differ more in their opinions about the cooperative than about private companies.

Let us now first turn to the difference between the groups in price perception by considering, for example, the 100% pooling strategies (Strategies 1 and 5). Why do cooperative farmers prefer Strategy 1 to 5 and why do private farmers prefer Strategy 5 to 1? One reason might be that, although it is a similar strategy, cooperative farmers on average expect a different subjective probability distribution of 100% pooling with a cooperative company than of 100% pooling with a private company. The expected utility of the strategy with a cooperative company could then be higher and preference for this strategy is therefore also higher. For private farmers on the other hand, the expected utility of 100% pooling with a private company might be higher than that of 100% pooling with a cooperative company. Alternatively, the prices associated with a strategy and, as a consequence, the expected utility of the strategy might be biased by the farmer's actual choice of wholesale company (a rationalization of choice).

In the second explanation, other attributes than price could be the reason for the differences. Perhaps farmers perceive exactly the same probability distribution of the 100% pooling strategy, irrespective of the type of wholesale company. The two strategies would then be equal in respect of expected utility. Although equal in expected utility, cooperative farmers might nevertheless prefer 100% pooling with a cooperative company because of such factors as the style of trading, a lower debtor risk, the system of payments for high quality potatoes, etc.

Since no significant effect of wholesale company on perception could be detected (see Section 5.3.3), the second explanation is most likely. Of course, in general a combination of both reasons is possible: a difference in price perception as well as a favorable attitude based on non-price attributes. In the model presented in Section 7.3.1 the effects of type of wholesale company and differences in price perception will therefore simultaneously be taken into account.

Strategy loyalty

For each individual, preference data are available in both years for 13 marketing strategies. These data will be used to study the loyalty towards strategy choice (it should be noted that loyalty here is studied with respect to preference and not to actual choice). Table 7.4 shows the descriptive statistics of Pearson and Spearman correlations computed *per individual*. For N = 191 individuals data are available. The mean correlation is 0.52 with a median correlation of 0.55. The third quartile is 0.69. For 8% of the respondents the correlation is negative.

Another measure of the stability of preference is the correlation computed *over individuals* and over strategies. Before computing the correlation over individuals the preference data were centered per individual (see 7.3.1). The resulting correlations are a Pearson correlation of 0.46 and a Spearman correlation of 0.45, both significant ($p < .001$).

Table 7.4 ***Stability of preferences; sample statistics of Pearson and Spearman correlations computed per individual (N = 191)***

	Mean*	Mean	St.dev.*	Percentiles 25	50	75	% < 0
Pearson	.520	.467	.400	.324	.540	.691	8
Spearman	.501	.453	.396	.285	.544	.670	8

* After Fisher r-to-z transformation

If the attention is directed towards the correspondence in the most favorite strategy in both years, another indication of stability of preference, then it turns out that 42% of farmers prefer the same strategy in both years. If first and second choice are taken together then 69% of the farmers can be classified as strategy loyal.

Loyalty is highest for strategies implying selling to a cooperative company (Strategies 1, 7 and 11). Loyalty towards the first choice of these strategies is no less than 80% (that is, 80% of the cooperative farmers prefer the same strategy in 1985 as in 1984). Apparently, cooperative farmers do not switch easily from e.g. 100% pooling to 50% pooling, 50% spot market or vice versa. It is concluded that they do perceive these optional strategies with a cooperative company as very different.

Loyalty for the remainder of strategies, all implying selling to a private company, is much lower; on the average this amounts to 28% of first choices of private farmers. Apparently, the optional strategies with a private company are perceived as less diverse from one another than those with a cooperative company. Private farmers easily switch from one strategy to another. Of these strategies with a private company, farmers appear to be most loyal (63%) towards Strategy 4 (100% spot market, selling at one moment). Particularly interesting is the loyalty towards the fixed-price contract. In 1984, the share of the first choices of this strategy is 13% decreasing to 7% in 1985. Many farmers thus switched from the fixed-price contract to another strategy in 1985. The most likely explanation for this decrease in preference is that in 1985 the level of the fixed-price is perceived as relatively low in comparison with the expected prices for other strategies (see Chapter 5).

The findings mentioned above show that the first choices of cooperative farmers did not change much between the years. Private farmers showed much more switching behavior than cooperative farmers. The stability correlations indicate that, the preference ranking of the marketing strategies is fairly alike in both years.

7.3 Test of the preference formation model

This section concerns itself with testing the preference formation model hypothesized in Chapter 3. In Section 7.3.1 the predictive validity of this model will be compared to the expected value model. This is followed by an analysis of the effect of substituting the utility function by the value function in the expected utility model (Section 7.3.2). A comparison of the predictive validity of the expected utility model with a pragmatic model of preference formation follows in Section 7.3.3.

7.3.1 The predictive validity of the expected utility and expected value models

Specification of the models

The formation of preference is hypothesized to be based upon two attributes. One attribute is the price farmers expect to receive with each marketing strategy. The second attribute is the type of wholesale company, differentiated into a cooperative or private company, that farmers sell their potatoes to. Thus we get the general model:

$$\text{Pref} = f(\text{price, type of wholesale company}) \quad (7.1)$$

Both attributes need further explanation and specification.

Firstly, consider the type of wholesale company. As stated in Chapter 3, the type of wholesale company is not by itself a reason for choosing the marketing strategy. We view the type of company as a proxy variable for differences between cooperative and private companies on a number of attributes. These attributes concern differences between companies in style of trading, debtor risk, type of contact with representative personnel, differences in the payment for high quality potatoes, etc. Since in the marketing strategies we distinguished solely between cooperative and private companies, the net effect of all the above mentioned attributes on preference can be represented adequately by a single dummy variable. This means that, by using the dummy variable of type of wholesale company, it can be tested whether a farmer evaluates marketing strategies which imply selling to a cooperative company on average higher (or lower) than marketing strategies which imply selling to a private company.

A complete review of which attributes or motives are most important in choosing the type of wholesale company and the differences between farmers in the importance they attach to each of these attributes, are issues which have been reported elsewhere (Smidts 1985).[2] In this section, the attention is directed

[2] The three main motives for choosing a cooperative company are: a) the smaller risk of bad debts; b) "the cooperative is your partner and not your opponent"; c) habit/from generation to generation. The main reasons for choosing a private company are: a) more freedom/less restrictions; b) habit/from generation to generation; c) cooperative is too large and bureaucratic.

towards a test of the expected utility model so that a single dummy variable suffices.

Secondly, in Model 7.1 also a clarification is needed for the specific meaning of the attribute price. Price stands for a subjective probability distribution. In order to enable testing of the model, this subjective probability distribution has to be converted into a single number for each marketing strategy for each farmer. If the expected utility model is assumed to govern preference, this single number will of course be the expected utility of the subjective probability distribution.

Taking the remarks above into account, Equation 7.1 can be rewritten as:

$$\text{Pref}_{ij} = f\,(\text{EU}_{ij}, \text{Company}_j) \tag{7.2}$$

$i = 1, 2, \ldots, n$
$j = 1, 2, \ldots, m$

where:

Pref_{ij} is the preference rating for marketing strategy j by farmer i,

EU_{ij} is the expected utility of marketing strategy j for farmer i,

Company_j is a dummy variable that indicates whether marketing strategy j implies selling to a cooperative company or to a private company.

In this Model 7.2 then, the preference for strategy j is allowed to differ between farmers i. Furthermore, the preference rating a farmer gives to a strategy is assumed to depend upon the farmer's expected utility of the strategy (EU_{ij}) and the type of wholesale company (Company_j). Of course, the expected utility of strategy j is modelled to differ between farmers i because of differences between farmers in the subjective probability distribution of strategy j, differences between farmers in risk attitude or both.

The expected utility of a marketing strategy, EU_{ij} in Equation 7.2, is computed according to the following expression:

$$EU_{ij} = \int_{10}^{70} f_{ij}(x)\, u_i(x)\, dx \tag{7.3}$$

where:

$f_{ij}(x)$ is the probability density of price for marketing strategy *j* as perceived by farmer *i*,

$u_i(x)$ is the utility function of farmer *i* on the price interval 10 to 70 cts/kg.

In the standard version of the expected utility model assumed in this section, $u_i(x)$ is the utility function measured by means of lotteries. In Section 7.3.2 the effect on predictive validity will be studied when $u_i(x)$ in 7.3 is be substituted by the value function $v_i(x)$, measured by means of riskless techniques.

In Chapter 5 it was shown that the subjective probability distribution of a marketing strategy could be represented satisfactorily by a lognormal distribution. So the probability density $f_{ij}(x)$ in Equation 7.3 concerns the density function of the lognormal distribution. Furthermore, it was shown in Chapter 6 that the farmer's utility function $u_i(x)$ could be represented adequately by a negative exponential function. Taking these findings into account, Equation 7.3 can be specified further as:

$$EU_{ij} = \int_{10}^{70} \left(\frac{1}{x\sigma_{ij}\sqrt{2\pi}} \, exp \left\{ - \frac{(\ln x - \mu_{ij})^2}{2\sigma_{ij}^2} \right\} \right) \left(\frac{1 - e^{-c_i(x-10)}}{1 - e^{-60c_i}} \right) dx \quad (7.4)$$

with

$$\mu_{ij} = \ln IMED_{ij}$$

and

$$\sigma_{ij}^2 = 2 \ln \frac{IMEA_{ij}}{IMED_{ij}}$$

In Equation 7.4, IMEA and IMED refer to the moments of the lognormal distribution; the mean of the distribution is denoted by IMEA and the median by IMED (see the notation used in Chapter 5). Equation 7.4 is computed using procedure DCADRE in the IMSL-library of FORTRAN programs.

In case of a risk neutral farmer or under the assumption that he is risk neutral, then the utility function is linear and expression 7.3 reduces to:

$$EU_{ij} = \int_{10}^{70} f_{ij}(x)\, x \, dx \equiv EV_{ij} \quad (7.5)$$

That is, the expected utility of the marketing strategy is now equal to the expected value (EV) of the probability distribution of price. The price risk of a strategy does not influence the farmer's preference for the strategy. This expected value model can be considered the benchmark model from which the expected utility model is evaluated.

To summarize, the test of the predictive validity of the expected utility model will concern the comparison of the two following models: the expected value model and the expected utility model.

Expected value model

$$\text{Pref}_{ij} = a + b\ \text{EV}_{ij} + c\ \text{Company}_j \tag{7.6}$$

Expected utility model

$$\text{Pref}_{ij} = a + b\ \text{EU}_{ij} + c\ \text{Company}_j \tag{7.7}$$

Beforehand, we would expect the expected utility model to outperform the expected value model in explaining preference, because the expected utility model takes price risk into account. Since price risk of marketing strategies is considerable, as was shown in Chapter 5, and since farmers are definitely not risk neutral, as was concluded in Chapter 6, risk should influence preferences for marketing strategies.

The models in 7.6 and 7.7 combine the attributes additively. Of course, other functions e.g. the multilinear function of which the additive function is a special case, have been proposed in combining attributes. Most noteworthy in this respect is the analysis of Keeney and Raiffa (1976) who provide an elaborate discussion on multiattribute models under uncertainty and present conditions, e.g mutual utility independence, in order to select the functions suitable for combining the attributes. Their analysis is not particularly relevant here, however. In this case, the combination of attributes is relatively simple since only one attribute, namely price, is represented by a probability distribution. The certain attribute, type of wholesale company, is therefore combined with price in the most simple, that is, additive manner.

Procedure for testing the models

By means of linear regression analysis *over individuals*, the parameters in Equations 7.6 and 7.7 will be estimated. Preferably, both models should be estimated *per individual* since parameters might differ between individuals. For example, for some farmers the type of wholesale company might be more important in the formation of preference than the price, whereas for others this might be the other way around. However, estimating the models per individual is not possible since the number of marketing strategies per individual for which perception data are available is fairly small. The maximum number of strategies per individual for which a subjective probability distribution is elicited is 7. This means that at best only 4 degrees of freedom would result when estimating Equations 7.6 or 7.7 per individual. Often however, even less than 7 probability distributions have been elicited. This small number of observations per individual thus necessitates an analysis *over* individuals.

In the regression over individuals, within-subject data (differences between strategies per individual) are pooled with between-subject data (differences between individuals per strategy). In that case, the same parameters are assumed for all individuals. One should test whether this implication of pooling is justified. For example, one could estimate the models separately for particular groups of respondents and see whether differences in parameters between these groups exist.

One such partial analysis should evidently be performed. The analysis in Section 7.2 showed that the type of wholesale company the farmers actually sell to will influence the parameter of the dummy variable 'company' in Equations 7.6 and 7.7. That is, farmers actually selling to a private company prefer marketing strategies implying selling to a private company on average more than cooperative marketing strategies, whereas for farmers actually dealing with a cooperative company the reverse effect shows up. In case the dummy variable 'company' is coded 0 for a strategy with a private company and 1 for a strategy with a cooperative company, then it is to be expected that the parameter of this dummy will be *negative* for individuals dealing with a *private* company and *positive* for individuals dealing with a *cooperative* company. Stated differently, an interaction effect will probably be present between the type of wholesale company implied in the strategy and the farmer's actual choice behavior with respect to the wholesale company.

One manner to analyse the effect mentioned above is to perform two regressions, one for respondents dealing with a cooperative company and one concerning respondents dealing with a private company. Alternatively however, it is also possible to estimate the effect in one regression. In Equation 7.8 the model is shown in which the hypothesized interaction effect is taken into account and can be estimated in one regression.

$$\text{Pref}_{ij} = a + b\ \text{EU}_{ij} + c\ \text{Company}_j + d\ \text{COOP}_i + e\ \text{Company}_j{*}\text{COOP}_i + e_{ij} \quad (7.8)$$

where:

Company_j is a dummy variable indicating the type of wholesale company implied in strategy *j* (coded 1 if it concerns a strategy with a cooperative company and coded 0 if it concerns a strategy with a private company),

$COOP_i$ is a dummy variable indicating the type of wholesale company farmer *i* actually deals with (coded 1 if he deals with a cooperative and 0 if he deals with a private company),

$Company_j * COOP_i$ is the multiplication of the dummy variables $Company_j$ and $COOP_i$, which represents the interaction effect,

e_{ij} is a random error term,

$i = 1, 2, \ldots, n$ and $j = 1, 2, \ldots, m$.

In this regression analysis the data consist of vectors of length (n x m). By testing whether parameters d and/or e are significantly different from 0, it is tested whether the two groups of farmers (cooperative and private farmers) evaluate the strategies differently.

In the expected value model (7.6) the same interaction effect is assumed. This expected value model has the same specification as Equation 7.8 but EU_{ij} is substituted by $EV_{ij} = IMEA_{ij}$. In correspondence with the notation used in Chapter 5, $IMEA_{ij}$ denotes the expected value of the lognormal distribution specified by farmer *i* for marketing strategy *j*.

Prior to the regressions the data have undergone a selection and a transformation. Firstly, a data selection has taken place by selecting only those respondents for which five or more subjective probability distributions were elicited. This selection has taken place because the analysis is primarily directed towards testing within-subjects effects. With at least five strategies per subject these effects can be estimated. The inclusion of subjects for which, say, only one or two probability distributions are elicited, would predominantly increase only between-subjects variance and would not be beneficial in testing within-subject effects. The maximum number of strategies per subject for which probability distributions are elicited is seven.

Secondly, the data are *centered per individual*. This means that the mean of a variable is computed per individual and subsequently subtracted from the individual's raw data. In this manner differences in mean scores between individuals are removed from the data. Differences between individuals were especially large with respect to the expected value of the subjective probability distributions.

Results of testing the models

Equation 7.8 was estimated by means of regression analysis over individuals. In order to enable a proper comparison between the expected value and expected utility model the same cases (respondents and strategies) are taken in the regressions concerning a particular year. Table 7.5 shows these results of the regressions in both years. In order to ease presentation, no t-values are shown in Table 7.5. However, the coefficient of each variable is statistically significant ($p < .001$).

Firstly, Table 7.5 shows that the hypothesized effect of type of wholesale company, represented by the variables COOP, Company and COOP*Company, is clearly present. For both years the combined effect of these variables is shown in Figure 7.1. Cooperative farmers evaluate strategies implying selling to a cooperative company on average clearly higher than strategies implying selling to a private company. With private farmers the reverse effect shows up. The difference in evaluation of cooperative and private strategies for cooperative farmers is larger (0.92 + 0.64 = 1.56) than for private farmers (0.64). In 1985 these differences are, respectively, 1.49 (1.04 + 0.45) for cooperative farmers and 0.91 for private farmers. These findings mean that on average cooperative farmers dislike strategies of the competitive company much more than private farmers do. Consequently, it will be more difficult to persuade a cooperative farmer to switch to a private company than vice versa.

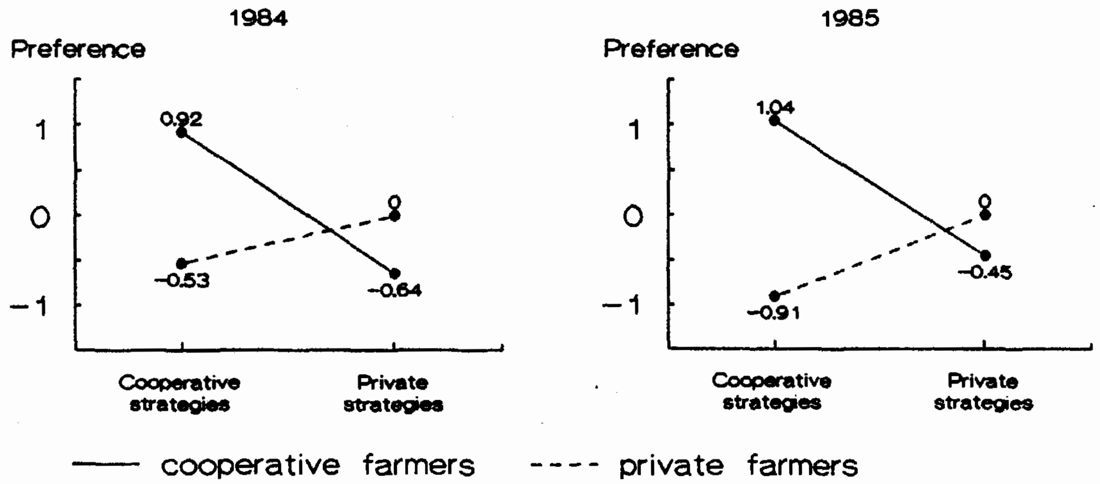

Figure 7.1 *Combined effect on preference of the type of wholesale company implied in the strategy and the type of company the farmer actually deals with, in 1984 and 1985*

Secondly, Table 7.5 shows that in both years, the inclusion of IMEA respectively EU in the regression results in a significant increase in fit of each model. Especially in 1984 the increase in R^2 due to these variables is substantial (0.098 due to IMEA and 0.118 due to EU).

The findings that both the type of wholesale company and the price farmers associate with a marketing strategy significantly affect preference, confirm the hypothesized preference formation model.

Table 7.5 *Predictive validity of the expected value model and the expected utility model in both years (regression over individuals; preference is measured on a seven-point scale (7 = very positive))*

	1984				1985			
	EXPECTED VALUE MODEL		EXPECTED UTILITY MODEL		EXPECTED VALUE MODEL		EXPECTED UTILITY MODEL	
VARIABLES	Regr. coeff.	*Beta*	Regr. coeff.	*Beta*	Regr. coeff.	*Beta*	Regr. coeff.	*Beta*
Constant	.167		.169		.178		.170	
1. COOP[a]	-.534	*-.161*	-.540	*-.163*	-.915	*-.221*	-.876	*-.211*
2. Company[b]	-.647	*-.209*	-.648	*-.209*	-.447	*-.134*	-.442	*-.133*
3. Company*COOP	2.110	*.465*	2.115	*.466*	2.397	*.378*	2.375	*.374*
4. IMEA	.212	*.316*	--	--	.120	*.181*	--	--
5. EU	--	--	1.01	*.346*	--	--	.670	*.230*
R^2	.226		.246		.118		.137	
St. error	1.35		1.34		1.53		1.51	
N	1135		1135		1093		1093	
Partial correlation								
r(PREF,IMEA)	.334				.187			
r(PREF,EU)			.367				.238	
History of R^2								
R^2 (vars. 1,2,3)	.128		.128		.086		.086	
R^2 (all vars.)	.226		.246		.118		.137	
R^2-change	.098		.118		.032		.052	
F-change	142.3		176.3		39.5		63.4	

-- = not included in the equation

[a] Dummy variable: coded 1 if the marketing strategy implies a cooperative company (Strategies 1, 7 or 11), coded 0 otherwise.

[b] Dummy variable: coded 1 if the farmer actually deals with a cooperative company, coded 0 if the farmer deals with a private company

The fit of both models of preference formation is clearly less in 1985 than in 1984 as is shown by both the R-square and the standard error of regression. This lower predictive validity in 1985 is due to both a smaller effect of type of wholesale company (R-square change in 1985 due to these variables is 0.086

compared to 0.128 in 1984) and, more particularly, to a smaller effect of the variables IMEA and EU, respectively. An explanation for this finding probably is that farmers expected low market prices in 1985. In their view, all strategies perform almost equally bad under these conditions (see Chapter 5). Therefore differences between strategies will be smaller in expected utility so that the correlation between expected utility and preference will be attenuated.

The most interesting feature of Table 7.5, of course, is the difference between the models in predictive validity. A comparison of fit of the expected value model and the expected utility model shows that in both years the expected utility model outperforms the expected value model. In both years the R^2 of the expected utility model is 0.02 higher than the expected value model. It is interesting to test whether this difference in R^2 between the models is significant. Steiger (1980) indicated a testing procedure concerning the significance of the difference between two 'correlated correlations' (both correlations are based on the same sample and share a variable). In Tabachnick and Fidell (1989, p. 158-160) the general procedure is described to test, with respect to multiple-R, whether one *set* of independent variables predicts a dependent variable better than another *set* (for the theoretical basis of an analogous testing procedure see Bouman (1988, especially p.242-263).

When the difference in multiple-R is tested, it turns out that the predictive validity of the expected utility model is indeed significantly higher than that of the expected value model in both years ($z = 3.15$, $p < 0.001$ in 1984 and $z = 4.11$, $p < 0.001$ in 1985). Apparently, by taking the price risk of a marketing strategy and the risk attitude of the decision maker into account, the predictive validity increases. This finding, consistent in both years, confirms the hypothesis that the expected utility model provides a better explanation of preference.

Even though the expected utility model in both years provides a significantly better fit than the expected value model, the increment in fit does not seem particularly large. A lack of reference studies makes it difficult to evaluate whether the increment in fit (increase in $R^2 = 0.02$) is less than one might expect, in this study the ordering of marketing strategies does not change very much whether solely the expected value of the probability distribution or the whole probability distribution is taken into account. Stated differently, a *linear* utility function (assuming a risk neutral farmer) predicts preferences almost equally well as a *non-linear* utility function (assuming a risk averse or risk seeking farmer).

Some further tests obtained by analyses per individual

One might wonder about the reasons for the seemingly small increment in fit of the expected utility model. Two lines of thought suggest themselves in the exploration of this issue. Firstly, it might be due to the subjective probability distributions that have been elicited. That is, differences between strategies in expected value may be relatively large compared to the differences in price risk. Consequently, the ordering of these distributions is primarily based on expected value and the ordering is hardly altered when price risk is taken into account (irrespective of the degree of risk aversion).

Secondly, how sensitive is the ordering of distributions to the degree of risk aversion? Although on average farmers were risk averse, perhaps the degree of risk aversion is relatively small so that for many farmers the concave curve can be approximated fairly well by means of a linear function. An interesting question that remains is whether, by assuming more risk aversion for all farmers, the difference in fit of the models increases. Another interesting question in this respect is whether, from the viewpoint of predictive validity, it is preferable to assess a decision maker's unique risk attitude or to assume the same risk attitude for all decision makers?

In order to gain insight into these issues, a number of analyses *per individual* have been conducted. By conducting analyses per individual attention is directed totally to within-subject effects. Table 7.6 shows sample statistics of several correlations computed per individual. For example, PREF, IMEA denotes the correlation between preference and IMEA computed over strategies per individual. Only Pearson correlations are presented. The Spearman rank order correlations were calculated too but they did not deviate much from the Pearson correlations. Correlations were calculated only when at least five data points per individual were available.

Based on correlations per individual it again turns out that the expected utility model performs better in explaining preferences than the expected value model. Table 7.6 shows that, although differences are small, the correlation between the preference rating and expected utility (correlation PREF, EU) exceeds on average the correlation between preference rating and expected value (correlation PREF, IMEA). This is found in both years of measurement.

In order to test whether the correlation between preference and expected utility significantly exceeds the correlation between preference and expected value, the *one sample t-test* for correlations should be used (Blalock 1979, p. 425). This test has to be applied *per individual*. However, in this test N-3 degrees of freedom should be used. Since the minimum number of observations per individual is 5 and the maximum number is 7, only 2 to 4 degrees of freedom would be left. Taking into account the small differences in magnitude between the correlations it is clear that it is extremely difficult to detect in this testing procedure a significant difference between the correlations per individual. Alternatively, the pairwise comparison between the correlations is analyzed *over individuals* by means of the pairwise t-test and the Sign test. The t-test was applied to the Fisher r-to-z transformed correlations.

Table 7.6 Descriptive statistics of Pearson correlation coefficients computed per individual

	Mean	Mean[a]	Percentiles 25	50	75	St.dev.[a]	% < 0
1984 (N = 180)							
PREF, IMEA	.326	.422	.052	.424	.741	.483	23
PREF, EU	.346	.446	.107	.420	.755	.470	21
PREF, EU(c = 0.12)	.354	.453	.103	.386	.750	.588	19
IMEA, EU	.978	.998	.990	.999	.999	.098	0 [b]
IMEA, ISTA	-.131	-.185	-.679	-.187	.425	.606	60
1985 (N = 137)							
PREF, IMEA	.211	.310	-.179	.255	.582	.485	33
PREF, EU	.234	.330	-.167	.267	.595	.477	31
PREF, EU(c = 0.12)	.269	.366	-.080	.323	.638	.614	28
IMEA, EU	.985	.997	.990	.998	.999	.055	0 [c]
IMEA, ISTA	.047	.076	-.561	.054	.646	.642	47

[a] After Fisher r-to-z transformation
[b] 7% of correlations is < 0.95, minimum = 0.13
[c] 6% of correlations is < 0.95, minimum = 0.41

EU Expected utility computed with the risk aversion coefficient parameter measured by the lottery technique
EU (c = .12) Expected utility computed with the risk parameter c = .12 for all farmers

Table 7.7 shows the results of these tests in both years. It is clear that the correlation between expected utility and preference significantly exceeds the correlation between expected value and preference in both years. However, Table 7.7 furthermore shows that in 1984, in no less than 40% (n = 73) of all cases the correlation between EU and preference is lower than the correlation between IMEA and preference. In 1985 this percentage is 36.5% (n = 50). Thus, for only 60% of the cases, the introduction of risk attitude results in a better fit, however small. Nevertheless, for the farmers as a group, it is shown that by taking risk attitude into account, preferences can be explained somewhat better.

It should be noted here that only the Pearson correlation coefficient is sensitive enough to detect differences between the expected value and expected utility model. The Spearman correlation coefficient, computed over the rank order of strategies provided by the farmers, resulted in a high percentage of ties: the correlation between preference and EU equals that between preference and IMEA. The percentage of ties is 82% in 1984 and in 1985 71%. Excluding the ties, two thirds of the correlations between preference and EU exceeded those between preference and IMEA.

Table 7.7 Pairwise test of expected utility model and expected value model based Pearson correlations computed per individual

	1984	1985
T-test		
t-value	2.31	2.11
p (one-tailed)	.011	.018
Sign test		
z-value	2.26	3.08
p (one-tailed)	.012	.001
N	180	137
r(PREF,EU) > r(PREF,IMEA)	104	87
r(PREF,EU) < r(PREF,IMEA)	73	50
r(PREF,EU) = r(PREF,IMEA)	3	0

r(PREF,EU) Pearson correlation between expected utility (EU) and preference (PREF)

r(PREF,IMEA) Pearson correlation between expected value (IMEA) and preference (PREF)

Although Pearson correlations show that the expected utility model outperforms the expected value model, differences between both models are small. This is illustrated further by considering the correlation between the expected value (IMEA) and expected utility (EU) of the strategy. This correlation is shown in Table 7.6 and appears to be very high. The median correlation in 1984 is 0.999 and 0.998 in 1985. The percentage of correlations lower than 0.97 is very small: 10% in 1984 and 9% in 1985. These very high correlations indicate that on the individual level for a very large portion of the decision makers the predicted preference order of strategies is hardly altered by taking price risk and risk attitude into account compared to assuming risk neutral decision makers. The ordering of marketing strategies is for most respondents fairly insensitive to the risk attitude assessed.

Two further analyses confirmed the relative insensitivity to the risk attitude. Firstly, since the risk attitude is assessed with measurement error, it was tested whether it would make a difference with respect to the prediction of preferences if the risk attitude parameter would have been higher or lower than the parameter assessed. To this end, for each individual a 10% higher and 10% lower parameter than the parameter assessed by means of lotteries is assumed and subsequently correlations between expected utilities and preference are calculated (the amount of 10% represents a relatively large measurement error because 10% is even somewhat higher than twice the average standard deviation of the parameter assessed). It turned out that the correlation computed with the 10% higher parameter is not significantly different from the correlation calculated with the 10% lower parameter. The ordering of marketing strategies is at least insensitive to measurement error present in assessing the risk attitude.

Secondly, Table 7.6 shows the sample statistics of the correlation between preference and EU(c = 0.12). EU(c = 012) denotes the expected utility that is calculated if for all farmers a risk parameter of c = 0.12 in the negative exponential function is assumed. The parameter of c = 0.12 implies a very risk averse decision maker. The parameter is three (1984) to four (1985) times higher than the mean parameter assessed in the lottery question. Compare in Table 7.6 the correlation between preference and EU with the correlation between preference and EU(c = .12). The mean correlation between preference and EU(c = .12) appears to be higher. Tested pairwise however, it turns out that the correlation between preference and EU(c = .12) is not significantly different from the correlation between preference and EU in 1984 ($p < 0.43$). In 1985 the difference in correlation is larger and almost statistically significant ($t(136) = -1.58$, $p < 0.06$, one-tailed). These findings implicate that, for the farmers as a group, the assumption of a very risk averse farmers instead of the uniquely assessed risk attitudes does not result in a significantly higher predictive validity.

With a view to the finding above, does it matter whether the risk attitude is assessed uniquely per individual or could the same parameter for each respondent be assumed equally well? Although differences are very small, the answer to this question is that it indeed does matter: the unique risk attitude performs somewhat better than assuming the same extreme risk attitude for each respondent.

This can be shown by testing the correlation between preference and expected value (PREF, IMEA) pairwise with a) the correlation between preference and EU (PREF, EU) and b) the correlation between preference and EU(c = .12) (PREF, EU(c = .12). In both pairwise tests the difference in correlations is significant but the level of significance of the t-test between expected value and a) is lower ($p = .011$ in 1984 and $p = .018$ in 1985) than the level of significance between expected value and b) ($p = .024$ in 1984 and $p = .034$ in 1985). This means that compared to the expected value model, the prediction of preference for some farmers improves when assuming the extreme risk attitude in comparison with the unique risk attitude, whereas for others it deteriorates. For example, in 1984 when using the assessed risk parameter, for 59% of the farmers the expected utility model gives a better prediction than the expected value model, whereas when assuming the same extreme risk attitude this percentage is 54%. Thus, for a lower percentage of farmers the predictive validity is higher with the assumption of the extreme risk attitude than with the assumption of the unique risk attitude (notice in this respect the larger standard deviation of the correlation between preference and EU(c = .12) compared to the deviation between preference and

EU in Table 7.6). It is therefore concluded that although the differences are very small, the risk attitude assessed by means of lotteries shows a higher predictive validity than the assumption of the same extreme risk attitude for all farmers.

Overall, the findings show the relative insensitivity of the preference ranking towards the risk attitude. This is not an entirely unexpected result. The analysis of perception in Chapter 5 already provided some indications for this finding. In Chapter 5, an analysis of stochastic dominance was presented. The elicited subjective probability distributions were compared pairwise with respect to second degree of stochastic dominance (= SSD). SSD for a pair of strategies means that the assumption of a concave utility function suffices for determining the preference order for that pair of marketing strategies. The magnitude of the risk parameter in the utility function is not important in that case. It turned out that in more than 50% of all pairwise comparisons of strategies, the risk aversion parameter does not influence the preference order, because SSD existed. With such a high percentage of pairwise dominance it is not surprising to find a small effect of risk attitude on the preference order of the strategies.

To elaborate upon this point, consider the correlation per individual between the expected value (IMEA) and price risk indicated by the standard deviation (ISTA). Table 7.6 shows that of all correlations between expected value (IMEA) and price risk (ISTA), 60% is negative in 1984 and 47% is negative in 1985. Although the correlations are fairly small for most farmers and far from -1, it still shows that for many farmers the relationship between expected value and price risk is weakly negative. This is surprising since in principle one expects a high mean price for a marketing strategy to go together with a large price risk, that is, IMEA and ISTA should be positively correlated. This positive correlation is expected because the essence of risky decision making concerns the question how much expected value the decision maker is prepared to trade-in for a reduction in risk. A negative correlation between expected value and risk means that choosing a strategy with a higher expected value goes together with a lower risk. Of course, in that case dominance between strategies exists. Apparently, many farmers perceive strategies with a high mean price to have a small risk. This explains to some extent why the expected utility model provides only a minor increase in predictive validity with respect to the expected value model.

7.3.2 The effect on predictive validity of substituting the utility function by the value function

In the former section the analysis was confined to the predictive validity of the standard expected utility model in which expected utilities were computed using the utility function. Now, the predictive validity of the utility function will be compared to that of the value function. That is, does it matter whether the risk attitude or the strength of preference is taken as evaluation function in the model?

In the standard version of the expected utility model the evaluation function is assumed to be measured by means of lotteries. Thus risk is incorporated into the measurement. In the measurement of the value function, however, no uncertainty is introduced. Consequently, it is hypothesized that the predictive validity of the expected utility model when using the utility function will be higher than the validity when using the value function. It was shown already in Chapter 6 that the utility function and value function are significantly different: the hypothesis of a relative risk attitude could not be refuted. The question here is, whether this difference between the functions affects the predictive validity and if so, whether the effect is in the hypothesized direction.

A second topic concerns the effect on predictive validity of the technique used in assessing the value function. The value function was assessed using two techniques: the midvalue splitting and the rating technique. In Chapter 6 the midvalue splitting technique was shown to be more stable and valid than the rating technique. The question here is, whether also with respect to predictive validity the midvalue splitting technique performs best.

The method of analysis uses Pearson correlations computed per individual. The expected utility of each marketing strategy is calculated per individual using the function assessed by each technique (i.e. lottery, midvalue splitting and rating respectively). Then, the correlations between preference and the respective expected utilities are computed over strategies and per individual. In this manner three correlations per individual result. Differences between correlations are tested pairwise by means of the pairwise t-test and the Wilcoxon-matched-pairs test.

Results of substituting the utility function by the value function

In Table 7.8 the descriptive statistics of the correlations per individual and the results of the pairwise tests are shown. Firstly, consider the difference in predictive validity of the utility (lottery) and value function (midvalue splitting, rating). No significant difference exists between the lottery and midvalue splitting technique (in 1984 $t = 0.03$, in 1985 $t = -0.31$). However, in both years a significant and substantial difference is found between on the one hand, the lottery and the midvalue splitting technique, and on the other hand, the rating technique. The predictive validity of both the lottery and midvalue splitting technique is much higher than that of the rating technique. The median correlation in 1984 of the lottery technique is 0.420, of the midvalue splitting technique 0.453, but for the rating technique only 0.181.

This pattern is found in both years although differences are smaller in 1985 (see the t-values). A total of 70% of the correlations between preference and expected utility computed with the lottery technique is larger than the correlation between preference and rating technique in 1984. In 1985, 58% of the correlations is larger. The same figures hold for the difference between the midvalue splitting and rating technique. However, due to the small number of pairwise observations in 1985 (n = 47) the large difference between the midvalue splitting and rating technique is only significant at p = 0.06 (one-tailed).

Table 7.8 *Descriptive statistics of Pearson correlation coefficients computed per individual between preference and expected utility, for each technique*

	Mean	Mean[a]	Percentiles 25	50	75	St.dev.[a]	% < 0
1984 (N=180)							
Lottery (neg. exp.)	.346	.446	.107	.420	.755	.470	21
Midvalue (neg. exp.)[b]	.349	.450	.094	.453	.753	.600	22
Rating (power)	.165	.217	-.146	.181	.488	.547	37
1985 (N=137)							
Lottery (neg. exp.)	.234	.330	-.167	.267	.595	.477	31
Midvalue (neg. exp.)[c]	.218	.284	-.018	.142	.515	.500	33
Rating (power)	.129	.145	-.161	.185	.404	.407	35

[a] After Fisher r-to-z transformation
[b] N = 166
[c] N = 47

Tests of significance (pairwise t-test; one-tailed)

	1984		1985	
Lottery-Midvalue	t = .03	(n.s.)	t = -.31	(n.s)
Lottery-Rating	t = 5.59	(p < .001)	t = 2.27	(p = .01)
Midvalue-Rating	t = 4.81	(p < .001)	t = 1.55	(p = .06)

Lottery (neg. exp.)	utility function/risk attitude measured by means of the lottery technique and a negative exponential function fitted to the data
Midvalue (neg. exp.)	value function/strength of preference measured by means of the midvalue splitting technique and a negative exponential function fitted to the data
Rating (power)	value function/strength of preference measured by means of the rating technique and a power function fitted to the data

The findings hint at the following conclusion. Again, as was clear from Section 7.3.1, this section shows that the ordering of marketing strategies is insensitive to the magnitude of the parameter in the negative exponential function. This can be concluded from the fact that no difference in predictive validity is found between the midvalue splitting and lottery technique, although the parameters in the negative exponential function are significantly different (see Chapter 6).

However, the ordering of strategies appears to be sensitive to the shape of the evaluation function. This is shown by the much smaller predictive validity of the rating technique (power function) in comparison with the lottery and midvalue splitting technique (both a negative exponential function). This sensitivity to the shape of the evaluation function is confirmed further by the finding of a large difference in predictive validity between the negative exponential and the power function in the lottery technique. The negative exponential function performs much better.[5] For example, in 1984 the median of the negative exponential function is 0.42 (see Table 7.8) compared to the median correlation of 0.17 of the power function.

In this study it is not possible to make a definite conclusion about the difference in predictive validity between the utility and value function (or, equivalently, between risk attitude and strength of preference). However, to say the least, the utility function performs equally well as the value function (comparison of lottery and midvalue splitting technique) or better than the value function (comparison of lottery and rating technique). Alas, since the ordering of strategies is fairly insensitive to the magnitude of the parameter in the negative exponential function, no difference can be detected between the lottery and midvalue splitting technique. However, with a view to the consistency in results in this and the previous section which all hint towards the validity of the expected utility model, would it be too optimistic to speculate that, in case of probability distributions which are more sensitive to the parameter in the function, the utility function would perform better than the value function?

7.3.3 Predictive validity of a pragmatic model of preference formation

Up until now the analysis of preference has been conducted in line with the expected utility model. The subjective probability distribution and utility/value function were combined in the normatively correct manner. It is clear that the application of the expected utility model necessitates elaborate measurements. Not only does a subjective probability distribution have to be elicited for each choice alternative, an assessment of the evaluation function also has to be made. In large scale survey research e.g. with farmers or consumers as respondents, these measurements place a great burden on part of the respondent (and researcher).

[5] This finding thus clearly enhances the validity of the expected utility model. It turns out that, firstly, it makes a difference what function specification is fitted to the assessed data and, secondly, the function that fits best (i.e. the negative exponential compared to the power function) has a substantially higher predictive validity.

One might therefore put forward the question of whether these measurements are worth the trouble. That is, is a pragmatic or naive preference model, using easier and more respondent friendly measurements, equally capable of predicting preferences as the sophisticated expected utility model? This question will be given attention in this section.

To avoid misunderstandings, it should be noted here that the comparison of the pragmatic model with the expected utility model concerns only the predictive validity of both models. This section thus concerns only an evaluation of the usefulness of the elaborate measurements of subjective probability distributions and risk attitude from the viewpoint of achieving a high predictive validity in the easiest way. Many other goals of analysis can be given which necessitate the elaborate measurement of probability distributions and evaluation functions. Many such goals have been pointed out in Chapters 5 and 6 and the analyses there showed the merits of the measurements.

Specification of the model

The most simple and pragmatic model of preference formation consists of a model in which mean price and price risk are traded-off linearly. Taking into account the type of wholesale company, the following specification of the model can be given:

$$\text{Pref}_{ij} = a + b \text{ MEAN-PRICE}_{ij} + c \text{ PRICE-RISK}_{ij} + d \text{ Company}_{j} \qquad (7.9)$$

In this model no risk attitude of a farmer needs to be assessed since the parameters b and c concern the trade-off between expected value and price risk. If the preference is known, then these parameters can be estimated by means of regression analysis.

In this study two measurements for MEAN-PRICE respectively PRICE-RISK are available (see Chapter 5). Price perception was measured by means of two techniques: a direct questioning technique and an indirect questioning technique. The direct question consisted of a magnitude estimation of risk and a direct question to assess the mean price farmers expected to receive with a marketing strategy. The respondents responded fairly easily and quickly to both questions. The indirect questioning procedure consisted of the elicitation of a subjective probability distribution. From this distribution mean price and the standard deviation of price are computed. These measurements enable us to compare the predictive validity of both measurement procedures.

In the *direct measurement* version of the pragmatic model, price risk is represented by the measurement obtained by magnitude estimation (denoted by RISK). Except for a centering of data per individual, the raw data of the magnitude estimation will be used. The direct measurement of mean price is denoted by

DMEA. Taking into account the effect of the type of wholesale company the farmer actually deals with (denoted by the variable $COOP_i$), the following specification results.

$$Pref_{ij} = a + b\ DMEA_{ij} + c\ RISK_{ij} + + d\ Company_j + e\ COOP_i + f\ COOP_i{*}Company_j \qquad (7.10)$$

$i = 1, 2, \ldots, n$
$j = 1, 2, \ldots, m$

where:

$Pref_{ij}$ is the preference rating for marketing strategy j by farmer i,

$DMEA_{ij}$ is the perceived mean price of marketing strategy j for farmer i (directly assessed),

$RISK_{ij}$ is the perceived price risk of marketing strategy j for farmer i (directly assessed),

$Company_j$ is a dummy variable that indicates whether marketing strategy j implies selling to a cooperative company (coded 1) or to a private company (coded 0)

$COOP_i$ is a dummy variable indicating the type of wholesale company farmer i actually deals with (coded 1 if he deals with a cooperative and 0 if he deals with a private company),

$Company_j{*}COOP_i$ is the multiplication of the dummy variables $Company_j$ and $COOP_i$, which represents the interaction effect.

In the *indirect measurement* version of the model the expected value of the subjective probability distribution (denoted by IMEA) and the standard deviation (denoted by ISTA) will be used.

$$Pref_{ij} = a + b\ IMEA_{ij} + c\ ISTA_{ij} + + d\ Company_j + e\ COOP_i + f\ COOP_i{*}Company_j \qquad (7.11)$$

The indirect measurement model should outperform the direct measurement model in prediction. In Chapter 5 it became clear that indirect measurement is much more difficult to carry out with respondents than simple direct measurement. To be worth the extra trouble of measuring the subjective probability distributions, the indirect measurement should show a substantially larger fit.

Preferably, with respect to predictive validity, one should make a direct comparison of Models 7.10 and 7.8: a comparison of the pragmatic model with the standard expected utility model. However, the predictive validity of Model 7.10 is biased upwards since in 7.10 an estimate of risk attitude is obtained by maximizing the fit of the model whereas in Model 7.8 the risk attitude is assessed. A fair comparison between the models could be obtained by applying a jackknifing procedure. Such a procedure was deemed too complicated and costly to be used here, so that it was decided to obtain an approximation of the model comparison by contrasting Models 7.10 and 7.11.

Method of estimating the models

Regression analysis over individuals is applied to estimate the Models 7.10 and 7.11, analogous to the procedure used to compare the expected value and expected utility model in Section 7.3.1. Again, as in the model presented in that section, an interaction effect between the type of wholesale company implied in the strategy and the type of wholesale company farmers are dealing with is included. Also, the data were centered per individual. In the regressions a linear trade-off is assumed between, on the one hand, DMEA and RISK, on the other hand, IMEA and ISTA. This assumption of linearity has been checked by including $RISK^2$ respectively $ISTA^2$ in the respective models. The inclusion of these variables did not significantly increase the fit of the models.

To enable a comparison between both models in each year, the same observations (respondents and marketing strategies) have been used. This leads to $N = 951$ observations in 1984. Only $N = 292$ observations are available in 1985, since the indirect and direct measurement of price perception were measured for only a portion of the respondents.

Results

In Table 7.9 the results of the four regressions are shown. All variables are significant at the significance level $p < .001$, except the variable RISK in 1985 for which $p < .03$ (one-tailed). Also, all effects are in the hypothesized direction.

Not surprisingly, recalling the results of the former sections, the overall fit of the models (indicated by R^2 and the standard error) in 1985 is less than the fit in 1984. Since the R^2 due to the effect of the type of wholesale company is almost equal in both years ($R^2 = .118$ in 1984 and $R^2 = .103$ in 1985), the lower R^2 in 1985 of the complete model is totally due to the lower correlation of preference with the variables mean price and price risk. For example, the partial correlation of preference and IMEA is .349 in 1984 and .177 in 1985.

Table 7.9 *Predictive validity of the indirect and direct measurement technique of price perception (regression over individuals; preferences measured on a 7-point scale, with 7 = very positive)*

	1984				1985			
	INDIRECT[1]		DIRECT[2]		INDIRECT[1]		DIRECT[2]	
VARIABLES	Regr. coeff.	*Beta*	Regr. coeff.	*Beta*	Regr. coeff.	*Beta*	Regr. coeff.	*Beta*
Constant	.182		.215		.158		.160	
1. COOP[a]	-.490	*-.148*	-.632	*-.191*	-.850	*-.218*	-.914	*-.234*
2. Company[b]	-.684	*-.219*	-.686	*-.220*	-.456	*-.136*	-.422	*-.126*
3. Company*COOP	2.151	*.473*	2.191	*.482*	2.603	*.399*	2.439	*.372*
4. IMEA/DMEA	.222	*.330*	.100	*.188*	.124	*.189*	.143	*.224*
5. ISTA/RISK	-.122	*-.128*	-.010	*-.260*	-.117	*-.182*	-.004	*-.101*
R^2	.234		.207		.140		.157	
St. error	1.35		1.38		1.47		1.46	
N	951		951		292		292	
Partial correlation								
r(Pref,IMEA/DMEA)	.349		.186		.177		.233	
r(Pref,ISTA/RISK)	-.143		-.257		-.171		-.108	
History of R^2								
R^2 (vars. 1,2,3)	.118		.118		.103		.103	
R^2 (vars. 1,2,3,4)	.218		.141		.114		.147	
R^2 (vars. 1,2,3,4,5)	.234		.207		.140		.157	
F-change (var. 5)	19.6		78.5		8.5		3.4	

1 **Indirect model includes IMEA and ISTA (see 7.11)**
2 **Direct model includes DMEA and RISK (see 7.10)**

a **Dummy variable coded 1 if the marketing strategy implies a cooperative company, coded 0 otherwise.**
b **Dummy variable coded 1 in case of a cooperative farmer, coded 0 in case of a private farmer.**

In accordance with the finding that the expected utility model outperforms the expected value model, in all four models fitted here, price risk significantly influences preferences. The coefficients of ISTA and RISK are in the hypothesized direction and significantly different from zero. In three instances, however, the increases in fit due to price risk are not particularly large. The fairly large contribution of RISK to the direct model of 1984 is an exception in this respect.

When comparing the predictive validity of the direct and indirect model, inconsistent results show up between both years. R^2 of the indirect measurement model is larger than the direct measurement in 1984 as hypothesized (0.234 compared to 0.207). The reverse, however, is shown in 1985 (0.140 compared to 0.157). In 1984, the difference in predictive validity is significant ($z = 1.36$, $p < 0.08$, one-tailed), in 1985 the difference is not significant ($z = -0.60$). (It should be noted that in 1985 only a subset of the respondents was included in the analysis, which might influence the results).

Furthermore, the contribution of the mean price respectively price risk in predicting preference is different in both years (see the partial correlations and changes in R-square). In the indirect model of 1984 IMEA is more important than ISTA, whereas RISK is most important in the direct model (RISK contributes 6.6% in variance whereas ISTA contributes only 1.6%). In contrast, IMEA and ISTA are equally important in the indirect model in 1985, whereas now DMEA provides the largest contribution to the direct model and RISK hardly correlates, although significantly ($p < .03$), with preference. These differences between the two years prevent generalizations about the contributions of the two components.

Since differences in fit between the models are small in both years, it seems most appropriate to conclude that predictive validity does not differ between both measurement techniques. It is therefore concluded that from the viewpoint of explaining preference, measuring subjective probability distributions does not seem worth the trouble. In this study, very simple direct techniques explain preferences equally well and should therefore be preferred.

It can be concluded further that in explaining preferences, price risk does contribute significantly in the hypothesized direction but this contribution is fairly small. These findings confirm the conclusions in the former section: price risk does indeed influence preferences but this influence is not substantial.

7.4 Relationship between the characteristics of a farmer and his preference for a marketing strategy

Farmers differ in their evaluation of marketing strategies. The same marketing strategy can be evaluated very positively by some farmers, and very negatively by other farmers. The question is whether there are variables describing farmers that can explain these differences. Such an analysis provides information about who likes or dislikes a particular marketing strategy and thus can be beneficial in decisions concerning e.g. market segmentation or product positioning.

Selection of variables

A number of characteristics of farmers are available in this study that can be expected to show a relationship with the preference for a marketing strategy. The most interesting variable in this respect is the *risk attitude* of a farmer measured by the lottery technique. For example, in Chapter 5 it was concluded that selling 100% at spot market prices (Strategies 4 and 6) were perceived as very risky strategies, whereas e.g. the 100% fixed-price contract was considered low in price risk. It is thus expected that highly risk averse farmers will evaluate Strategy 3 more positively and Strategies 4 and 6 more negatively than moderately risk averse farmers.

A second important variable is the *type of wholesale company* the farmer actually deals with. Already in Section 7.2 significant differences in preference showed up between cooperative and private farmers. Other variables for which the relationship with preferences will be analysed are the *level of education* of the farmer, his *age*, the *region* his lives in and his ancestors *region of descent*.

Two situational factors that might influence preferences are the percentage of arable land the farmer allocates to ware potatoes (*the cultivation intensity*) and his usual *moment of delivery*. It is hypothesized that a farmer with a high intensity of potatoes, whose income is therefore very much dependent upon the results obtained with potatoes, will prefer relatively safe marketing strategies. The moment of delivery is expected to influence particularly the preferences for pooling and spot market strategies. If a farmer, because of the quality of his storage facilities, has to deliver early in the selling season, say before January, he has not much flexibility in timing his spot market sales. For example, in case of low prices early in the season he has no opportunity to wait and see if it gets better. Or, if he wants to reduce risk by spreading his sales, then he has a very limited time interval to do so. In these cases pooling is an ideal strategy because, although the farmer delivers early in the season, the price he receives for his potatoes is the average price calculated over sales which are spread out over the total selling season. We therefore expect that farmers delivering early in the season will evaluate pooling strategies more positively and spot market strategies more negatively than farmers who deliver towards the end of the season.

Method of analysis

The analysis is conducted per marketing strategy by means of regression analysis. That is, the preference rating (centered per individual) of a particular strategy is the dependent variable and the characteristics of farmers and their farming situation are taken as independent variables. Since preference ratings are available for 13 strategies in 1984 and 18 strategies in 1985, a total of 31 regression analyses is performed. In each regression a series of specifications were checked in order to arrive at a final model.

All independent variables, including the interval scaled variables like age and risk attitude, are recoded into one or more dummy variables. This is done because it increases the flexibility of the model since also non-linear relationships between independent and dependent variables can be handled. For example, a parabolic relationship between age and preference exists in case middle aged farmers prefer a particular strategy more than do both young and old farmers. Secondly, the use of dummy variables somewhat simplifies the interpretation of effects. All interval scaled variables are coded into two dummy variables so that three levels of the variables are distinguished. With respect to risk attitude the farmers are classified into three classes (low, medium and high risk averse) in such a way that the classes contain respectively 25%, 50% and 25% of the farmers.

In all regressions the first order interaction effects between the independent variables have been checked. Only a few of these interactions appeared to be significant.

Results concerning the relationship between farmer characteristics and preference

In Table 7.10 the results of the regression analyses per marketing strategy are shown. The presentation and discussion here is limited to the 13 strategies of 1984 since the pattern of effects in 1985 turned out to be fairly comparable to that in 1984. In Table 7.10 the regression coefficients of only the significant variables are presented ($p < 0.05$, one tailed). For ease of presentation no t-values are given. However, when one is interested in the importance of effects, the rank order of the coefficients is similar to the rank order of t-values.

To illustrate the interpretation of the results in the table, here the findings with respect to marketing Strategies 1 and 4 will be discussed elaborately.

Five variables are significantly related to the preference rating of 100% pooling at a cooperative company (Strategy 1). These variables are: the type of wholesale company the farmer deals with, the moment of delivery, the region, the age and the level of education of the farmer. The regression coefficients in Table 7.10 show that cooperative farmers rate this strategy on average 2.08 higher than do private farmers. This is a substantial difference on the 7-point rating scale. As hypothesized, farmers who have to deliver early in the selling season (September to December) evaluate the 100% pooling more positively than farmers delivering late in May to July (a difference of 1.06). Also, farmers who deliver in January-March are on average more positive than farmers delivering late in May to July (a difference of 0.57).

Two regions are differentiated: the older polder (NOP) and the new one (OF) (see Chapter 2). It turns out that farmers living in the NOP-polder are on average *less* fond of 100% pooling at a cooperative company than farmers living in the OF-polder (a difference of 0.83). With respect to age it turns out that old farmers (> 50) evaluate 100% pooling more positively than farmers younger than 50. Finally, medium and highly educated farmers evaluate the strategy more positively than lowly educated farmers. For both age and level of education no differences show up between, respectively, young and middle aged farmers or between highly and medium educated farmers. Taken all variables together the R^2 is 0.46 which is fairly high and the highest of all strategies.

The preference for 100% spot market, selling at one moment (Strategy 4) is significantly related to four variables: the type of wholesale company the farmer deals with, the moment of delivery, the region the farmer lives in and the risk attitude of the farmer. It turns out that private farmers, farmers delivering late in the season and farmers in the NOP are more fond of this strategy.

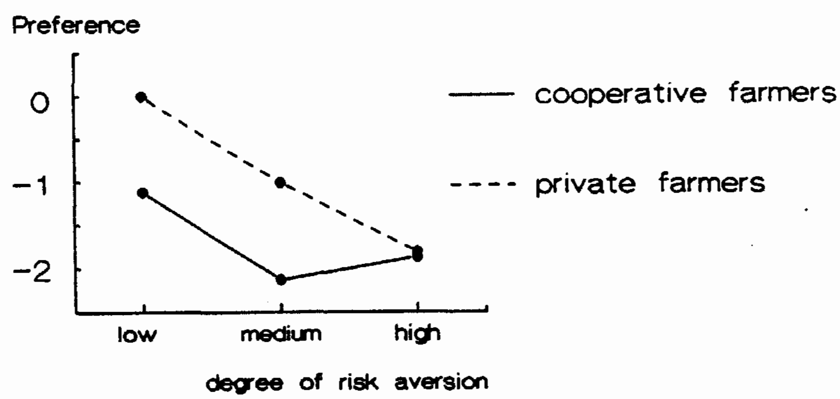

Figure 7.2 *Effect of risk attitude on preference for 100% spot market strategy, shown separately for cooperative and private farmers.*

The total effect of risk attitude on preference is a combination of variables 'Averse-medium', 'Averse-high' and the interaction of risk attitude and type of wholesale company (Comp*Averse-medium). Figure 7.2 shows the combined effect of these variables. The effect of risk attitude on preference is profound: both types of farmers evaluate 100% spot market more negatively when they are more risk averse. Overall, private farmers evaluate 100% spot market more positively than do cooperative farmers, except highly risk averse private farmers. In contrast with private farmers, for cooperative farmers no difference in evaluation exists between medium and highly risk averse farmers (this is implied in the positive interaction effect of Comp*Averse-medium). The R^2 of the regression is 0.21 which is substantially lower than the R^2 of the 100% pooling strategy.

In the same manner the results with respect to the other strategies could be described using Table 7.10. We will not perform this description, but alternatively discuss a number of findings per variable over strategies.

Firstly, consider the effect of *risk attitude* on preferences (see Table 7.10). Clear and large effects of risk attitude show up with three marketing strategies: the 100% fixed-price strategy (Strategy 3) and both 100% spot market strategies (Strategies 4 and 6). The effects show up in the expected direction. With the fixed-price contract more risk aversion induces a higher preference; with the

100% spot market strategies more risk aversion induces a lower preference. From the viewpoint of amount of price risk these strategies are most extreme: the fixed-price is perceived as least risky and 100% spot market as most risky.[4] Apparently, the preference for the strategies which are extreme in price risk (either with very small or with very large risk), is clearly influenced by the risk attitude, whereas the risk attitude does not influence preferences for strategies which are mediocre in price risk. The risk attitude is not particularly relevant in inducing differences in preference between the strategies which are mediocre in price risk, probably because farmers perceive only minor differences in expected price and price risk for these strategies.

It should be noted here that in 1985 an effect of risk attitude is only present for two marketing strategies, namely Strategies 3 and 13. No significant effect of risk attitude shows up with respect to the 100% spot market strategies.

Secondly, with respect to the effect of *moment of delivery* the following can be concluded (see Table 7.10). The clearest effects show up for the 100% pooling strategies (Strategies 1 and 5). Farmers who, due to the quality of their storage facilities, have to deliver early in the season, show a high preference for 100% pooling strategies. This effect is in the hypothesized direction: the opportunity of delivering (and selling) later in the season invokes a lower preference for these 100% pooling strategies. Also bottom-price and fixed-price contracts (Strategies 2, 3 and 13) are evaluated more positively by farmers who deliver early in the season. In 1985 comparable results were found.

For the remaining marketing strategies which all imply selling all or a part of the harvest at the spot market, the preference of farmers delivering later in the season is more positive than the preference of farmers delivering early in the season. This effect is found in both years although in 1985 the effect of moment of delivery is quite large only for Strategy 4 (100% spot market selling at one moment). It should be noted that most often only a difference exists between delivering in September-December and delivering in May-July. Few effects are found between delivering in January-March compared to May-July.

To summarize the findings with respect to moment of delivery: pooling, bottom-price and fixed-price contracts are especially attractive to farmers very limited in their selling opportunities at spot market prices, namely farmers who have to deliver in September-December. Farmers delivering later in the season are more attracted to the spot market. Therefore it is concluded that the moment of delivery does have a significant effect in the hypothesized direction. The internal validity of the preference measurement is enhanced by this finding.

The effect of *type of wholesale company* is clearly shown in Table 7.10. The effects of this variable, however, were already discussed elaborately in Section 7.2 and will not be repeated here.

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[4] Very risk averse farmers also evaluate Strategy 13 more positively. This strategy is perceived as the second least risky strategy.

Table 7.10 ***Relationship between preference and characteristics of a farmer obtained by regression analysis per strategy (regression coefficients; $p < .05$, one-tailed); high score = very positive)***

STRATEGY	1	2	3	4	5	6	7	8	9	10	11	12	13
STRATEGY NAME	100% Pc	100% Bp	100% Fp1	100% Sm1	100% Pp	100% Sm2	50%Pc 50%Sm1	50% Bp 50% Sm1	50% Fp1 50% Sm1	50% Pp 50% Sm1	50% Pc 50% Sm1	50% Fp1 50% Sm2	50% Fp1 40% Bp 10% Sm1
VARIABLES													
Constant	-1.12	-.12	-.71	.48	-.58	.94	-.56	.60	.58	-.03	.02	.75	.38
Company	2.08	-.30	--	-1.12	.40	-.90	1.49	-.83	-.58	-.26	1.10	-.43	-.73
Del-Sept/Dec	1.06	.59	--	-.57	1.24	--	-.51	--	-.66	-.50	--	-.53	.48
Del-Jan/April	.57	--	.35	--	.36	--	--	-.40	--	--	--	--	--
Averse-medium	--	--	.57	-1.01	--	-.60	.34	--	--	--	--	--	--
Averse-high	--	--	.94	-1.81	--	-.99	--	--	--	--	--	--	.44
Region	-.83	--	--	.45	-1.04	--	-.53	.30	.23	--	--	.29	--
Int-low	--	--	--	--	--	--	--	-.55	--	.36	--	--	--
Int-medium	--	--	.51	--	--	--	-.33	--	--	--	-.48	--	--
Age-young	-.64	--	--	--	--	--	--	--	.49	--	--	--	--
Age-middle	-.58	--	--	--	--	--	--	--	.48	.32	--	--	--
Educ-medium	.69	--	--	--	--	-.58	.47	--	--	--	-.41	--	--
Educ-high	.70	--	--	--	--	--	.46	--	--	--	--	--	--
Desc-North	--	--	--	--	.49	--	--	--	--	--	--	--	--
Desc-S/W	--	--	--	--	.50	--	--	--	--	--	--	--	--
Comp*Region	--	--	--	--	--	--	.58	--	--	--	--	--	--
Comp*Averse-medium	--	--	--	--	--	--	-87	--	--	--	--	--	--
Comp*Averse-high	--	--	--	1.06	--	--	--	--	--	--	--	--	--
R^2	.46	.03	.11	.21	.22	.16	.30	.17	.16	.09	.27	.07	.09
N	220	219	218	220	217	206	219	218	220	215	192	192	205

Company	type of wholesale company the farmer deals with (1 = cooperative; 0 = private)
Del-Sep/Dec	moment of delivery (1 = September-December; 0 = other) (basis = May-July)[1]
Del-Jan/April	moment of delivery (1 = January-April; 0 = other) (basis = May-July)
Averse-medium	degree of risk aversion (1 = medium risk averse; 0 = other) (basis = lowly risk averse)
Averse-high	degree of risk aversion (1 = highly risk averse; 0 = other) (basis = lowly risk averse)
Region	region the farmer lives in (1 = NOP; 0 = OF)
Int-low	intensity of potato cultivation (1 = $\leq$ 19% ; 0 = other) (basis = $\geq$ 33%)
Int-medium	intensity of potato cultivation (1 = 19% < x < 33% ; 0 = other) (basis = $\geq$ 33%)
Age-young	age of the farmer (1 = < 35 year; 0 = other) (basis = > 50 year)
Age-middle	age of the farmer (1 = 35 $\leq$ x $\leq$ 50 year; 0 = other) (basis = > 50 year)
Educ-medium	level of education of the farmer (1 = medium; 0 = other) (basis = low)
Educ-high	level of education of the farmer (1 = high; 0 = other) (basis = low)
Desc-North	region of descent of former generation of farmer (1 = North; 0 = other) (basis = East)
Desc-S/W	region of descent of former generation of farmer (1 = South or West; 0 = other) (basis = East)

1 Basis refers to the reference category if both dummy variables: DEL-Sep/Dec and DEL-Jan/April are included in the regression.

With respect to the other variables some isolated effects show up. The most important results are discussed. Most often the *region* shows an effect. Effects are present especially for 100% pooling and 100% spot market selling at one moment (Strategies 1, 4 and 5). Farmers living in the NOP-polder are less enthusiastic about the 100% pooling strategies than farmers from the OF-polder, whereas the OF-farmers prefer 100% spot market selling less than the NOP-farmers. The actual choice behavior of farmers confirms these preferences (Smidts 1985). For example, in 1983 41% of the farmers in the NOP sold more than 85% of their harvest at spot market prices, whereas only 16% of the farmers in the OF-polder did so. In contrast, only 18% of the farmers in the NOP sold all or part of their harvest by means of pooling, whereas in the OF-polder 58% of the farmers chose pooling.

Explanations for these effects of region on preferences are hard to give. Since differences in e.g. risk attitude, age, level of education, potato cultivation intensity between the polders are controlled for, these variables cannot explain the difference in preference. One might speculate that, since contract forms like pooling are fairly new, farmers living in the older polder (NOP) are more habituated to the more traditional spot market selling. Consequently, the adoption of marketing strategies other than spot market selling could be slow. Farmers living in the newer polder (OF) perhaps required less risky marketing strategies when they settled in the polder and started their farming. At that time contract forms like pooling were available. Also, the private wholesale companies in the NOP might be relatively less active in introducing and promoting e.g. pooling contracts than the wholesale companies in the newer polder. The wholesale companies in the NOP are more used to spot market selling, too.

Potato cultivation intensity, age and level of education show significant effects on preference for some marketing strategies. For example, age and level of education influence preferences for the 100% pooling strategy (Strategy 1). These effects were already discussed above. Overall, however, the effects of these variables are fairly small and not very consistent over strategies. These variables are therefore fairly unimportant in explaining differences in preference.

The percentage of variance in preference ratings explained by the characteristics of farmers are highest for the three strategies implying selling to a cooperative company. The R-squares in 1984 of these strategies are 0.46 (Strategy 1), 0.30 (Strategy 5) and 0.27 (Strategy 11). In 1985 these figures are 0.42, 0.26 and 0.26 respectively. Also the R-squares of Strategies 4 and 5 are above average. This means that the characteristics of farmers are most useful in guiding market segmentation for these three to five strategies.

To summarize, the analysis of the relationship between background characteristics and preferences for marketing strategies showed important effects in the hypothesized direction of: the risk attitude of the farmer, the type of wholesale company the farmer deals with, the moment of delivery and the region. Small and isolated effects were found for variables like age and level of education of the farmer. Effects of risk attitude most clearly showed up with strategies which are extreme in price risk, namely the fixed-price contract and 100% spot market sales. For strategies with an intermediate level of price risk no effects of risk attitude showed up.

7.5 Summary and conclusions

The main finding in this chapter concerns the confirmation of the hypothesized model of preference formation. The results indicate that preference for a marketing strategy is dependent upon two attributes: the probability distribution of *price* farmers associate with a marketing strategy and the *type of wholesale company* used in the strategy.

Furthermore, it was shown that taking the whole subjective probability of price into account in accordance with the expected utility model yields a significantly higher predictive validity than taking solely the expected value of the probability distribution of price into account. Stated differently, price risk of a strategy and risk attitude of a farmer influence the preference for a marketing strategy. Price risk and risk attitude are relevant for explaining farmers' preferences for marketing strategies and for improving predictive validity. The results mentioned are consistent over the years. Although the predictive validity of the preference formation model is lower in 1985 compared to 1984, in both years the expected utility model shows a higher predictive validity than the expected value model.

A further finding concerns the relative insensitivity of the preference order predicted by the expected utility model to the degree of risk aversion. The assumption of a 10% larger or 10% smaller parameter in the utility function than the one assessed by means of the lottery technique did not affect the order of strategies. Also, assuming a large parameter for all farmers, implying very risk averse decision makers only affected the preference order to a small degree. For some farmers predictive validity improved, for others it decreased. Overall, the predictive validity of the model did not significantly improve. On the contrary, indications were found that the risk attitude assessed by means of lotteries performed somewhat better than assuming the same extreme risk averse risk attitude for all farmers.

With respect to the effect of the marketing channel it was found that the influence of the type of wholesale company on preference is mediated by the farmer's actual choice of type of wholesale company. That is, farmers actually dealing with a private wholesale company prefer, on average, the marketing strategies supplied by a private company to strategies supplied by a cooperative company, irrespective of the strategy's probability distribution of price. In a similar vein, this result applies to farmers actually dealing with a cooperative company. This finding hints towards a two-stage decision process: in the first stage, the farmer chooses the type of wholesale company and in the second stage the farmer ranks marketing strategies on the basis of the attribute price.

In this study we found that the difference in predictive validity between the expected utility and expected value model, although significant, is relatively small. One can speculate why this is the case here. The main reason for the small difference between the models and also for the insensitivity of predictive validity to the magnitude of the risk aversion coefficient in the utility function, should be sought in the farmers' price perception.

In Chapter 5, the analysis of perception showed a high percentage of pairwise second degree of stochastic dominance between the strategies. This implies that a concave utility function suffices for ranking the strategies. The magnitude of the risk aversion coefficient is not important in those cases. Analyses of the subjective probability distributions showed that for about 50% of the farmers a negative correlation, computed on the individual level, is found between the expected value and the standard deviation of a strategy. A negative correlation will result in dominance between strategies. In cases of dominance between the strategies, the rank order of strategies predicted by the expected utility model will be equal to that predicted by the expected value model.

Considering these findings with respect to price perception, it is even more noteworthy to find that the expected utility model performs significantly better than the expected value model in both years. A data set with less stochastic dominance would most likely have yielded a larger difference in fit between the models.

A second topic that has been dealt with in this chapter concerns the difference in predictive validity between the utility function (risk attitude) and value function (strength of preference). It was hypothesized that the utility function assessed by means of the lottery technique would perform better than a value function assessed by means of riskless techniques, i.e. the midvalue splitting and rating technique.

This hypothesis was only partly confirmed: no significant difference in predictive validity showed up between the lottery and midvalue splitting technique but both these techniques performed better than the rating technique. Firstly, this result confirms the findings in Chapter 6 concerning the validity of the rating technique. In that chapter the rating technique was judged less reliable and valid in assessing evaluation functions than both the lottery and midvalue splitting technique. In this chapter the predictive validity of the rating technique is shown to be inferior, too. Secondly, this result confirms once more that in this study the predictive validity is fairly insensitive to the magnitude of the parameter in the evaluation function. For both the lottery and the midvalue splitting technique this evaluation function concerns a negative exponential function. In Chapter 6 the parameter of this function was proven to differ significantly between the techniques. The high degree of stochastic dominant subjective probability distributions, however, prevents a proper testing of the difference in predictive validity of the lottery and midvalue splitting technique. The issue of the difference in predictive validity between risk attitude and strength of preference therefore, can therefore not be resolved with the data set in this study.

A further conclusion that can be drawn from the results concerns the recommendation of the lottery technique in assessing evaluation functions. Firstly, in Chapter 6 our judgment of the lottery technique was more positive than that of the midvalue splitting technique. Secondly, the predictive validity of the lottery technique is at the least equal to that of the midvalue splitting technique. We would therefore prefer to use the lottery technique in studies in which, for whatever reason, only one assessment technique can be applied. Of course, the general recommendation is to apply more than one assessment technique whenever possible. In the latter case the midvalue splitting technique should be considered the next best alternative after the lottery technique. The rating technique is considered the least appropriate technique in assessing evaluation functions.

A third issue concerned the predictive validity of a pragmatic model. In this model, mean price (expected value) and price risk are combined in a linear additive manner. Two versions of this model have been compared. The direct measurement version utilizes perceptions of mean price and price risk obtained with simple and quick direct questioning techniques. The indirect version uses expected value and standard deviation which are drawn from the elicited subjective probability distributions. This indirect version thus necessitates much more elaborate measurements than the direct version. In order to be worth this extra effort the predictive validity of this indirect model should be higher.

Firstly, it is found that in both versions, both mean price and price risk significantly influence preferences for marketing strategies. The statistically significant effect of price risk is in agreement with the finding that the expected utility model outperforms the expected value model. Secondly, the findings indicate that the indirect and direct model perform more or less equally well with respect to predictive validity. From a pragmatic point of view therefore the straightforward direct measurements should be preferred to eliciting subjective probability distributions. These direct measurements are much easier and less time-consuming on the part of both the respondent and analyst. In case decisions under risk of a large number of decision makers e.g. if consumers are modeled, such a pragmatic approach seems appropriate considering the findings in this study.

However, before definite conclusions can be drawn in this respect, more studies are certainly needed in which explicit comparisons are made between the sophisticated expected utility model and naive or pragmatic preference formation models to confirm or refute the findings in this study. Of course, in case predictive validity is not the sole goal of an analysis, the expected utility model is much more appropriate to describe and model the decision making process than some pragmatic model.

Finally, the analysis of the relationship between the preference for a marketing strategy and the characteristics of farmers and their farming situation yielded interesting results. The most important variables affecting preferences are: the farmer's risk attitude, the type of wholesale company he deals with, his usual moment of delivery and the region he lives in.

The effects of risk attitude are in the expected direction and were shown to be most influential if strategies with an extreme price risk were concerned. That is, both for strategies with very small price risks and for strategies with large price risks, the risk attitude is clearly related to the farmers' preferences. Effects of e.g. the farmer's age and level of education were small and valid for only some strategies.

The relationship between the characteristics and the preferences was strongest with respect to pooling at a cooperative company and in case of selling the total harvest at spot market prices. For these strategies the farmers' characteristics yield most information for marketing decisions to be made by wholesale companies.

CHAPTER EIGHT

MAJOR FINDINGS AND CONCLUSIONS

This study is concerned with decision making under risk. The three main objectives of the study are: a) to review and discuss a number of theoretical notions on individual decision making under risk; much attention is specifically given to the definition and empirical testing of the concept of relative risk attitude, b) to investigate in a large scale survey research the validity, reliability and practical feasibility of measurement procedures for measuring subjective probability distributions, risk attitude and strength of preference, and c) to develop and test empirically a model which describes the farmer's decision making process with respect to the choice of a marketing strategy for ware potatoes.

The theoretical and methodological issues in this study are analyzed in the context of a farmer's choice of a marketing strategy. A field study was conducted in which a large number of farmers (250) were interviewed three times in two consecutive years. The test-retest design of the study not only enables an analysis of the stability of the measured concepts but also provides insight into whether findings and conclusions in the first year of measurement can be replicated in the second year. In total, the data collected per farmer amount to about four hours of interviewing time. The response percentages in the three consecutive surveys and the respondents' motivation were high.

In the following three sections the major findings of the study will be presented and the main conclusions will be drawn. This chapter is structured in accordance with the three objectives of the study. Findings concerning each objective which are spread over several chapters of this book, will be brought together here in separate sections. The implications of the findings for studying decision making under risk are dealt with and with respect to each issue some suggestions for further research will be given.

8.1 Findings and conclusions with respect to the theoretical issues

Three general fields of study of risky decision making can be distinguished: utility theory, behavioral decision theory and decision analysis. We characterize the utility theory approach as 'normative, theoretical'. The focus in this approach is on how a decision maker *should* choose between risky alternatives and on deriving theoretically optimal solutions for individual and market behavior. The behavioral decision theory approach is characterized as 'descriptive, empirical'. In this field of inquiry the focus is on *how* decision makers arrive at their judgments and decisions, and on providing explanations for the deviations of those judgments and decisions from the rational models developed in utility theory. Much empirical, especially experimental research is conducted.

The third field, decision analysis tries to reconcile the efforts of the aforementioned approaches. We characterize this field as 'normative, empirical'. The main objective of decision analysis is to structure a decision problem and to select the (normatively) best alternative, given the decision maker's risk perceptions and risk attitude. Much attention is therefore paid to the procedures of the measurement of risk perceptions and risk attitudes.

In this study, theoretical and methodological notions of all three fields are used. Briefly stated, utility theory provides the fundamental normative models for analyzing individual decision making. Behavioral decision theory provides information on how effectively these models describe individual decision making and suggests alternative descriptive models. The methodology used in this study stems mainly from decision analysis.

Expected utility theory

Two models of the utility theory are extensively discussed: the expected utility models of Bernoulli and of von Neumann-Morgenstern. In both models, to choose the alternative with the highest expected utility is considered rational (Chapter 3).

An essential element in the Bernoulli model concerns the strength of preference notion. Outcomes are transformed into subjective values by means of the strength of the preference function v(x). These subjective values are seen as representing intensity of satisfaction. By introducing a decreasing marginal value function v(x), Bernoulli is able to explain risk aversion. One problem with his model concerns the question why it would be rational to choose the alternative with the maximum expected utility if the function v(x) only represents a decision maker's evaluations in *riskless* conditions? Moreover, why would it be rational to maximize expected utility?

The expected utility model of von Neumann-Morgenstern (1947) provides a solution to these problems. From a small number of compelling axioms they prove that, if one abides the axioms, it is rational to maximize expected utility. An essential difference between their model and the Bernoulli model concerns their utility function u(x), which does not represent strength of preference. U(x) describes a decision maker's evaluations in *risky* conditions since this function is measured by means of lotteries. The function u(x) represents the indifference probabilities in standard lotteries tickets. As such, it would be better to call u(x) a probability indifference function than a utility function. One problem with the model is that, since no strength of preference interpretation is given to u(x), the von Neumann-Morgenstern theory does not yield an explanation for risk aversion.

The relative risk attitude

The concept of relative risk attitude (also referred to as intrinsic risk attitude) has been introduced recently (see e.g. Bell and Raiffa 1982). We see this concept as a bridge between the Bernoulli and the von Neumann-Morgenstern model. The relative risk attitude model states that u(x) is a confounded measure of a decision maker's strength of preference and his 'true' risk attitude. In the model, the outcomes x are transformed into subjective values by means of the strength of preference function v(x). Subsequently, these subjective values are evaluated under risk to yield the utility function u(x). The relationship between the u(x) and v(x) function is called the relative risk attitude: $u(x) = g(v(x))$. Only if u(x) and v(x) are linearly related ($u(x) = a + b\ v(x);\ b >$), the models of Bernoulli and von Neumann-Morgenstern coincide. In this case, the decision maker is said to be relatively risk neutral. In case of a non-linear relationship between u(x) and v(x), the decision maker is said to be relatively risk averse (if the transformation function g is concave) or relatively risk seeking (g is convex). Risk aversion is thus seen as the effect of decreasing marginal value *plus* the aversion against the dispersion in subjective values.

Several authors, e.g. Bell and Raiffa (1982) and Sinn (1983), hypothesize that the transformation of v(x) into u(x) is governed by a negative exponential function. This function implies a *constant absolute* as well as an *increasing proportional* relative risk attitude on the part of the decision maker.

The main advantage of the concept of relative risk attitude is that a superior descriptive measure of the 'true' risk attitude of the decision maker is obtained. This relative risk attitude is considered less dependent upon the attribute under consideration or upon the specific decision context than the traditional indicator of risk attitude (i.e. the function u(x)).

Another advantage is especially relevant for modeling (multiattribute) decision making under risk of a large number of decision makers, e.g. consumers. If indeed a negative exponential function links v(x) to u(x) and if the parameter in this function does not depend upon the attribute, it would be fairly easy to transform a multiattribute value function, describing decision making under *certainty*, into a multiattribute utility function, describing decision making under *risk*. Only a small number of extra assessments would suffice. Since multiattribute value functions can be measured more easily than multiattribute utility functions, this would greatly simplify modeling decision making under risk.

The concept of relative risk attitude is not generally accepted, though. A number of authors state that v(x) and u(x) are one and the same function (i.e. a linear relationship). One group of critics defines axioms or conditions which imply a linear relationship between u(x) and v(x) For example, if strength of preference is assumed to exist for lotteries, the equivalence of the functions can be shown (Sarin 1982). The axiom of cardinal isovariance of Allais (1979) also leads to this result. Another group of critics, e.g. von Winterfeldt and Edwards (1986), claim that differences between the functions are entirely the result of method variance. Different assessment methods systematically result in differences between u(x) and v(x). As a result respondents should be urged to resolve these inconsistencies in assessment between the methods. In the view of both groups, decreasing marginal value is the sole reason for risk aversion. The standpoint of these authors, of course, implies that modeling (multiattribute) decision making under risk is even more simplified, since in their view a (multiattribute) value function can be used directly for decision making under risk.

A review of the literature shows that empirical research into the differences between u(x) and v(x) is rare. Furthermore, the results of these studies are inconclusive. In some studies method variance is found to be so large that this variance blurs possible true differences between the functions. Others only find marginal differences between the functions, whereas e.g. Krzystofowicz (1983a,b) discovered significant differences between both functions and a confirmation of the hypothesis of a negative exponential relationship.

In this study, the concept of relative risk attitude is tested empirically. Our study differs in this matter from other empirical studies in several respects. It concerns a) decision makers confronted with their own decision problem instead of hypothetical decision contexts, b) a large number of decision makers was included in the study in comparison with the small number of subjects in other studies, and c) for the first time, the stability of the concept of relative risk attitude has been analyzed and the relationship between background characteristics of the decision maker and relative risk attitude has been assessed.

In our study the relationship between u(x) and v(x) was assessed per respondent. The results clearly indicate that the hypothesis of a relative risk attitude cannot be dismissed. In both years, a significant difference was found between the strength of preference and the utility function (for the method of testing applied, see Section 6.7). Moreover, the relationship between u(x) and v(x) was described better by the hypothesized negative exponential function than by either the linear or the power function. This finding implies that the respondents exhibit a constant absolute and an increasing proportional relative risk attitude.

As a group, the respondents exhibit a slight tendency towards relatively risk seeking behavior. Whereas in 1984 the percentage of relatively risk averse respondents almost matched the percentage of relatively risk seeking respondents, the tendency towards relatively risk seeking in 1985 was larger than in 1984. In 1985 about 75% of the respondents can be classified as relatively risk seeking. This shift towards more respondents with relative risk seeking attitudes in 1985 is entirely due to a temporal shift in u(x). The strength of preference function v(x) did not shift significantly between the years. Consequently, the gap between the functions widened (for further results see Sections 6.7, 6.9 and 8.3).

The stability of the relative risk attitude is low and not statistically significant due to the significant shift in u(x). It was expected that the relative risk attitude would be a stable characteristic of the decision maker. In that case a shift of the utility function would coincide with a shift of strength of preference function. The results in our study do not confirm this hypothesis.

No clear relationships were detected between the relative risk attitude and personal or situational variables (see also Section 8.3).

From the significant difference between u(x) and v(x) it can be concluded that, in general, the introduction of risk into the decision making process induces decision makers to choose differently. Consequently, a preference formation model which incorporates u(x) should have a higher predictive validity for risky choices than a model which contains v(x). This hypothesis was tested with respect to the farmers' preferences for marketing strategies.

The hypothesis was not confirmed in this study. No significant difference in predictive validity could be detected between the models, although in 1985 the model incorporating u(x) performed somewhat better than the model incorporating v(x) (Section 7.3.2). The main reason for not finding a difference between the models is the high percentage of second degree of stochastic dominant subjective probability distributions in our data set. This precludes a proper testing of the models. The issue of the difference in predictive validity between a utility and a strength of preference function, therefore cannot be resolved with the data set in this study.

The empirical confirmation of the concept of relative risk attitude in this study indicates that it constitutes a proper link between the Bernoulli and the von Neumann-Morgenstern model. By means of the concept more insight is gained into the meaning of risk aversion. This study found that the difference between u(x) and v(x) is not merely a method effect. Our empirical research demonstrates a fundamental difference between preferences under certainty and under risk.

An implication of our results is that primarily for theoretical reasons, both risky and riskless techniques are required in assessing a decision maker's risk attitude. It is advised to apply at least one risky and one riskless technique routinely when studying decision making under risk. This refers especially to basic research in decision making under risk but we would recommend this procedure for applied research too. Moreover, even when decisions are modeled under certainty, e.g. in consumer research, it should be standard practice to use risky measurement procedures next to riskless techniques. For example, in conjoint measurement not only rank order or ratings of profiles should be obtained but also a number of probability indifference judgments (see e.g. Currim and Sarin (1983) for an example of a procedure for assessing probability judgments for job descriptions). In this way, much empirical evidence would be obtained concerning differences between strength of preference and utility functions and more insight would be obtained into the effect of risk on decision making. The concept of relative risk attitude provides an interesting agenda for research, particularly with respect to consumer decision making. This concept could be seen as a stimulation of the use of sophisticated models in consumer decision making under risk replacing the 'old' perceived risk approach.

More research is certainly needed to confirm and further expand our results. In particular, it would be interesting to study whether the negative exponential function describes the relationship between u(x) and v(x) well, irrespective of the attribute or the specific decision context. Also, models under certainty should be compared explicitly to models under risk as regards to predictive validity. Research into these topics could turn out to be very beneficial for modeling (multiattribute) decision making under risk.

Furthermore, it is necessary to investigate further whether the relative risk attitude is a more stable characteristic of a decision maker than the conventional measurement of risk attitude. In this study this hypothesis was not confirmed. Our results indicate a weakness of the concept namely that it can be assessed only indirectly via u(x) and v(x). Measurement error and changes in true score of both these sources therefore enters into the measurement of the relative risk attitude. A priori chances of finding differences between subsequent assessments of a decision maker's relative risk attitude are therefore fairly large.

The subjective expected utility model and alternative models

The subjective expected utility model of von Neumann-Morgenstern (the SEU-model) is essentially a normative model. It prescribes how a decision maker should choose given his risk perceptions and risk attitude. A review of the literature shows that as a descriptive model, it has received a lot of criticism. A host of mainly experimental psychological studies indicate that decision tasks can be designed in which decisions deviate systematically from the prescribed decisions. A review is given of the most important violations of the SEU-model.

The deviation from the normative model stimulated the development of a large number of alternative descriptive models which may account for the deficiencies of the SEU-model. The majority of these models originate from utility theory and are fairly formal. In these models, typically, one or more axioms of the original theory are weakened or replaced by some other assumption. This often implies that the utility of an outcome is made dependent upon the probability distribution, upon other feasible outcomes, or both.

In behavioral decision theory an important alternative descriptive model is developed, too. It concerns Prospect Theory (Kahneman and Tversky 1979) which incorporates as compactly as possible recent insights into the way decision makers deal with risky choices. The model is built on the basis of experiments on decision making under risk. As such, it can explain most of the deviations from the normative model. An essential element in the model is the hypothesis of a convex/concave strength of preference function which is defined on gains and losses with respect to a reference point. Another important element is the decision weight function which transforms subjective probabilities into decision weights. We noted that the decision weight function can be seen as another way of proposing the relative risk attitude. The hypothesized general underweighting of probabilities then leads to the hypothesis of, in general, relatively risk averse decision makers.

A comparison of the alternative models with the subjective expected utility model resulted in the following observations (Section 3.4). It was concluded that all these models are essentially expectancy-value models like the expected utility model. This means that utilities/values are multiplied by probabilities/decision weights and then these components are added up. This implies that any criticism on the expectancy-value nature of the expected utility model, is also pertinent to the alternative models. Another feature of the alternative models is that extra parameters are introduced. Consequently, the models are more complex than the expected utility model, more difficult to falsify, and less easily empirically tested.

Taking into account the difficulties which surround the alternative descriptive models, we concluded that within the realm of expectancy-value models, the subjective expected utility model is still the most useful model for analyzing decision making under risk, not only for normative purposes but also for descriptive purposes. Until other models are being constructed which will be able to explain and predict preferences under risk better than the SEU-model without a substantial loss on theoretical and operational tractability, the SEU-model is still a worthwhile bench-mark model and frame of reference for studying decision making under risk. Consequently, the expected utility model is chosen for modeling the farmer's decision making process in this study.

The predictive validity of the SEU-model

In order to test the predictive validity of the SEU-model, this model has been applied in this study to the preference formation of marketing strategies (Section 7.3). The predictive validity of the SEU-model was compared to the subjective expected value model (referred to as SEV-model). This latter model can be seen as a bench-mark model in which risk neutral decision makers are assumed. Analyses were conducted both *over* individuals and *per* individual.

In both years, the SEU-model outperformed the SEV-model in predictive validity. Apparently, by taking the decision maker's risk attitude into account a better explanation of preference is obtained. The increment in fit of the SEU-model relative to the SEV-model is not particularly large. A lack of reference studies makes it difficult to judge the increment in fit, but with the data set in this study a linear utility function (i.e. a risk neutral decision maker) predicts preferences almost equally well as a non-linear utility function (assuming a risk averse or risk seeking decision maker).

The most important reason for the finding that the rank ordering of choice alternatives is fairly insensitive to the magnitude of the parameter in the utility function, is the high percentage of second degree of stochastic dominance (referred to as SSD) between pairs of strategies. In 50% of all pairwise comparisons SSD existed. This means that for these comparisons the magnitude of the parameter in the concave utility function does not affect the preference order of the pair of strategies. With such a high percentage of SSD it is not surprising to find a fairly small effect of risk attitude on preference. Considering this finding with respect to price perception, it is even more noteworthy to find that the SEU-model performs significantly better than the SEV-model. A data set with less stochastic dominance would most likely have yielded a larger difference in fit between the models.

If the SEU-model is to be utilized, it is necessary to elicit subjective probability distributions (spd's). As will be concluded in the next section these elicitations are far from easy to both the respondent and the interviewer. An important question therefore is whether the predictive validity of a model using the elicited spd's is higher than a model using more simple measurements. This question is particularly relevant to survey research.

In order to analyze this topic a 'pragmatic' model of preference formation was developed (Section 7.3.3). In this model, mean price (expected value) and price risk are combined linear additively. As such, this model is in line with standard modeling practices in marketing research. A direct measurement version of this model utilizes perceptions of mean price and price risk obtained with the simple and quick direct questioning techniques. The indirect version uses the moments of the elicited spd's.

Firstly, it has been found that in both versions, both mean price and price risk significantly influence preferences for marketing strategies. This statistically significant effect of price risk is in agreement with the finding that the SEU-model outperforms the SEV-model.

Secondly, no significant difference is found in predictive validity of the models. The indirect and direct model perform equally well. From a pragmatic point of view therefore the results suggest that straightforward direct measurements should be preferred to eliciting spd's. These direct measurements are much easier and less time consuming on the part of the respondent, the interviewer and analyst. In case of e.g. large scale research in which decisions under risk are modeled, such a pragmatic approach seems appropriate considering the findings in this study. By means of direct scaling techniques an approximation of the perception of risky choice alternatives is obtained. Especially, in applied research with many respondents and many risky alternatives such an approximation might be deemed satisfactory if one accepts to forego a theoretical consistent model of decision making under risk. Of course, in case predictive validity is not the sole goal of analysis, the greater richness of the expected utility model may be an important reason to choose that model.

8.2 Findings and conclusions with respect to the methodological issues

Two observations motivated the elaborate attention given to methodological issues in this study. Firstly, the measurement procedures for the elicitation of subjective probability distributions and the assessment of risk attitude and strength of preference mainly stem from decision analysis. Typically, a decision analysis takes place in ideal measurement conditions, such as a small number of decision makers who are highly motivated, a substantial amount of time available for the interviews, one expert interviewer and so forth. However, the circumstances in a survey are much less ideal. The question therefore arises to what extent the techniques of decision analysis are feasible in these survey conditions.

Secondly, most research on validity and reliability issues is conducted in experimental settings, often conducted with students and hypothetical decision contexts. In field studies the validity and reliability of the measurement procedures has been studied much less. The field studies concerning decision making under risk that have been carried out typically involved a fairly small number of respondents, usually applied only one measurement technique in eliciting subjective probability distributions and in the assessment of risk attitudes, and in most cases these measurements took place only once with each respondent.

This study contributes to the insight into validity and reliability of the measurement of risk perception and risk attitude in survey conditions. For this purpose a multiple indicator approach has been applied in combination with a test-retest measurement. Each important concept (risk perception, risk attitude and strength of preference) has been operationalized in two ways and each respondent was interviewed twice with a year in-between. Furthermore, a large number of respondents was interviewed, enabling more statistical analyses to be made like for example causal modeling.

First, major findings and conclusions with respect to risk perception measurement are given, followed by a discussion of the results of risk attitude and strength of preference measurement.

Risk perception measurement

The task of eliciting subjective probability distributions was reviewed extensively (Section 5.2). A general assertion is that probability encoding is a difficult task and involves many errors. In order to clarify the discussion on the difficulties in probability encoding, a distinction has been made between biases and distortions. Biases refer to the systematic or random errors introduced by the elicitation technique; a difference is created between the subject's responses and his 'true' probability distribution. Distortions refer to a difference between a subject's true probability distribution (his perception) and an objective probability e.g. a relative frequency. Examples of distortions are: the gambler's fallacy, conservatism, ignoring regression towards the mean effects, etc. The distinction between biases and distortions makes it clear that many of the judgment errors in probability assessment pertain to distortions and do not necessarily refer to errors introduced by the elicitation technique.

In this study, the process of how respondents form their judgments and the possible distortions involved in this process were not studied. The attention is focused on measuring the probability judgments with a minimal bias. Important means to this end are: a clearly structured and defined decision context, sensitivity to the possible deteriorating effects of the heuristics of anchoring and adjustment, availability and representativeness and the extensive training of the interviewer.

A review of the literature indicates general stability and convergent validity of the elicitation techniques. However, these conclusions are based mainly on experimental studies in laboratory circumstances or in decision analysis and mostly concern binary distributions. Few studies exist in which these techniques are applied and evaluated with respect to validity and reliability in large scale survey research. In fact, trying to elicit several subjective probability distributions per respondent for a sample of respondents of this size, to our knowledge, is rather unique.

In this study, a representative stimulus set of marketing strategies (13 in 1984 and 18 in 1985) was created. Ideally, for each marketing strategy a subjective probability distribution (an spd) of prices associated with the strategy should be elicited. To this end, two techniques, the probability wheel and interval technique, were selected of which the suitability was analyzed in test interviews. The probability wheel technique did not work with those respondents. The respondents, however, felt comfortable with the interval technique. This technique was therefore chosen in the final study. In the interval technique percentiles of the cumulative probability distribution are elicited.

The test interviews, however, indicated that the elicitation of spd's takes ample time and respondents tend to loose interest and motivation when a large number of distributions have to be elicited. These constraints necessitated us to limit the number of elicited distributions (marketing strategies) to seven per respondent taking about 20 to 30 minutes to complete the total task.

By using the interval technique we elicited five percentiles per distribution. A lognormal and a Weibull distribution were fitted to these five data points per individual and per marketing strategy. The lognormal distribution fitted the elicitations clearly better than the Weibull distribution, in both years of measurement.

Insight into the validity of the elicitations was obtained by means of an elaborate testing of the internal consistency of the elicited distributions. In this respect, the effects on a subject's perception of moment of delivery, the number of selling moments at spot market prices and the type of wholesale company were analyzed. In both years of measurement, the effects were in the hypothesized direction. Further testing showed some systematic interviewer bias. Particularly, the elicitation of the minimum and the maximum of a distribution proved somewhat sensitive to the interviewer. This interviewer effect limits comparisons to be made between respondents. However, the effects of the interviewer were small in comparison with the hypothesized effects of moment of delivery, number of selling moments and type of wholesale company.

Taking the findings into account, it can be concluded that in both years the interval technique proved appropriate for eliciting valid subjective probability distributions in survey conditions. As far as can be tested, these elicitations yielded plausible and consistent results. It turned out to be a fairly difficult task to the respondents, too. About 15% of the respondents failed to respond to the question. Respondents had to think hard before being able to express their vague and unarticulated ideas about prices associated with a marketing strategy into quantitative judgments, especially for strategies they were less acquainted with. Consequently, a lot of time is necessary for this task. Respondents' fatigue with the task limit the number of distributions which can be elicited per respondent. Effects of boredom can probably be diminished if the elicitations are divided over the interview.

The survey context did not allow the elicitation of spd's by means of two techniques. Still, in order to gain insight into convergent validity aspects, direct techniques were applied as an additional source for information about the respondent's risk perception (Sections 5.4 and 5.5). The mean price farmers associated with a marketing strategy was asked directly and by means of magnitude estimation the price risk of a strategy was assessed. Both techniques are conventional scaling practices in social sciences, especially in marketing research (perceived risk approach). The main advantage of these techniques is that they can easily be applied in survey research. The main disadvantage is, of course, that no probability distribution is obtained, so that the expected utility model cannot be applied.

Respondents showed no difficulty in responding to the direct techniques. It took only about 4 minutes to complete each task and the nonresponse percentage with each task was very low. By testing the effects of moment of delivery, number of selling moments and type of wholesale company the internal consistency of the measurements proved to be high. A systematic interviewer bias showed up for the magnitude estimation task. Overall, it is concluded that in both years of measurement, the direct measurements provide a reasonable and consistent picture of the respondents' perceptions.

If a comparison is made between the measurements obtained by the indirect (the elicitation of spd's) and direct technique the following results come up. Firstly, when tested pairwise per respondent, the direct elicitation of mean price appears to be significantly higher than the indirect elicitation for all marketing strategies in both years. An explanation for this finding was given by pointing out the difference in focus of both questions. The direct questioning is focussed more towards the past than the indirect technique. Consequently, the heuristics of anchoring and adjustment and of availability probably have induced the higher direct estimates.

Secondly, the correspondence in measurements of both techniques can be analyzed by computing correlations per respondent over strategies. This analysis showed positive results. Significant and positive sample median correlations for mean price (0.32 in 1985 and 0.25 in 1985) and even higher median correlations for price risk (0.56 in 1984 and 0.39 in 1985) were obtained. This means that in both years to a large extent convergent validity has been established.

Risk attitude and strength of preference measurement

A review of techniques for assessing utility functions indicated a sensitivity of the measurement to response mode, the probabilities used in the lotteries, chaining, range effects and the like (Section 6.1). In the literature it is concluded that at this moment in time it is not possible to select the best technique. It is therefore advised to use a multiple of techniques to guard against the sensitivity of assessments to biases. The multiple method approach is seen as a key factor for reliable and valid assessment of utility functions, particularly in basic research.

In this study, we applied two techniques, the lottery technique and conjoint measurement, in assessing the utility function u(x) or, equivalently, the risk attitude (Sections 6.2 to 6.4). In the *lottery* technique, also often referred to as midpoint chaining or bisection technique, the respondent has to assess the certainty equivalent of a binary 50/50 lottery (a standard-gamble approach). By chaining the lotteries, a series of equivalents is obtained to which a utility function can be fitted. In test interviews the midpoint chaining technique was compared to the frequently recommended probability equivalence technique. The midpoint chaining technique was clearly judged to be the most easy technique.

In the *conjoint measurement* task the respondents have to rank a set of 50/50 lotteries with respect to preference. This task can be seen as a series of preference comparisons of binary lotteries (a paired-gamble approach). By means of regression analysis the trade-off between expected value and standard deviation is obtained. Surprisingly, conjoint measurement has not yet been routinely applied in assessing risk attitude. This technique seems particularly suitable for assessing risk attitude in survey research because it is thought to be a fairly easy and quick task for the respondent. Furthermore, e.g. in marketing research much experience is accumulated on how to conduct conjoint measurement analyses.

The strength of preference function v(x) is also measured by two techniques, i.e. the *midvalue splitting* technique and the *rating* technique (Section 6.6) . In the rating technique a number of stimuli (price levels) are rated on a scale from 0 to 10. In the midvalue splitting technique respondents have to specify a point C in such a way that, according to the respondent, a change from A to C equals in value a change from C to B (A < C < B). By appropriately chaining the assessments, a series of values is obtained to which a function can be fitted. The midvalue splitting technique to a very large extent resembles the midpoint chaining technique. A fundamental difference, of course, is that the midvalue splitting technique concerns a riskless measurement.

Two approaches were chosen to analyze the data. In what we called the utility theory approach, the focus is entirely on the utility and strength of preference functions themselves. The shape of each function, the difference in location of the functions and the functional relationship between the utility and the strength of preference function are the main points of concern. Alternatively, in the so-called latent variable approach the concepts of risk attitude and strength of preference are both conceived as a latent, that is not directly observable, variable which can be measured by means of one or more indicators. Each respondent is represented by a score on an indicator and the focus in this approach is on the correlation between respective indicators, computed over individuals. The analytical framework of LISREL is suitable in this correlational approach for analyzing the convergence and stability of assessments. The latent variable approach provides a useful supplement to the type of analyses usually performed in utility theory and decision analysis.

The four measurement techniques (lottery, conjoint, midvalue splitting and rating technique) were compared with respect to several criteria. A brief overview of the most important conclusions will be given below (Table 6.23 in Section 6.9 provides a numerical overview).

The rating and conjoint measurement task are found to be most easy to both the respondent and the interviewer. The lottery and midvalue splitting technique are more difficult in these respects. The findings obtained with the techniques indicate that all techniques yield internally consistent results.

The stability correlations differ between the techniques, but all are positive and significant. The lottery technique is highest in stability, followed by the conjoint measurement. Likewise, convergent validity correlations are all positive and statistically significant. Convergent validity of the risk attitude assessment is higher than that of strength of preference. Although, due to a lack of reference studies, the magnitude of the correlations is difficult to evaluate, to us their magnitude is judged as not particularly high, e.g. the highest correlation, between the lottery and conjoint measurement in 1984, is 0.49. These results show the danger of relying on only one measurement procedure and thus prove the necessity of applying a multiple indicator approach, even in applied research. Furthermore, it signals that more research into the concepts and their measurement has to be conducted in order to develop superior procedures.

With each technique we came across a number of response effects. The lottery technique and midvalue splitting technique assessment tended somewhat towards S-shape functions. This effect could concern a pure method effect due to the chaining of assessments and the varying range of outcomes in the assessment task. Alternatively it could be attributed to an effect of a reference point as is hypothesized in Prospect Theory. Since the effect is relatively small a method effect seems most likely. The conjoint measurement assessment appeared to be sensitive to the inclusion of sure profiles in the set of profiles, although the effects found were much smaller than expected on the basis of a comparable study. Both for the conjoint measurement and the rating task an interviewer bias was detected.

Our findings clearly indicate that in basic research into decision making under risk a multiple indicator approach should be applied. However, the elaborateness of the measurement tasks to respondent, interviewer and analyst will probably hamper the use of this approach, particularly in applied research. Most likely, a choice will have to be made between the techniques. Our results indicate that if a choice has to be made the lottery technique should be preferred. Of the four techniques, the lottery technique is highest in internal consistency and stability and at the least equal but probably somewhat higher in predictive validity than other techniques. Conjoint measurement and the midvalue splitting technique are next best choices. Overall, the rating task is judged as the least reliable and valid method of assessment. The results of this technique deviate too much from the other techniques. Further research into the methodological aspects of the measurement procedures in survey research, conducted with respect to different types of decisions and different decision makers e.g. small business managers or consumers, is needed to extend our findings.

The perception and attitude component in the SEU-model

If from methodological perspective a comparison is made between the elicitation of risk perception and the assessment of risk attitude, the following conclusion can be drawn. Our study showed that the difficulty of the spd' elicitation task to the respondent and the interviewer and the time needed for the task are definite problems in survey research. Although the assessment of risk attitude and strength of preference are also far from easy and sensitive to response effects, our experiences in this study leads us to conclude that the crux of studying decision making under risk in survey context is not so much the measurement of the utility component in the SEU-model but concerns the elicitation of spd's. This would justify much time to be spend on the elicitation of perceptions in interviews.

Possibly, part of the difficulties can be removed by using interactive computer programs in the elicitation task. This would enable more internal consistency measurements to be made, immediately following the initial elicitations. Furthermore, a combination of techniques could be used to verify the answers by any technique within a reasonable amount of time. Also, the task could probably be made more interesting by e.g. using graphic displays. We think that the availability of portable and relatively cheap computer devices will stimulate more field research to be conducted into eliciting several distributions for many respondents. Of course, the assessment of risk attitude will probably also benefit from such devices. Notwithstanding these aspects, however, the elicitation of spd's is essentially a difficult task and will continue to require hard thought on the part of the respondent and a substantial amount of interviewing time, irrespective of the method applied.

8.3 Findings and conclusions with respect to the farmers' marketing behavior

In the agricultural economics literature, risk is given much attention to. Most of this attention concerns total farm planning, e.g. the derivation of optimum cropping plans, or concerns specific production decisions like fertilizer input decisions and pest management. The major part of these analyses is theoretical or involves simulations. Far less studies concern empirical research into the farmers' decision making under risk. Little empirical research deals with the farmers' marketing behavior under risk. In this study, this marketing decision making has been paid attention to.

The decision problem in this study concerns a farmer's choice of a marketing strategy for ware potatoes (Chapter 2). Of the crops grown at a typical farm in the region in which this study took place, ware potatoes contribute most to the farmers' income. However, the gross margin of ware potatoes is highly variable. This variability is mainly due to variability in market prices for potatoes. By means of the marketing strategy the farmer can respond to the substantial variability in ware potato prices.

A marketing strategy is defined here as a) a farmer's choice of a marketing channel, b) given this channel choice, his choice of allocating the harvest to selling-options and the timing of selling, and c) his choice of a moment of delivery. Examples of selling-options open to the farmer are: a fixed-price contract (16%), a bottom-price contract (5%), a pooling contract (36%) and selling at spot market prices (42%); the market share is given between brackets (computed on kgs. of harvest in 1983 (Smidts 1985)). Typically, farmers choose a combination (portfolio) of selling-options e.g. 35% of harvest is sold via a fixed-price contract and 65% via spot market sales.

We conceived the marketing strategy as a multiattribute alternative. In structuring the decision problem it was concluded that ultimately only two attributes are seen as relevant in modeling preferences for marketing strategies. These attributes are the *price* farmers associate with a marketing strategy and the *marketing channel*. The price is a random variable, so that risk is introduced into the decision problem. The marketing channel concerns the type of wholesale company the farmer deals with. The farmer can either choose to deal with a cooperative company or with one or more privately-owned companies. It is suggested that the farmer chooses a marketing strategy in a two-phase process. First, he chooses a marketing channel on the basis of non-price attributes, e.g. contracting risk, the quality assessment and payment system, services offered by the company and so forth. Within a marketing channel, the farmer chooses a combination of selling-options in accordance with his risk attitude.

A conceptual model of the decision making process was developed in which, in respect of the attribute price, the elements of risk perception and risk attitude are seen as central in the two-attribute model preference formation model. The combination of risk perception and risk attitude is modeled by means of the SEU-model. The main findings will be summarized below.

Perception of marketing strategies

Our findings show that farmers in both years associated average prices with the strategies (expected values of strategies are +/- 23 Dfl/100 kg). On hindsight, farmers were clearly too optimistic in both years, considering that the average prices farmer actually received were respectively 17.4 and 16 Dfl/100 kg (Table 2.1). Farmers perceived more price risk in 1985 than in 1984. Apparently in 1985 farmers were less sure about prices.

Considering the average prices that farmers expected, it is not surprising to find that the farmers thought that of the total set of marketing strategies two fairly safe strategies would do well in these circumstances. More specifically, the *100% bottom-price contract* (Strategy 2) and the *50% fixed-price contract, 50% spot market (selling at one moment)* (Strategy 9) were perceived as very attractive strategies by risk averse farmers. Many farmers perceived both strategies on the efficiency frontier in both years. Both strategies involve a safety against very low market prices. Contrariwise, many farmers perceived the *100% spot market* strategies (Strategies 4 and 6) in such a manner that they would be unattractive for a risk averse farmer. Both strategies are characterized by a high price risk (i.e. a high standard deviation) which does not go together with a substantially high expected value. Furthermore, selling at two moments at spot market prices is considered unattractive in this respect.

An analysis of the effects on perception of moment of delivery, number of selling moments and type of wholesale company yielded the following results. Farmers perceive, as expected, a higher mean price when delivering later in the marketing year. This finding confirms the expectations since inventory costs should be taken into account. Nevertheless, the finding is relevant with respect to the validity of the elicitation of spd's since the effect is found in a between-subjects design.

Selling at two moments at the spot market reduces mean price and price risk compared to selling only at one moment, as was hypothesized. Furthermore, farmers perceive no difference between strategies which are similar in every aspect, but type of wholesale company. Stated otherwise, the subjective probability distribution of price does not depend upon the marketing channel.

The heterogeneity in perception was tested with respect to the type of wholesale company the farmer actually deals with. Farmers might perceive higher mean prices and/or smaller risks for strategies of the company they actually deal with than for strategies of the competing company. However, no significant differences in perceptions have been found in this respect. This means that farmers neither rationalize their choice of a company nor choose a company with the expectation of receiving higher mean prices with equal or smaller risks. Apparently other motives than price play a role in the choice of a marketing channel. In Smidts (1985) an enumeration of these motives can be found. The findings confirm the hypothesized two-phase process. The implication of this finding for the marketing strategy of cooperative and private wholesale companies is that each company should emphasize and communicate other choice criteria than price in order to distinguish themselves from competing companies. Examples of such criteria are the amount of contracting risk, the amount of advice given during the growth and storage of potatoes, the type of relationship between sales personnel and the farmer.

Risk attitude

On the basis of the lottery technique, 82% of the farmers can be classified as risk averse and 12% as risk neutral in 1984. A total of 6% is (slightly) risk seeking. In 1985 these figures are: 68% risk averse, 23% risk neutral and 9% risk seeking. These figures indicate a temporal shift in risk attitude towards risk neutrality. An explanation for this shift can only be given when an increasing absolute risk averse utility function for wealth is assumed. With the conjoint measurement no significant temporal shift in risk attitude has been found. The variation between farmers in risk attitude is substantial.

In both years of measurement, a negative exponential function fitted the data of the lottery technique clearly better than a power function. The negative exponential function implies that a farmer can be characterized by a *constant absolute* and an *increasing proportional* risk attitude. To the farmer's decision problem a constant absolute risk attitude implies that a farmer responds similarly to the risk of losing or gaining, say, 10 cts/kg, in a year with high market prices relative to a year with low market prices. Increasing proportional risk aversion implies that the farmer will respond more conservatively towards a risk of losing or gaining, say, 10%, in a year with high market prices relative to a year with low market prices.

Strength of preference

With respect to strength of preference, plausible measurements are obtained. In the rating task all the farmers are, in both years, classified as exhibiting decreasing marginal value, as expected. A power function, implying a decreasing absolute risk attitude and a constant proportional risk attitude fitted the data best.

With the midvalue splitting technique 9% of the farmers have a linear value function in 1984; for 1985 this percentage is 5%. The remaining farmers exhibit decreasing marginal value. Similar to the lottery technique, a negative exponential function clearly fitted the data best. No temporal shift in strength of preference is found for the midvalue splitting technique; with the rating technique the curve in 1985 was somewhat more concave than in 1984.

Relative risk attitude

In 1984, 43% of the farmers can be classified as relatively risk averse, 51% as relatively risk seeking and 7% as relatively risk neutral. In 1985 a shift towards relatively risk seeking shows up: 20% relatively risk averse, 76% relatively risk seeking and 4% relatively risk neutral. This shift should not come as a surprise, of course, since the utility function (assessed by means of the lottery technique) shifted towards risk seeking whereas the strength of preference function (midvalue splitting technique) did not shift (see also Section 8.1).

In the study, the relationship between assessments of risk attitude, strength of preference and relative risk attitude and a number of personal and situational variables have been analyzed. Neither strong nor consistent relationships were found. This result suggests that the measurements of risk attitude and strength of preference are strongly context specific, so that general characteristics of the farmer are hardly relevant for these context specific preferences and choices. With context specific here is meant that farmers can be strongly risk averse with respect to marketing ware potatoes, but can at the same time be less risk averse with respect to e.g. pest management or choice of ware potato cultivation intensity. It should be noted here that in this study it was not possible to relate indicators of the financial structure of the farm to the risk attitude measurement. Such factors might be more influential on risky choice behavior than factors like age and level of education.

The model of preference formation

The proposed preference formation model was largely confirmed. Both price and marketing channel significantly influence preferences for marketing strategies in the hypothesized direction. This finding confirms that indeed risk perceptions and risk attitude influence farmer's preferences for marketing strategies. Although the model is confirmed in this study, the fit of the model is fairly low.

It was found that the effect of the marketing channel on preference is mediated by the farmer's actual choice of the type of wholesale company. Farmers actually dealing with a cooperative company evaluate strategies implying selling to a cooperative company on average clearly higher than strategies implying selling to a private company. With farmers actually dealing with a private company the reverse effect shows up.

The analysis of the relationship between the preference for a marketing strategy and the farmer's personal and situational characteristics yielded interesting effects. The most important variables affecting preferences are: the farmer's risk attitude, the type of wholesale company he deals with, his usual moment of delivery and the region he lives in. The significant effect of risk attitude again confirms the preference formation model.

The effects of risk attitude are in an expected direction and were shown to be most influential if strategies with an extreme price risk were concerned. That is, for strategies both with a very small, and large price risk, the risk attitude is clearly related to the preferences of farmers. Effects of e.g. the farmer's age and level of education were small and only present for some strategies.

The relationship between the characteristics and the preferences was most clear with respect to pooling at a cooperative company (Strategy 1) and in case of selling the total harvest at spot market prices (Strategies 4 and 6). These results imply that for these strategies the farmers' characteristics yield most information for decisions on e.g. market segmentation to be made by wholesale companies.

The differences in risk attitude between farmers and the finding that risk attitude indeed influences preferences, suggest opportunities for wholesale companies to use a farmer's risk attitude more explicitly as a market segmentation variable. Specific services could be tailored to each risk attitude segment. For example, until now, wholesale companies market single selling-options from which a farmer can construct his own combination of options. The large majority of the farmers indeed makes combinations of selling-options. Alternatively, a wholesale company could construct a number of portfolios of selling-options themselves in such a way that these portfolios increase both in expected value of price and in price risk. For each risk attitude segment such a portfolio of selling-options could be developed and marketed. This would ease the choice problem for farmers.

The present research concentrated heavily on one aspect of the farmer's decision making: modeling the choice of a marketing strategy. Several fields of inquiry are interesting enough to warrant future research.

It would be interesting to analyze further *how* farmers form their perceptions concerning market prices. That is, what are the basic factors that govern these perceptions, which information sources are used and how is information from these sources weighted and combined into an overall judgment. Furthermore, how are subjective, intuitive judgments about the market combined with more objective information from e.g. the futures market or yield estimates? In general, according to von Winterfeldt and Edwards (1986) this latter topic of combining subjective and objective information is one of the most interesting research topics in decision analysis in the years to come. Especially, within the context of decision support systems these aspects could be analyzed. This applies of course not only to farmers' decision making processes but also to (marketing) decision making in general.

Another interesting topic concerns the hypothesis that the decision maker's relative risk attitude is not dependent upon the context of the decision or the attribute under consideration. It would be interesting to test this hypothesis with respect to the diverse fields of the farmer's management task. For example, this could concern marketing decisions with respect to other crops with large market risks e.g. onions, production management decisions e.g. decisions concerning fertilizer input and pest management, investment decisions or decisions concerning the adoption of new technologies or management tools. If such a stable characteristic of the farmer would be found for each of these, probably multiattributed decisions, this would clearly increase our insight into the farmer's decision making.

A further topic concerns the effect of social factors on the choices under risk. In this study, the farmer's decision making process has been modeled as an individual process isolated from the presence of other people. However, preferences and choices of reference farmers (e.g. the farmer's neighbours) or the farmer's wife will probably also influence the choice behavior. For example, are farmers more risk averse if more people are influencing the decision making process?

Overall, the findings in this study show that the farmer's decision making process provided a good empirical setting for studying a number of theoretical and methodological issues. Since it concerned individual decision making of a large number of decision makers, typically research into the decision making processes under risk of small-businesses and of consumers could benefit from our findings. It will be interesting to study whether findings and conclusions can be confirmed and enhanced by studying the topics for other decision makers (e.g. managers in horticulture, small retailers, consumers), other decisions e.g. hedging on the futures market, and for group instead of individual decision making. The concept of relative risk attitude seems promising for the study of group decision making too (Dyer and Sarin 1982). Furthermore, a longitudinal approach with more than two moments of measurement is considered worthwhile. In this manner the changes in risk perceptions, risk attitudes and strength of preference can be studied in response to changes in the market circumstances or in the decision maker's situation.

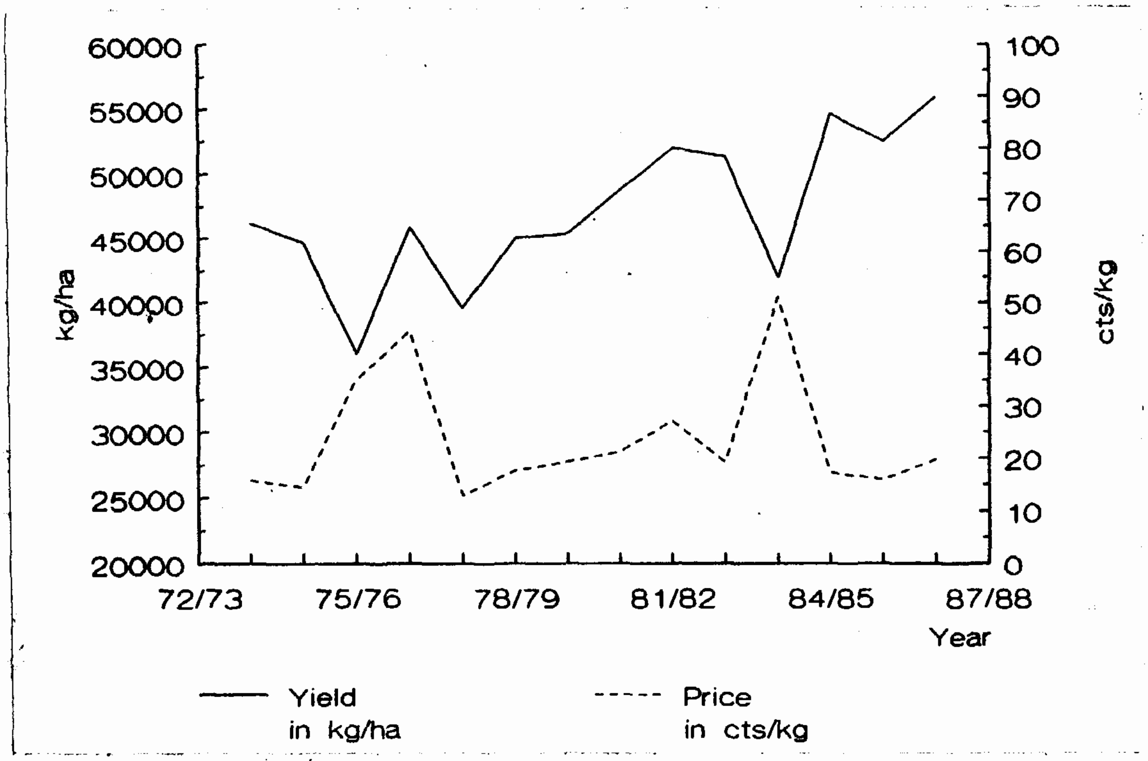

Figure I.1 *Yield (in kg/ha.) and price (in cts/kg) for ware potatoes*

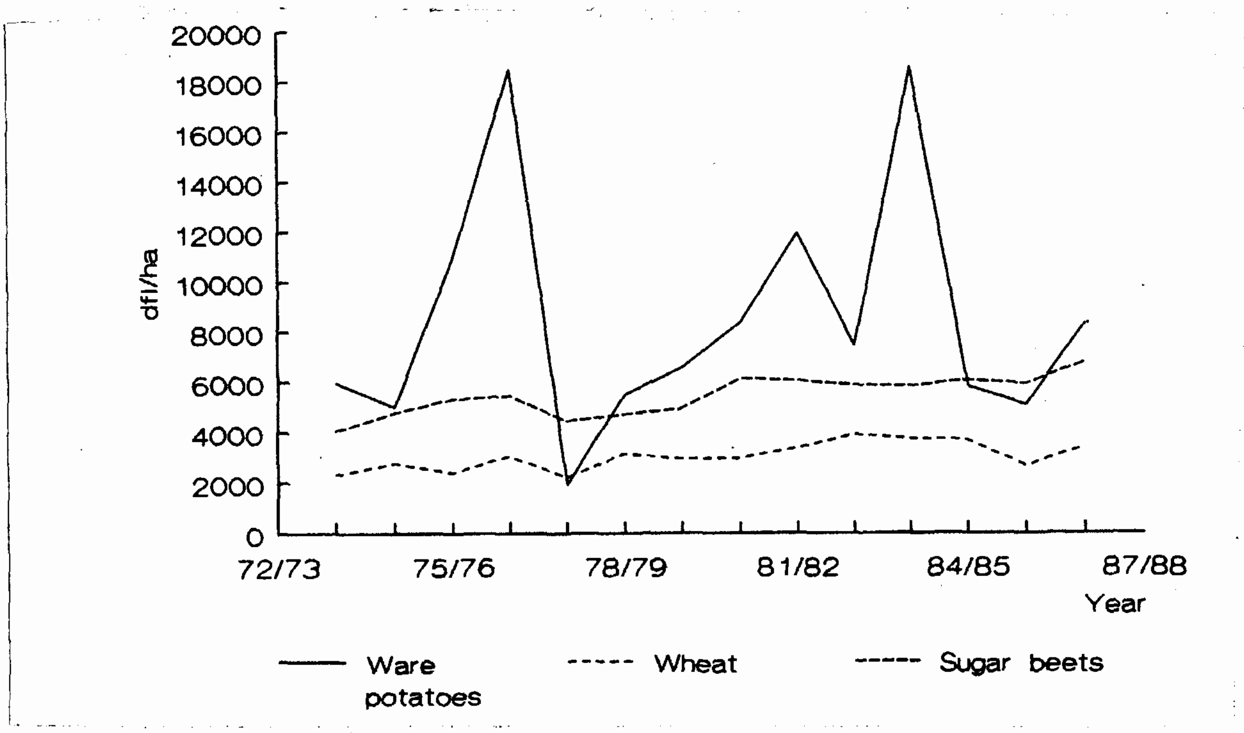

Figure I.2 *Gross margin (in Dfl/ha.) for a number of crops in the Central Clay area*

APPENDIX II

Average results of indirect measurement of price perception in '84 and '85, per marketing strategy and per moment of delivery in cts/kg

Year 1984

	STRATEGY	Sept-Dec. MU IMEA	Sept-Dec. SD MEA	Jan.-March MU IMEA	Jan.-March SD IMEA	April-July MU IMEA	April-July SD IMEA	SIG.
1.	100% Pc	21.97	4.50	23.16	2.55	23.71	4.21	x
2.	100% Bp	22.00	3.41	23.02	2.70	24.35	3.34	xxx
4.	100% Sm1	20.04	2.86	23.90	4.16	24.26	6.13	xxx
6.	100% Sm2	19.71	2.56	23.05	3.84	23.89	5.18	xxx
7.	50% Pc/50% Sm1	21.32	3.59	23.53	2.95	23.65	3.88	xxx
9.	50% Fp1/50% Sm1	21.39	3.08	24.62	2.58	25.23	3.48	xxx

Year 1984

	STRATEGY	Sept-Dec. MU ISTA	Sept-Dec. SD ISTA	Jan.-March MU ISTA	Jan.-March SD ISTA	April-July MU ISTA	April-July SD ISTA	SIG.
1.	100% Pc	2.38	1.80	2.22	1.72	2.41	1.68	--
2.	100% Bp	2.08	1.51	2.00	1.35	1.98	1.83	--
4.	100% Sm1	2.14	1.53	3.34	3.21	4.57	3.88	xxx
6.	100% Sm2	1.77	1.01	2.72	2.20	3.26	2.47	xx
7.	50% Pc/50% Sm1	2.09	1.43	2.28	1.57	2.88	2.05	xx
9.	50% Fp1/50% Sm1	1.39	.68	1.84	1.35	2.54	1.68	xxx

APPENDIX II

continued

Year 1985

	STRATEGY	Sept-Dec. MU ISTA	Sept-Dec. SD ISTA	Jan.-March MU ISTA	Jan.-March SD ISTA	April-July MU ISTA	April-July SD ISTA	SIG.
1.	100% Pc	2.90	1.98	3.47	2.66	3.29	2.25	--
2.	100% Bp	2.68	1.72	2.99	2.36	2.75	2.05	--
4.	100% Sm1	3.05	2.50	5.43	4.37	6.07	4.44	xxx
5.	100% Pp	3.35	2.08	3.91	3.18	3.60	2.48	--
6.	100% Sm2	3.00	2.27	4.52	3.43	4.79	3.52	--
7.	50% Pc/50% Sm1	3.98	2.45	4.65	3.14	3.84	3.22	--
8.	50% Bp/50% Sm1	1.90	1.60	3.34	2.37	3.30	3.06	--
9.	50% Fp1/50% Sm1	1.93	1.19	3.63	3.04	3.16	2.01	--
10.	50% Pp/50% Sm1	3.32	2.80	4.57	2.65	4.71	2.96	--
11	50% Pc/50% Sm2	3.42	1.94	2.22	1.40	3.83	2.77	--
16	50% Pp/50% Sm2	2.84	1.91	3.39	2.71	3.53	1.35	--

Significance: x = $p < .05$
(one-tailed) xx = $p < .025$
xxx = $p < .01$

APPENDIX III

Average results of direct measurement of price perception in 1984 and 1985, per marketing strategy, per moment of delivery, in cts/kg

Year 1984

	STRATEGY	Sept-Dec. MU DMEA	Sept-Dec. SD DMEA	Jan.-March MU DMEA	Jan.-March SD DMEA	April-July MU DMEA	April-July SD DMEA	SIG.
1.	100% Pc	23.56	4.45	24.91	4.76	25.27	3.13	-
2.	100% Bp	24.33	3.85	24.02	4.10	25.55	3.98	xx
4.	100% Sm1	21.23	2.99	25.62	6.46	28.46	6.61	xxx
5.	100% Pp	23.21	4.58	24.52	6.93	25.35	3.85	-
6.	100% Sm2	20.30	2.08	24.32	5.58	26.41	5.19	xxx

Year 1985

	STRATEGY	Sept-Dec. MU DMEA	Sept-Dec. SD DMEA	Jan.-March MU DMEA	Jan.-March SD DMEA	April-July MU DMEA	April-July SD DMEA	SIG
1.	100% Pc	22.33	3.64	23.66	3.34	25.19	4.81	-
2.	100% Bp	23.50	2.20	23.82	3.40	25.22	3.50	-
4.	100% Sm1	20.56	3.01	23.21	3.79	27.25	4.98	xxx
5.	100% Pp	22.55	3.04	23.76	3.43	25.34	2.62	xx
6.	100% Sm2	20.91	3.07	23.69	3.95	24.77	3.75	x

Significance: x = $p < .05$
(one-tailed) xx = $p < .025$
xxx = $p < .01$

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SAMENVATTING

Deze studie gaat over besluitvorming onder onzekerheid. Een drietal onderwerpen komt in de studie aan de orde. Ten eerste wordt een overzicht en evaluatie gegeven van de belangrijkste theoretische inzichten met betrekking tot het nemen van beslissingen onder risico. Veel aandacht in dit verband gaat uit naar het concept van de *relatieve risico-attitude*. Een tweede onderwerp betreft het onderzoek naar de betrouwbaarheid, validiteit en praktische haalbaarheid van methoden voor het meten van risicopercepties en risico-attitudes in grootschalig survey onderzoek. In de derde plaats wordt een model ontwikkeld en getoetst betreffende de keuze van de afzetstrategie door telers van consumptieaardappelen. Uit een overzicht van de literatuur blijkt dat beperkt empirisch onderzoek is verricht naar marketing beslissingen onder risico van boeren.

De theoretische en methodologische vragen worden empirisch onderzocht voor het beslissingsgedrag van telers van consumptieaardappelen in de IJsselmeerpolders. Dit beslissingsgedrag blijkt hiervoor uitermate geschikt te zijn, o.a. vanwege het homogene produkt dat verhandeld wordt en het grote aantal, voornamelijk individuele, beslissers die allen geconfronteerd worden met dezelfde marktrisico's en allen uit dezelfde keuzemogelijkheden kunnen kiezen om op deze marktrisico's te reageren.

Voor het beantwoorden van de onderzoeksvragen is een veldonderzoek gehouden onder 250 telers welke drie keer geïnterviewd zijn in twee opeenvolgende oogstjaren (84/85 en 85/86). Op deze wijze is iedere teler in totaal ruim vier uur lang geïnterviewd. Desondanks waren de bereidheid om mee te werken aan het onderzoek en de motivatie van de respondenten hoog. In hoofdstuk 4 wordt een uitgebreide beschrijving van de opzet en uitvoering van de empirische studie gegeven. Onderscheidende kenmerken van deze studie ten opzichte van reeds verrichte studies op dit gebied zijn de test-retest opzet, de toepassing van meer dan één methode voor het meten van risicopercepties en risico-attitudes, het grote aantal beslissers dat onderzocht wordt en het feit dat de analyse betrekking heeft op beslissers die geconfronteerd worden met hun eigen, jaarlijks terugkomende, beslissingsprobleem.

In hoofdstuk 2 wordt aangegeven dat het inkomen van de akkerbouwers in de IJsselmeerpolders voor een groot deel bepaald wordt door de resultaten die behaald worden met consumptieaardappelen. Deze resultaten zijn echter aan sterke schommelingen onderhevig vanwege de grote prijsschommelingen van het vrije produkt consumptieaardappelen. Door middel van de keuze van de afzetstrategie ('marketing strategy') kan een teler de grootte van het prijsrisico beïnvloeden. Zo kan hij kiezen voor een vast-prijscontract (16%), een bodemprijscontract (5%), pooling (36%) en verkopen tegen dagprijs (42%); tussen haakjes is telkens het marktaandeel van de verkoopmogelijkheid gegeven, berekend op basis van afgezette hoeveelheden in 1983 (Smidts 1985). Gebruikelijk is dat telers

een combinatie van deze verkoopmogelijkheden ('selling-options') kiezen, bijvoorbeeld 35% van de fysieke opbrengst verkopen tegen een vaste prijs, 25% volgens pooling en de rest verkopen tegen dagprijs. Deze dagprijsverkopen kunnen gespreid worden over het verkoopseizoen dat loopt van september/oktober tot en met juni/juli. Tevens dient de teler een afzetkanaal en een leveringstijdstip te kiezen. De keuzes van de teler met betrekking tot de combinatie van verkoopmogelijkheden, het leveringsmoment en het afzetkanaal wordt gedefinieerd als zijn afzetstrategie.

Een model wordt geschetst voor de preferentievorming van de teler voor een afzetstrategie (hoofdstuk 2). De preferentie wordt volgens het model bepaald door twee attributen: de prijs die behaald kan worden met de strategie (een stochastische variabele) en het afzetkanaal. Bij het afzetkanaal kan de teler kiezen voor de coöperatie of voor één of meer particuliere groothandelaren. Attributen welke bij de keuze van het afzetkanaal een rol spelen zijn het debiteurenrisico, het contractrisico, gewoonte e.d. (zie Smidts 1985). Aan de preferentievorming betreffende het attribuut prijs liggen twee aspecten ten grondslag. Dit zijn de *subjectieve kansverdeling* van de prijs bij een bepaalde strategie en de *risico-attitude* van de teler. Aan de meting van beide onderdelen wordt in deze studie veel aandacht besteed.

In hoofdstuk 3 worden de theoretische inzichten besproken voor het nemen van risicobeslissingen. Als uitgangspunt zijn de 'expected utility' modellen van Bernoulli uit 1738 en van von Neumann en Morgenstern (1947) genomen. Geconstateerd wordt dat een essentieel verschil tussen beide modellen de definiëring en meting van de evaluatiefunctie betreft. In het Bernoulli model wordt deze functie gezien als een cardinale nutsfunctie die de intensiteit van psychologische satisfactie met een bepaalde uitkomst weergeeft (in het vervolg een 'strength of preference' functie genoemd en aangeduid met v(x)). Deze functie wordt gemeten onder zekerheid. Bernoulli stelt dat deze functie gekenmerkt wordt door dalend marginaal nut (een concave curve) zodat dit de verklaring is voor risicomijdend gedrag. Een probleem bij deze theorie is echter de vraag waarom evaluaties van beslissers onder *zekerheid* iets zouden zeggen over hun evaluaties onder *onzekerheid*. In het model van von Neumann-Morgenstern wordt daarom een evaluatiefunctie verondersteld die gemeten wordt onder onzekerheid met behulp van zogenaamde loterijen (deze functie wordt in het vervolg aangeduid met kansindifferentie of nutsfunctie u(x)). In dit model is geen verwijzing naar 'strength of preference' nodig om te bewijzen dat het rationeel is 'expected utility' te maximaliseren. Een probleem bij dit model is echter dat geen verklaring voor risicomijdend gedrag gegeven wordt. Een beslisser die in loterijen indifferentiekansen specificeert welke een concave u(x) impliceren, wordt risicomijdend genoemd zonder te verklaren hoe de beslisser tot deze indifferentiekansen komt.

Het concept van de *relatieve risico-attitude* (ook wel aangeduid als intrinsieke risico-attitude) is geïntroduceerd om een verbinding tussen beide bovengenoemde modellen te geven. Er wordt gesteld dat u(x) een combinatie is van de evaluaties onder zekerheid (de 'strength of preference' van een beslisser voor uitkomsten) en de werkelijke risico-attitude van een beslisser. Door bij dezelfde beslisser het verschil tussen u(x) en v(x) te meten kan de werkelijke risico-attitude vastgesteld worden. Aangezien zowel u(x) als v(x) schalen zijn op intervalniveau, dient in zijn algemeenheid de relatie tussen beide functies bestudeerd te worden: u(x) = f(v(x)). Wanneer deze relatie lineair is dan wordt de beslisser *relatief risico-neutraal* genoemd, is het verband concaaf dan is de beslisser *relatief risico-mijdend*, is het verband convex dan kenmerkt de beslisser zich als *relatief risicozoekend*.

Wanneer wordt nagegaan welke functies in aanmerking komen om de relatie tussen u(x) en v(x) te beschrijven dan blijken er twee functionele verbanden mogelijk te zijn. Ofwel het verband is lineair (in dat geval vallen u(x) en v(x) samen en is derhalve het Bernoulli model identiek aan het von Neumann-Morgenstern model), ofwel het verband wordt beschreven door een negatief exponentiële functie. In het laatste geval worden beslissers gekenmerkt door een *constant absolute* en *toenemend proportionele* relative risico-attitude (voor een uitleg van de begrippen constant absoluut en toenemend proportioneel risico-mijdend wordt verwezen naar pagina 43 t/m 45). Argumenten voor en tegen ieder van de relaties worden gegeven in hoofdstuk 3. Tevens wordt geconstateerd dat empirisch onderzoek naar het verband schaars is en tegengestelde resultaten te zien geeft. In deze studie wordt een empirische bijdrage geleverd aan het vraagstuk. Aangetoond wordt dat het lineaire verband tussen u(x) en v(x) verworpen dient te worden ten gunste van het negatief exponentiële verband.

Vervolgens wordt in paragraaf 3.4 een evaluatie gegeven van het 'subjective expected utility' model van von Neumann-Morgenstern (aangeduid met SEU-model) als descriptief model. Uit de literatuur blijkt dat het SEU-model als descriptief model veel kritiek gekregen (als normatief model wordt het SEU-model weinig ter discussie gesteld). In zijn algemeenheid kan gesteld worden dat het model slechts bij benadering het beslissingsgedrag onder risico kan verklaren en voorspellen.

De problemen met het SEU-model als descriptief model hebben geleid tot de formulering van alternatieve descriptieve modellen. Een aantal van deze modellen die afkomstig zijn uit zowel de nutstheorie (o.a. de modellen van Machina (1982), Loomes and Sugden (1982), Becker and Sarin (1987)) als de psychologie (Prospect Theory (Kahneman en Tversky 1979)) worden besproken. Vastgesteld wordt dat ieder van die modellen aanzienlijk complexer is dan het SEU-model en tevens één of meer elementen bevat welke moeilijk of niet geoperationaliseerd kunnen worden. Het is bovendien nog niet aangetoond dat deze modellen ondanks hun grotere complexiteit en uitgebreidere dataverzameling een betere beschrijving van beslissingen geven (zie bijvoorbeeld Currim and Sarin 1989). In deze veldstudie worden deze modellen dan ook niet toegepast.

Hoofdstuk 3 sluit af met een modellering van het beslissingsprobleem van de teler volgens het SEU-model. De predictieve validiteit van dit SEU-model zal vergeleken worden met die van het SEV-model (het 'subjective expected value' model). Dit laatste model veronderstelt risiconeutrale beslissers. Als de telers niet risiconeutraal zijn dan mag verwacht worden dat de predictieve validiteit van het SEU-model die van het SEV-model zal overtreffen.

In de hoofdstukken 5, 6 en 7 worden achtereenvolgens de resultaten besproken van de meting van risicoperceptie, de risico-attitude, de relatieve risico-attitude en van de combinatie van percepties en risico-attitude in de preferentievorming voor afzetstrategieën.

De prijs die de teler verwacht te kunnen ontvangen bij een bepaalde afzetstrategie is op twee manieren gemeten: indirect en direct (hoofdstuk 5). Met indirect wordt hier bedoeld dat een subjectieve kansverdeling per strategie is gemeten waarna, indirect, de momenten (zoals gemiddelde en standaardafwijking) van de kansverdeling worden bepaald. In de directe methode wordt een teler rechtstreeks gevraagd naar de gemiddelde prijs en wordt het prijsrisico van een strategie direct gemeten met 'magnitude scaling'. Een groot verschil tussen de methoden is dat de directe methode geen kansverdeling oplevert die gebruikt kan worden in het SEU-model. Daarentegen is deze directe methode aanzienlijk sneller en eenvoudiger.

In het algemeen kan gesteld worden dat het meten van subjectieve kansverdelingen veel tijd kost en door respondenten als moeilijk ervaren wordt. Het aantal afzetstrategieën waarvoor een kansverdeling gemeten kon worden diende derhalve beperkt te worden tot zeven. Vanwege de moeilijkheidsgraad van de meting kon desondanks voor een zesde deel van de respondenten geen kansverdeling gemeten worden. In tegenstelling hiermee kon met de directe methode voor vrijwel alle respondenten in korte tijd de perceptie vastgesteld worden van alle strategieën.

De resultaten van de perceptiemetingen worden uitgebreid besproken in de paragrafen 5.3 t/m 5.7. Aangezien de telers voor beide oogstjaren relatief lage prijzen verwachten blijken de strategieën *100% bodemprijs* en *50% vaste prijs/ 50% dagprijs (verkoop op één moment)* zich in beide jaren op de efficiënte grens te bevinden (het betreft hier de gemiddelde perceptie; individuele telers kunnen hiervan afwijken). Dat wil zeggen dat beide strategieën aantrekkelijk zijn voor risicomijdende beslissers; de mate van risicomijdendheid is bepalend of een teler de ene dan wel de andere strategie prefereert. Uit de metingen blijkt tevens dat de risicovolle *100% dagprijs* afzetstrategieën onaantrekkelijk zijn voor risicomijdende beslissers.

De validiteit van de perceptiemetingen is onderzocht door de effecten te toetsen van het leveringsmoment, het aantal verkoopmomenten bij verkoop tegen dagprijs en het afzetkanaal. Zowel bij de indirecte als de directe meting worden in beide jaren resultaten gevonden die consistent zijn met de verwachtingen. Wanneer de metingen verkregen met de directe en indirecte techniek vergeleken worden per respondent, dan blijkt een goede overeenkomst van de metingen. Wel levert de directe meting systematisch een significant hogere gemiddelde prijs op dan de indirecte methode. Als verklaring hiervoor is aangegeven dat in de directe vraagmethode meer dan in de indirecte vraagmethode, de teler gefocussed werd op de (hoge) prijzen in voorgaande oogstjaren en vervolgens onvoldoende gewicht toekende aan de verwachtingen over de (lage) prijzen van het komende oogstjaar (een voorbeeld van de zogenaamde 'anchoring and adjustment' heuristiek).

De heterogeniteit in perceptie is onderzocht door te kijken of telers die leveren aan de coöperatie strategieën anders percipiëren dan telers die leveren aan de particuliere groothandel. Geen significante verschillen tussen beide groepen konden worden vastgesteld.

Ondanks de moeilijkheidsgraad van de metingen van subjectieve kansverdelingen laten de resultaten van deze studie laten zien dat het mogelijk is een aantal consistente en plausibele subjectieve kansverdelingen per respondent te meten in een survey. Dit veronderstelt wel dat ruim tijd voor deze metingen wordt uitgetrokken en dat de interviewers goed geoefend zijn.

De methoden voor het meten van risico-attitude (u(x)) en 'strength of preference' (v(x)) worden uitgebreid besproken in hoofdstuk 6. Vastgesteld wordt dat voor het betrouwbaar en valide meten van deze concepten ieder concept met meer dan één methode gemeten dient te worden (aangeduid met de term 'multiple method approach'). In deze studie is de risico-attitude gemeten op twee manieren. In de loterij techniek dienen respondenten zekerheidsequivalenten te specificeren voor 50/50 loterijen. Door een tiental loterijen aan respondenten voor te leggen worden tien punten van de nutsfunctie verkregen. Met niet-lineaire regressie wordt een functie door de punten gefit. De tweede techniek die is toegepast is conjunct meten. Respondenten moeten in deze taak een set van 50/50 loterijen naar voorkeur ordenen. Daarna wordt met regressieanalyse de lineaire trade-off bepaald tussen gemiddelde en standaardafwijking van de loterij. De trade-off is dan een maat voor de risico-attitude van de beslisser.

'Strength of preference' is eveneens op twee manieren gemeten, namelijk met de middenwaarde ('midvalue splitting') en de 'rating' techniek. In beide gevallen worden tien punten van de curve v(x) gemeten. De curves u(x) en v(x) zijn voor alle technieken gemeten voor het attribuut prijs (in guldens per 100 kg), en voor prijzen tussen de 10 en 70 gulden per 100 kg.

Een belangrijk deel van hoofdstuk 6 is gewijd aan de resultaten die in beide jaren verkregen zijn met ieder van de technieken, waarbij aandacht wordt besteed aan het gemak waarmee respondenten en interviewer met de techniek omgaan, de interne consistentie, de stabiliteit en responseffecten. Tevens wordt de convergente validiteit bepaald van de concepten risico-attitude en 'strength of preference'. In tabel 6.23 (pagina 237) worden de belangrijkste bevindingen samengevat. De loterij techniek blijkt op de meeste punten het meest positief beoordeeld te kunnen worden, de rating techniek daarentegen blijkt de minst betrouwbare en minst valide meettechniek.

Bij de loterij techniek blijkt de negatief exponentiële functie de gegevens het best te beschrijven. Telers kunnen daarom gekarakteriseerd worden door een constant absolute en een toenemend proportionele risico-attitude. Het grootste deel van de telers wordt in beide jaren als risicomijdend geclassificeerd (82% in 1984 en 68% in 1985). De rest van de telers is risiconeutraal tot enigszins risicozoekend. Gemiddeld waren telers in 1985 minder risicomijdend dan in 1984. Een bevredigende verklaring voor deze verschuiving bleek moeilijk te geven.

Wat betreft v(x) blijkt dat voor vrijwel alle telers, volgens verwachting, de curve concaaf is, hetgeen dalend marginaal nut impliceert. Weinig significante verbanden zijn gevonden tussen de diverse metingen van risico-attitude en 'strength of preference' en de persoonlijke en situationele kenmerken van de teler.

In paragraaf 6.7 wordt de hypothese van de relatieve risico-attitude getoetst. In de toets zijn de metingen gebruikt die verkregen zijn met de loterij en met de middenwaarde techniek. Per individu is het verband tussen de gegevens verkregen met beide technieken geschat volgens een negatief exponentiële en een machtsfunctie. In beide jaren blijkt dat er een significant verschil bestaat tussen u(x) en v(x) en dat de relatie tussen beide functies beter door de theoretisch verwachte negatief exponentiële dan door de machtsfunctie wordt beschreven.

Wanneer gekeken wordt naar de klassicifatie van de telers naar *relatieve* risicoattitude dan blijkt dat er in 1984 evenveel relatief risicomijdende als relatief risicozoekende telers zijn. In 1985 is ongeveer driekwart van de telers relatief risicozoekend. Deze verschuiving in de relatieve risico-attitude wordt veroorzaakt door een significante verschuiving in u(x) in de richting van een geringere risicomijdendheid, terwijl v(x) niet verschilt tussen de jaren.

De hypothese van een relatieve risico-attitude wordt derhalve in deze studie bevestigd. Beslissers evalueren uitkomsten onder zekerheid anders dan onder onzekerheid, zodat het Bernoulli model wordt verworpen als model voor het beschrijven van beslissingen onder risico ten gunste van het von Neumann-Morgenstern model. In de paragrafen 6.7 en 6.9 wordt verder ingegaan op de theoretische en praktische implicaties van de gevonden resultaten. Eén implicatie is dat het niet alleen vanuit methodologisch oogpunt maar ook vanuit theoretisch gezichtspunt aanbeveling verdient om in onderzoek naar beslissingen onder onzekerheid altijd tenminste één meettechniek onder zekerheid en één onder onzekerheid toe te passen. Verschillen tussen beide metingen kunnen geïnterpreteerd worden als het netto effect van risico op beslissingen. Op deze wijze wordt een betere indicator van de risico-attitude van een beslisser verkregen dan met de conventionele meting die alleen gebaseerd is op u(x).

Wanneer methodologisch de perceptiemetingen vergeleken worden met de metingen van risico-attitude en 'strength of preference' dan leren de ervaringen in deze studie ons dat de crux van het modelleren van besluitvorming onder onzekerheid ligt bij de perceptiemetingen. Het tijdsbeslag, de motivatie van de respondent, de mogelijke invloed van de interviewer en de kans op responseffecten zijn duidelijk problematischer bij de meting van subjectieve kansverdelingen. Een veelvuldiger gebruik van theoretisch consistente modellen voor beslissingen onder onzekerheid, zoals het SEU-model, in onderzoek met grote aantallen beslissers, bijvoorbeeld consumenten, zal dan ook afhangen van de mate waarin het meten van kansverdelingen sneller en respondent vriendelijker gemaakt kan worden. Wellicht dat computergestuurde interactieve metingen hiervoor mogelijkheden bieden.

In hoofdstuk 7 worden perceptie- en attitudemetingen samengebracht in de toets van het preferentiemodel. Geprobeerd wordt de voorkeur van een teler voor verschillende afzetstrategieën te verklaren. De resultaten laten een bevestiging zien van het veronderstelde twee attributen model. In de eerste plaats blijkt het afzetkanaal duidelijk van invloed op de voorkeur voor afzetstrategieën. Dit bevestigt het veronderstelde twee-fasen keuzeproces. Dit proces houdt in dat een teler op basis van andere attributen dan prijs kiest voor een afzetkanaal en daarbinnen een verkoopstrategie kiest die past bij zijn risico-attitude met betrekking tot prijs. Verder blijkt dat het effect van afzetkanaal op de voorkeur duidelijk afhankelijk is van de huidige keuze van de teler voor het kanaal. Daarbij valt op dat de negatieve houding van telers bij de coöperatie tegenover de particuliere groothandel groter is dan omgekeerd. Het zal daarom relatief gemakkelijker zijn een teler die levert aan de particuliere groothandel van afzetkanaal te laten veranderen dan omgekeerd.

In de tweede plaats blijkt in beide jaren het SEU-model een betere verklaring van de voorkeur voor afzetstrategieën te geven dan het SEV-model. Hieruit volgt dat de risicoperceptie en risico-attitude significant van invloed te zijn op de voorkeur van een teler voor een bepaalde strategie. Het verschil in verklaring van beide modellen is echter niet zo groot. Nadere analyse geeft aan dat de oorzaak hiervoor waarschijnlijk gezocht moet worden in het hoge percentage tweede graads stochastisch dominante subjectieve kansverdelingen ('second degree of stochastic dominance'). Dit houdt in dat de preferentievolgorde van twee kansverdelingen niet afhankelijk is van de mate van risicomijdendheid van de beslisser; iedere concave curve leidt tot dezelfde voorkeursvolgorde tussen beide kansverdelingen. Door dit hoge percentage paarsgewijs stochastisch dominante kansverdelingen (in beide jaren ongeveer de helft van alle paarsgewijze vergelijkingen) is de door het model voorspelde volgorde van afzetstrategieën relatief ongevoelig voor de specifieke risico-attitude van een beslisser. Het valt aan te nemen dat wanneer het percentage lager zou zijn geweest, het verschil in verklaring tussen het SEU en het SEV-model groter zou zijn geweest.

Onderzocht wordt tevens wat het effect is wanneer u(x) in het SEU-model vervangen worden door v(x). Immers, de analyse in hoofdstuk 6 heeft laten zien dat u(x) en v(x) significant van elkaar verschillen en dat alleen u(x) voorkeuren onder risico beschrijft. Op basis daarvan wordt verwacht dat het model met u(x) voorkeuren onder risico beter zal verklaren dan een model met v(x). Deze hypothese wordt gedeeltelijk bevestigd. In beide jaren kon geen significant verschil in predictieve validiteit aangetoond worden tussen de loterij meting en de middenwaarde meting; wel geeft de loterij meting een iets betere fit te zien. In beide jaren is er echter wel een significant verschil tussen de loterij meting en de 'rating' meting van v(x). De predictieve validiteit van de loterij meting is duidelijk groter. De verklaring voor deze gemengde uitkomsten wordt gezocht in het percentage stochastisch dominante kansverdelingen in combinatie met de functie die bij iedere techniek de beste fit van de data geeft (bij de loterij en middenwaarde techniek een negatief exponentiële functie, bij de rating techniek een machtsfunctie).

Tevens wordt in hoofdstuk 7 nagegaan of een model dat gebruik maakt van de indirecte perceptiemetingen een betere verklaring van de voorkeur van telers geeft dan een zogenaamd pragmatisch model dat gebruik maakt van de directe metingen (dit pragmatische model vertoont veel overeenkomsten met de zogenaamde 'perceived risk' benadering in consumentenonderzoek). Uiteraard zou de verklaring met de indirecte metingen aanzienlijk groter dienen te zijn omdat de investering in tijd en moeite voor het verzamelen van de indirecte gegevens veel groter is dan die voor de directe metingen. Samengevat blijkt dat de resultaten wat dit betreft niet duidelijk zijn. In 1984 blijkt het indirecte model enigszins beter, in 1985 is er weinig verschil tussen de modellen. Op basis van deze bevinding wordt dan ook geconcludeerd dat wanneer in grootschalig survey onderzoek de interesse slechts uitgaat naar de predictieve validiteit, het gebruik van de eenvoudige directe metingen in een naïef model de voorkeur verdient boven het gebruik van de indirecte metingen. In de overige gevallen zal het theoretisch consistente 'expected utility' model de voorkeur verdienen.

Tenslotte wordt bekeken in hoeverre de voorkeur voor een bepaalde afzetstrategie samenhangt met persoonlijke en situationele kenmerken van de teler. De resultaten hiervan worden beschreven in paragraaf 7.4. Opnieuw blijkt uit deze analyse dat de risico-attitude van de teler effect heeft op zijn voorkeur. Zo hebben bijvoorbeeld sterk risicomijdende telers een grotere voorkeur voor weinig riskante afzetstrategieën dan minder sterk risicomijdende telers. Andere factoren die de voorkeur van telers beïnvloeden zijn het gebruikelijke leveringsmoment van de teler, de regio (Noordoost polder of Oostelijk Flevoland) en of de teler levert aan de coöperatie of aan een particuliere handelaar. Factoren als leeftijd, opleiding en intensiteit van aardappelverbouw geven slechts bij enkele strategieën effecten op de voorkeur te zien.

Hoofdstuk 8 bevat tenslotte een samenvatting van de belangrijkste bevindingen en conclusies geordend volgens de drie onderwerpen van het onderzoek. Een aantal implicaties van de bevindingen wordt genoemd en tevens worden per onderwerp enkele suggesties gedaan voor verder onderzoek.