Chapter 3

HUMANS AS INFORMATION PROCESSORS

3.1 Introduction

Any consideration of the constraints on the acquisition, and incorporation into semantic memory, of data along with the subsequent transformation of the data into expectations, prior to its incorporation into formalised decision structures, requires the study of both the data-supply structures within the decision environment and the decision makers themselves. The intent in this chapter is to review constraints of humanity and the characteristics exhibited by decision makers relevant to the processes of data acquisition and judgement. The ambit of the chapter is shown in Figure 3.1.

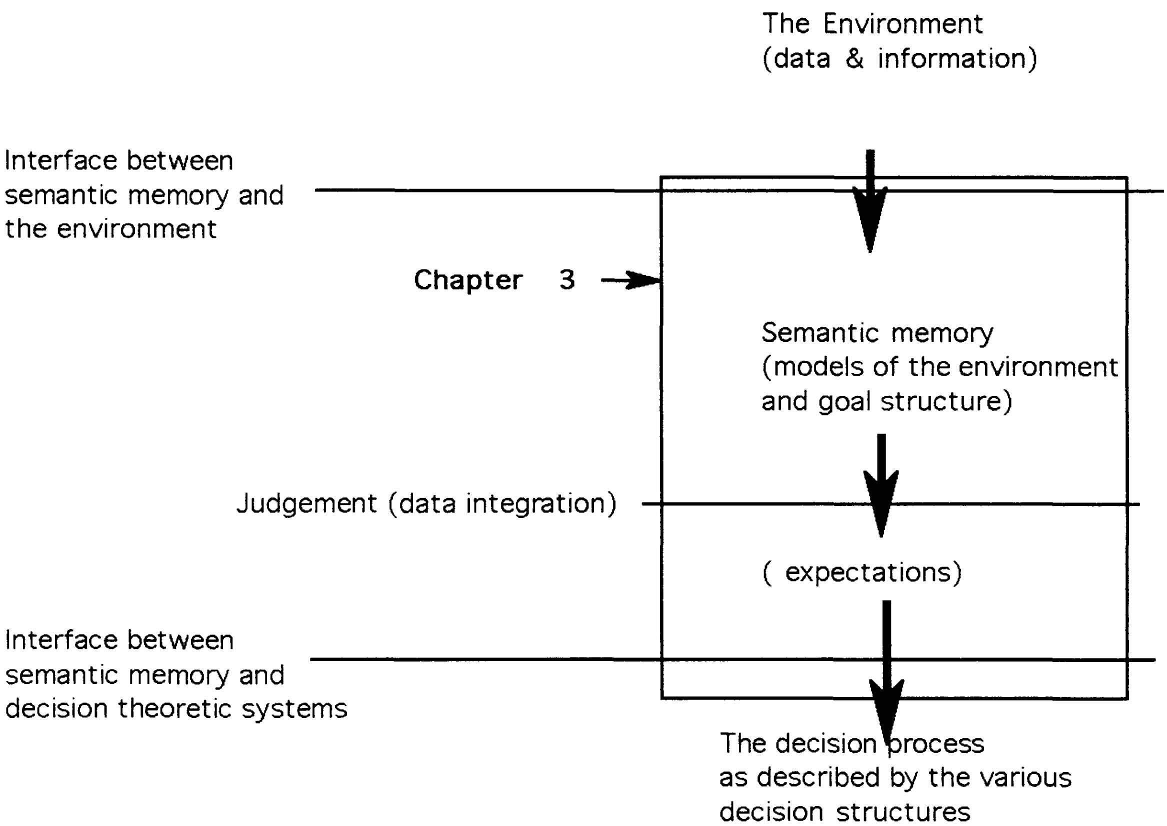


Figure 3.1 The Environment - Memory - Decision Process Interfaces
(adapted from Humphreys and Berkeley 1983)

It is to be noted that within this study the terms "judgement" and "integrating" will be used interchangeably and be taken to refer to the cognitive processes involved in the transformation of stimuli (external data) and knowledge held in memory into expectations which in turn become the data inputs for a particular decision structure.

There is considerable evidence to suggest both that humans are inefficient in the acquisition of data and that the adoption of particular decision structures will influence the informational search patterns adopted by decision makers (Nakajima and Hotta 1988).

The literature relating to the means by which producers actually form expectations as to future commodity prices and volumes is relatively sparse, a situation that appears to have changed little since William's 1951 (p. 20) comment:

> Relatively little has been done to determine how farmers, in the dim light of their imperfect knowledge, actually formulate their decisions in response to changes inherent in the economic environment in which they operate.

Reports of current price modification (e.g. Williams 1953) in light of expected changes in supply and demand or other key variables are considered too narrow in their modeling of the process by Freebairn (1978) who suggests that stimuli relating to farmers' perceptions of data sources, their ability to comprehend data and data constraints, along with incomplete adoption of outlook information, are significant to the process.

On the basis that the formation of price expectations may be viewed as an inferencing task it is considered relevant, to this thesis, to review the literature relating to inferencing, especially that involving inferencing in a stochastic environment. This is undertaken to gain an insight into the human constraints and limitations on the transformation of market data to expectations for incorporation into any particular decision structure.

That is, the chapter examines the cognitive ability of humans to mimic the statistically correct rationality assumed in many decision structures. While the common approach, within mainstream agricultural economics, to the analysis of human inferencing has revolved around the examination of human ability to undertake effective "Bayesian" judgement, reference to an alternate school of research into judgement, the "regressionists" school, will be made. This is considered necessary as the concept of man the intuitive statistician, a concept considered inappropriate by Brehmer and Kuylenstierna (1978), is itself open to question as a description of human inferencing.

The size of the job facing the decision maker is briefly described below, along with some comments on the imprecision of the job description. DeCanio (1979), Smith (1967) and Slovic and Lichtenstein (1971) comment on the vagueness of the literature, employing the concepts of rational expectations, when or if at all it addresses the question of how such hypothesised "rationality" should be achieved in the judgement process; it appears that at this point decision theorists leave producers to their own devices. Such vagueness can be illustrated by quoting Dillon (1971, p.6) on the formation of subjective probability estimates:

> Naturally in establishing these probabilities the decision maker will take account, to a greater or lesser degree, of historical data and available predictions. (1971, p.6)
>
> He may rely solely on past frequencies but if so he is making a subjective judgement that the future will be like the past and that no additional relevant information is available. (Dillon 1971, p. 7)

With particular reference to the formation of market expectations, Muth (1961) stated that such expectations should take into account all market parameters and the time structure of the disturbance process.

Even given the availability of adequate and reliable data it is not surprising that humans, unaided, fall short of statistical ideals in undertaking such complex computation. For, whilst probability theory appears to provide an initial approximation of the psychology of human intuition, human inferencing (judgement) in uncertain environments has been shown to consistently deviate from that of the normatively correct "statistical man" (Asch 1946, Anderson and Barrios 1961, Ackoff 1967, Peterson and Beach 1967, Kahneman and Tversky, 1972, 1973, Mynatt, Doherty and Tweney 1977, Wallsten 1981, Nisbett et al. 1983, Fischoff and Bar-Hillel 1984).

Tversky and Kahneman (1986 , p. 252) go so far as to argue,

> that the deviations of actual behaviour from the normative model are too widespread to be ignored, too systematic to be dismissed as random error, and too fundamental to be accommodated by relaxing the normative system.

If, in fact, human inference is at significant variance to rational expectations and if there are no "algorithm based information and computational techniques available to agents at some reasonable cost", one must question the relevance of "rational expectations" and those decision structures based on them, to "income-maximizing economic agents"(DeCanio 1979, p. 48). Further, the potential for error in estimation of variable scale values and judgements as to probability distributions of such variables is seen by Heath and Tversky (1991) as resulting in ambiguity, which is considered to be a factor of major importance in decision making under risk, and a factor excluded from consideration in many decision structures.

These observations lead to the conclusion that it is important to attempt to understand the human capacity to transform data into expectations if we are to comment on the appropriate nature of the MIS that is to deliver market data to the producer.

However, should the decision maker conform to the strictures of statistically correct inferencing and the appropriate choice procedures are implemented, these prescriptive (normative) decision structures become adequate descriptive models of judgement and choice.

Yet, possibly the most powerful descriptive theory of human behaviour is contained in the following question and answer.

> Q: What is he doing?
> A: He's doing the best he can. (Edwards 1971, p. 644)

3.2 The Human Resource

Whilst there is significant variability within any biological population, by reason of both genetic and environmental variation, species are recognisable by the general expression of their genetic characteristics, which confer on members of the group certain capacities and limitations. Humans, as decision makers, are not exempt from this fact of nature, exhibiting definite limitations in their data processing faculties, their cognitive capabilities and their memory capacity.

Newell and Simon's (1972) model of the human decision machine is based on the concept of a processor, motor output and three types of memory (long term, short term and external), where the processor is believed to work in a serial rather than a parallel fashion. Further, the writing of long term memory appears to be significantly slower than its retrieval (reading) (Davis and Olson 1985).

In quantitative terms, it is estimated that on average it will take between 50 to 100 seconds to store in long term memory a 10 digit number, yet the recall of the number will require only a few milliseconds. Short term memory, on the other hand, can be written and read at a much faster rate; however, its capacity is restricted. Estimates place short term memory capacity in the range seven plus or minus two symbols (Miller 1956), reducing to two when alternate tasks are undertaken (Davis and Olson 1985). Such limitations have practical implications in situations such as the acquisition of market data from the electronic media as, in many instances, the data volume and density (symbols per unit time) result in overloading of the individual's memorisation capacity. Some reduction of this problem appears to be possible through the condensation of data into symbols such as graphs or the utilisation of market indices.

Another human constraint was noted by Miller (1956) who demonstrated a consistent, cross-sensory, constraint on the differentiation of the magnitude of unidirectional stimulus. The accuracy of judgement decreased significantly when subjects were required to differentiate more than seven (plus or minus two) stimuli categories on a unidimensional scale. The inclusion of additional descriptive dimensions (multi-scale augmentation) in any stimulus communicated to the subjects increased, but at a decreasing rate, the subject's ability to accurately differentiate increasing numbers of stimulus categories. This trend was exhibited for both correlated or partially correlated (redundant) and uncorrelated stimulus dimensions (cues).

Such a constraint would be expected to be of varying significance in the formation of expectations, depending on the dimensional nature of the data received and the number of scalar categories required by a given decision structure. The extreme of the latter is illustrated by assumptions of continuity in production functions or subjective probability distributions.

Some techniques are available to achieve greater differentiation of the magnitude of stimuli in judgemental situations.

> The three most important of these devices are (a) to make relative rather than absolute judgements; or if that is not possible, (b) to increase the number of dimensions along which the stimuli can differ; or (c) to arrange the task in such a way that we make a sequence of several absolute judgements in a row (Miller 1956, p. 90).

However, human capacity to integrate data relating to a number of dimensions is also limited, as shown by the findings of Bettman, Johnson and Payne (1990) who demonstrated that subjects in choice tasks using a weighted adding rule had difficulty with problems with more than four attributes (dimensions).

Given that humans have a limited capacity to absorb data and to produce output (decisions) (Howell and Burnett 1978), and the common occurrence of multifactorial problems in agriculture, the potential for problems associated with the capacity to absorb data, given the size of the data set providing an adequate description of the decision environment, appears significant . Several mechanisms by which humans attempt to prevent such information overload have been described.

One approach based on the filtration of information and the selection of information for further processing is described by Davis and Olson (1985). The exclusion of information from the decision process is seen to be a function of the decision structures employed, the decision maker's "frame of reference" (patterns recognised by the decision maker, based on prior knowledge and experience) and the constraints of decision making under time stress. It was also noted that filtering may in fact block data which is inconsistent with established frames of reference (prior knowledge and experience).

Such constraints and limited computational capacity are seen, by Nisbett et al. (1983), to be a major contributing factor in producers dependence on heuristics in probabilistic situations involving inductive reasoning, with the associated violations of statistical principles, as a form of satisficing, or cost-efficient inferential shortcuts.

In addition to the restriction of human mental capacity, Australian agriculture is characterised by relatively low levels of labour and management inputs. The typical Australian farm business is described as engaging, on average, 1.5 persons in a combination of ownership, labour and management roles (Schapper 1979). The importance of the limited management time available, to business success, appears to be recognised by primary producers themselves, as 45% of Ontario farmers surveyed by Harling and Quail (1990) rated the amount of managerial time available as the single most important limiting resource within their business. As well, Bock (1976) reports that limited time available to seek information was a significant constraining factor in the amount of information utilised by Australian farmers.

To conclude, these owners and operators are seen to be operating in an information overload environment (Longworth 1969) in which "they experience difficulty in sifting usable information from the mass of material in the information flow" (Hudson 1990, p. 5). Such difficulties are held to cloud the issues and to increase the complexity of decision making, resulting in the retardation of the process.

3.3 Humans as Data Processing Systems

Individuals' perceptual and thinking behaviour (collectively referred to as their "cognitive style"), which at times is task- and situational-dependent, has been shown to exhibit pervasive tendencies (Zmud 1979). Such predilections are significant to the process of decision making to the extent that they introduce biases into the human inferencing system. It is these individual differences in stimuli perception and cognitive processes that contribute to the diversity of human responses to particular task environments (Bateman 1976).

The importance of this area of investigation to the economic well-being of agriculturalists can be attributed to the significance of the Lichtenstein and Fischhoff (1977, p. 160) assertion that

> The quality of people's probability assessments sets an upper limit on the quality of their functioning in uncertain environments.

Humphreys and Berkeley (1983) also observed that, in any attempt to aid decision makers with the view to reducing such biases, the critical point to note is that it is necessary to understand the inferencing structure employed prior to provision of assistance. On this basis reference to the human capacity for probabilistic inferencing appears relevant to this study.

3.3.1. Humans and probabilistic inferencing

In agricultural economics the convention has been that market outcomes are to be viewed as the products of a random process and that producers need to construct some form of stochastic modeling of the process to aid in the description of the likelihood of future outcomes. The efficiency of decision making in a stochastic environment is seen to be dependent on decision maker ability to effectively achieve the specification of such probability distributions (Anderson 1974).

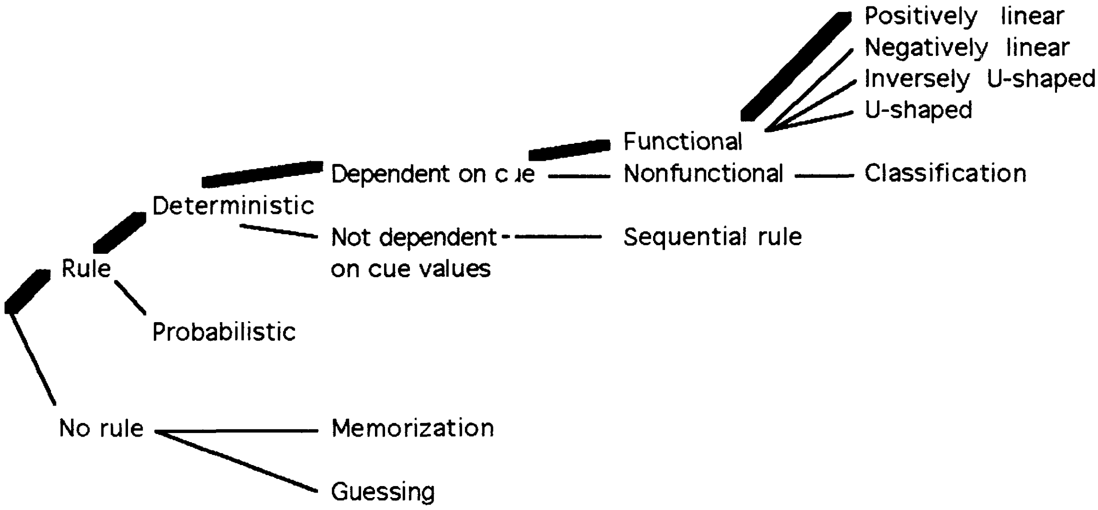
In making such an assumption (that market outcomes be considered the result of a chance-generating system), though one consistent with the treatment of market variation in most normative decision structures, it is necessary to recognise that it may be just as plausible to suggest that producers model markets in a deterministic fashion. A producer who has some idea of supply and demand theory, in its basic form a deterministic model, is unlikely to view the market place as a chance-generating process. Hence, rather than look for probability distributions in the observed instances, producers may be expected to look for a deterministic process and, for example, predict outcomes on the basis of representativeness. That is, they would be expected to try to "pick the market" or outcomes instead of looking for random variation around a mean or a trend line. Such a process would be consistent with an observation made by Nisbett et al. (1983, p. 345):

> Even though people recognize the possibility of error in their judgements of social situations, they do not try to construct probability models; rather they rely on the representativeness heuristic.

While the preceding may suggest that the search for human cognitive schemata consistent with the principles of Bayesian statistics is a fruitless field of enquiry, the question remains as to whether inherent human ability is a bar to the "real world" application of decision structures dependent on a given level of conceptualisation of variance in the decision world (and, by implication, at what level of Humphreys and Berkeley's (1983) taxonomy of decisions do mortals normally operate?).

In a study of managers' perceptions of variance in their decision environment Green (1967) observed that managers have difficulty with the concept of variance around some average variable and that they often try to "explain" random error. Further, he suggests that requests of managers to add "uncertainty" to their forecasts may be seen to reflect adversely on their ability to forecast the variable concerned. This observation is supported by Conrath (1973) who suggests that managers are more at ease with point estimates of decision variables and that, in fact, they have difficulty in conceiving of probability distributions. March and Shapira (1987, p. 1407) make a similar observation of managerial behaviour in stating that "there is little inclination to equate the risk of an alternative with the variance of the probability distribution of possible outcomes that might follow choice alternatives."

These observations are consistent with results obtained in a series of experiments involving probabilistic inferencing tasks conducted by Brehmer (1980) in which he traced the hierarchy of environmental (task) modeling strategies used by his subjects. The results (summarised in Figure 3.2) show a strong propensity by subjects to seek evidence of causality in the environment rather than view the tasks as being probabilistic in nature.



Source: (Brehmer, 1980 p. 231)

Figure 3.2 Summary of Results From Studies on Probabilistic Inferencing Tasks

> As shown in this figure, subjects prefer to assume that there is a rule, rather than that there is no rule, that this rule is deterministic, rather than probabilistic, that the values to be predicted from the cue values do in fact depend on these cue values, rather than on other aspects such as trial number, that the rule is functional, rather than nonfunctional, and that the rule is a positive linear function, rather than any other function. If the hypothesis about linearity fails, the subjects try some of the other functional rules before backtracking their decision tree, trying a nonfunctional rule, or a rule that does not assume cue dependence, such as a sequential rule, meaning that the ordinal number of the cue values, rather than their actual values, are used to form their hypothesis. For example, the subject may believe that low criterion values are regularly followed by high criterion values, or *vice versa*. When these rules fail, the subjects tend to assume that there is no rule at all, rather than to seriously consider the possibility that the rule may be probabilistic in character. Therefore, they go to a memorization strategy, or they may just give up and guess (Brehmer 1980, p. 232).

In summary, such work would suggest that in general people do not have the cognitive schemata capable of the efficient conceptualisation of decision environments in terms of a statistical model of probability. However, such stochastic schemata may be hidden given "inferential goals are such that at least some violation of statistical principles should be regarded as a form of satisficing, or cost-efficient inferential shortcuts" (Nisbett et al. 1983, p. 340).

These contentions, along with the summation that the empirical evidence neither confirms nor denies the hypothesis that producer's price forecasts are in fact consistent with rational expectations (Freebairn 1976), lead to the question as to how people actually do make inferences about the environment in which they operate.

3.3.2. Integration of data and information

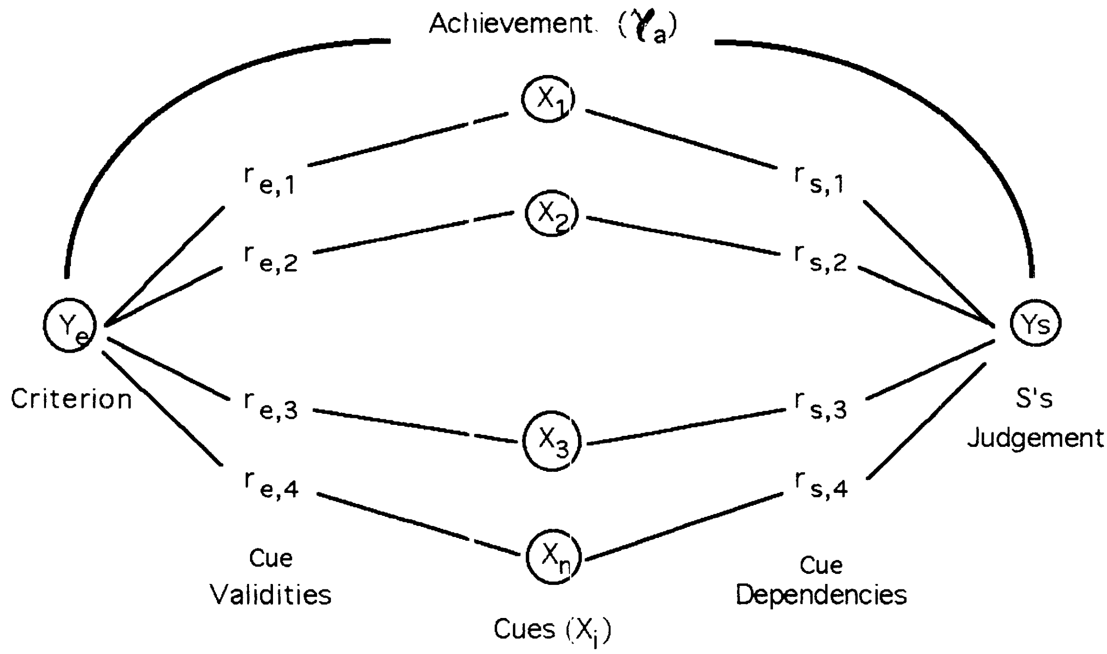
Initially, it is necessary to draw a distinction between the integrating of data used to format expectations for subsequent utilisation as data inputs to a particular decision structure and the manipulation of the data within a decision structure. Whilst there are similarities between some of the descriptions of the former, a predominantly mental task, and components of the decision structures reviewed, in this section concentration is on the processes by which decision makers integrate data derived from various sources in the decision world. In essence, this section is an attempt to scratch the surface of Dretske's (1983, p. 55) question "... what is this interpretive ability that can transform 'meaningless' stimuli into thoughts, beliefs and knowledge?"

The regression approach to the modeling of judgement

The regression approach to the study of the judgement process is characterised by its use of multiple regression and analysis of variance (ANOVA) techniques (Slovic and Lichtenstein 1971). Typically, two types of paradigm have been employed in experimental investigations related to the regression approach, namely the "correlational" and the "ANOVA" paradigms.

Experimental investigations based on the correlation paradigm rely on the investigation of the relationships between the cues available to the inferring person and the expressed judgements or inferences. The investigation of the relationships between current market price, last year's realised price, official forecast prices and the price expectations held by producers would be consistent with this approach to research.

Brunswik's (1956) lens model, illustrated in figure 3.2 , provided the basis for the development of the correlationist's approach. It describes the efficiency with which cues may transmit information about the criterion to the subject, the correlation between judgements and outcomes, cue validities and cue dependencies.



(Source: Brunswik 1956)

Figure 3.3 Lens Model of Judgement

In Tucker's (1964) development of the lens model, the correlation between the judgement (estimated value) formulated on various cues relating to the criterion being estimated is derived on the basis of the formula

$$\gamma_a = GR_eR_s + C\sqrt{1-R_e^2}\sqrt{1-R_s^2}$$

Where

γ_a = the correlation between Y_e and Y_s

G = the correlation between the linear prediction of Y_e and Y_s from the cue values

R_e = the multiple correlation between the cues and Y_e

R_s = the multiple correlation between the cues and Y_s

C = the correlation between the unpredicatable components of the task system and the subject's judgemental system which is unaccounted for by linear component G.

Hammond and Summers (1972) were able to show, using Tucker's (1964) developments, that humans were able to derive quite accurate knowledge (models) (as indicated by G values of .98 and .99) of both linear and nonlinear three cue probabilistic inferencing tasks. This, along with the consistently low correlations between criteria and judgements (for example, low values of γ_a, that is low correlation between Y_e and Y_s) observed, led to the conclusion that, while able to develop "correct" inferencing strategies, people were inconsistent in their application. This frailty has been addressed in the decision aiding approach, generally referred to as "bootstrapping" (Slovic and Lichtenstein 1971, Davis and Olson 1988).

Using such an approach, Yntema and Torgerson (1961) demonstrated that the vast majority of judgemental responses could be predicted using linear models of cue integrating in a varied range of tasks.

Whilst linear models of human judgement (cue-judgement relationships) appear to be reasonably predictive, verbal introspection indicates that judges believe that cues are integrated in a variety of nonlinear ways. It is suggested that cues may relate to judgements in a curvilinear manner or a configural manner. In this context "configurality" is taken to mean that a "judge's interpretation or weighting of an item of information varies according to the nature of other available information" (Slovic and Lichtenstein 1971, p. 659). This would be illustrated by the demonstration of difference in weight given to equivalent rises or declines of the wool market indicator on days of high and low trading or during periods of relative market stability or instability.

The excessive complexity of the introduction of cross-product terms into the models describing judgement, to account for configural effects, has prompted a number of researchers to adopt ANOVA techniques in attempts to capture the linear, curvilinear, and configural aspects of the judgement process (Slovic and Lichtenstein 1971).

The Bayesian approach to the modeling of judgement

The applications, reported in the psychology literature, of the Bayesian approach to the description of judgement are seen by Slovic and Lichtenstein (1971) as being firmly embedded within the framework of decision theory. The expression of opinions (judgements of likelihood) in terms of subjective or objective probabilities and the integrating of new information via Bayes's theorem form the basic tenets of this approach. As a normative theory Bayes's theorem prescribes how data should be integrated, in a statistically correct fashion, to form an estimate of the occurrence of a particular state of nature in the form of a distribution of the probabilities of occurrence of each state in the hypothesised set of states of the world.

Where such probability distributions are definable for the various potential states of nature within a probabilistic choice situation, they can be combined with a range of outcome-valuing scales and utilised in various maximising choice rules. This is illustrated by Schroeder and Featherstone's (1990) application of decision theory to the question of retention or sale of livestock in a breeding herd.

These two approaches to the modeling of the human judgement process suggest differing data composition procedures. The regression approach is founded on a global measure of the impact of all data, with modification to each piece of data based on dimension or data source correlations. In the Bayesian approach, the source or dimensionality of the datum is irrelevant, with each piece of data being assessed individually on the basic measure of its subjective likelihood ratio (Slovic and Lichtenstein 1971).

In summation, Edwards (1971, p. 647), commenting on work founded on these two approaches to modeling human inferencing, suggests that "no one has even begun to ask which works better, when". Yet, whilst not excluding the possibility that alternate hypotheses may be capable of describing producers' expectations in the Australian wool industry, Fisher (1983, p. 219) concludes that "the rational expectations hypothesis provides a valid way of modelling short-term *aggregate* expectations in the wool industry" (emphasis added).

3.3.4. Models of Data Integration

"Integration theory" (Anderson 1968, 1969, 1970) is an example of the analysis of variance approach to evaluating judgement.

A piece of information in integration theory is represented by subjective scale value and a weight, the weight being the salience or importance of the information. The basic model is

$$R = C + \sum_{k=0}^{n} W_k S_k$$

Judgement (R) is seen to be the sum of weighted and scaled values of the initial opinion held ($W_o S_o$) plus additional items of information.

Levin, Johnson and Faraone (1984) suggest a weighted averaging model to account for the information integration. An averaging process was introduced to account for the observation that the effect of increasing the number of dimensions relevant to the integrating is to decrease the effect of a particular stimulus.

$$R = \frac{W_o S_o + W_1 S_1 + W_2 S_2}{W_o + W_1 + W_2}$$

Where: R = response; W_1 and S_1 are weight and scale values respectively;

W_o and S_o are the weight and scale values of the subject's initial opinion or response.

Levin, Johnson and Faraone (1984) further developed this model in an attempt to account for responses where the subjects were deprived of information describing S_2 yet were inclined to infer the value of S_2 given a value for S_1. The model becomes

$$R_{inferred} = \frac{W_oS_o + W_1S_1 + W'_2S'_2}{W_o + W_1 + W'_2}$$

W'_2 and S'_2 are the inferred weights and values of the second stimulus.

Given such an analysis, a producer presented with data describing changes to the wool market indicator and sales volumes may infer an alteration to market prices at variance to inferences based on the single cue of change in the market indicator price. In the latter case the producer may attempt to infer the level of sales volume, in which case the difference between R and $R_{inferred}$ will be a function of the producer's ability to infer W'_2 and S'_2 on the basis of S_1. Alternatively the response may be based on the integrating of the sole stimulus. In such a case the model contracts to,

$$R = \frac{W_oS_o + W_1S_1}{W_o + W_1}$$

In general, Levin, Johnson and Faraone (1984, p. 101) conclude that "traditional averaging models provide a good description of how responses vary over stimulus combinations in a wide variety of informational tasks" and that " inferences on interstimulus relationships appear to occur only when the relationship between stimulus dimensions is strongly established and when the missing information is deemed crucial to the required judgement."

An alternate description of information integration is provided by Ashton and Ashton (1990) in the form of the "contrast/surprise model for updating beliefs", originally proposed by Einhorn and Hogarth (1985 a), which attempts to account for a number of data and information (referred to as evidence) characteristics excluded from consideration in the normative models of inferencing.

> The Einhorn and Hogarth (1985 a) model requires little working memory or computational ability, involves an anchoring-and-adjustment revision strategy and relies on the notion that people are sequential information processors with limited capacity. New

evidence is evaluated as supporting (positive evidence) or not supporting (negative evidence) a single hypothesis or current belief, and the evaluated evidence is used to update the current belief. The revised belief then becomes the anchor for the next adjustment, and the process continues sequentially.

The model differs in important ways from the Bayesian model of belief revision. While the normative appeal of the Bayesian model is strong because it is a logical consequence of conditional probabilities and can be embedded easily in a general theory of rational choice, research has established that it is incomplete as a descriptive model of belief revision. Like Bayes' theorem, the contrast/surprise model incorporates the evidence characteristics of direction, strength, and type. Unlike Bayes' theorem, however, it also incorporates order, presentation mode, and one's 'attitude' towards evidence, all of which is normatively irrelevant.

Direction of evidence refers to whether the new evidence is positive or negative with respect to the current belief, while evidence *strength* refers to its conclusiveness. Evidence *type* refers to whether all the additional evidence is of the same direction (either positive or negative), referred to as consistent evidence, or whether some is positive and some negative, referred to as mixed evidence. The contrast/surprise model explicitly considers the fact that evidence possessing these characteristics can be combined in different *orders* and displayed via different *presentation modes*. Note that evidence can be presented sequentially, as assumed in discussions of order effects , and one's belief revised after each piece of evidence is received. Alternately, evidence can be presented 'simultaneously', or all at once, and one's beliefs revised only once in response to all of the evidence. The Einhorn and Hogarth (1985 a) model predicts smaller revisions for either sequential or simultaneous presentation, depending on the individual's responsiveness to evidence. Specifically, the model predicts smaller revisions for *sequential* presentation for individuals who are evidence-insensitive, and smaller revisions for *simultaneous* presentation for individuals who are evidence-sensitive. Evidence insensitivity implies a reduction in the subjective strength of evidence, while evidence-sensitivity implies that the evidence gains

> in subjective strength - because of one's 'attitude' towards evidence. Einhorn and Hogarth (1985 a) label the smaller revisions that result from the combination of sequential (simultaneous) presentation and evidence-insensitive (evidence-sensitive) attitudes as 'dilution' effect. (Ashton and Ashton 1990, p. 5)

A model with the capacity for the accommodation of ambiguity affects in the inferencing process is proposed by Einhorn and Hogarth (1985). Ambiguity is deemed to arise from limitations to the decision maker's understanding of the processes that generate the outcomes to be inferred from available data. The postulated "anchoring-and-adjustment" strategy for assessing probabilities is structurally similar to the data-integrating models proposed by Anderson (1968,1969, 1970) in that final judgement as to an event probability $S(P_A)$ is seen to be a function of an initial estimate of the probability P_A and the net effect of the adjustment process, k.

$$S(P_A) = P_A + k$$

The model hypothesises a mental simulation of alternate values of P which are then incorporated in the adjustment term k. Further, three factors are seen to influence k (the net effect of simulation): (a) the value of P_A : $-P_A / k / (1-P_A)$; this sets the maximum downward and upward adjustment respectively; (b) the absolute level of ambiguity perceived (Ø); the greater the perceived ambiguity the greater the level of adjustment: 0 / Ø / 1; and (c) the person's attitude toward ambiguity in the circumstances (ß); this factor accommodates the tendency to apply differential weights to values of P that are greater or smaller than P_A.

The algebraic expression of the adjustment process is;

$$k = k_g - k_s$$

where imagined value of P greater and smaller than P_A are denoted by k_g and k_s respectively. For any given P_A the maximum possible upwards adjustment (k_g) is $1 - P_A$, the corresponding downward maxima (k_s) being P_A.

The influence of k_g and k_s on the adjustment term k is said to be moderated by the absolute level of ambiguity perceived (Ø) as described by the equations

$$k_g = Ø(1-P_A)$$

and

$$k_s = ØP_A.$$

This assumes an equal weighting of upward and downward adjustments of P_A.

To accommodate differentiality in weighting, Einhorn and Hogarth (1985) incorporate a weight ß relevant to the downward adjustment term (k_s) such that

$$k_s = ØP_A^{ß} \quad (ß \geq 0)$$

The full model of probability inferencing under conditions of ambiguity becomes

$$S(P_A) = P_A + Ø(1- P_A - P_A^{ß}).$$

The authors draw several points from this equation: (1) Ø (level of felt ambiguity in the situation) influences the absolute size of the adjustment factor; (2) $S(P\ )$ is regressive to P ; (3) "complementary probabilities are additive if Ø = 0, or ß = 1, or P_A = 0,1; otherwise, there is subadditivity if ß < 1, and superadditivity if ß > 1. (Einhorn and Hogarth 1985a, p. 438).

With respect to the two parameters Ø and ß the authors make the following comments.

> The Ø parameter reflects perceived ambiguity and the degree to which one simulates values of P that might be. However, situational factors are also likely to affect Ø, for example, the absolute amount of evidence available, the unreliability of sources, lack of causal knowledge regarding the process generating outcomes, and so on. The ß parameter reflects the extent to which one differentially weights in imagination possible values of P that are

> smaller versus larger than p_A.
> As such, ß may be related to an optimism-pessimism attitude at the individual level. However, we argue that ß is also influenced by situational variables such as the sign and size of the payoff that are contingent on the ambiguous probability. (Einhorn and Hogarth 1985a, p. 438)

It is claimed that this theory, by way of the underlying simulation process, provides a "plausible psychological mechanism" to account for a number of observed deviations of human inferencing regarding ambiguous probabilities from that predicted by the normative theories of judgement (Einhorn and Hogarth, 1986).

3.3.5. Bayesian conservatism

From the Bayesian approach to the modeling of inferencing there has been consistent reporting of conservatism in subjects' revisions of probability estimates. Various authors have sought the explanation of this prevalent shortcoming in three areas: (1) misperception; (2) misaggregation; and (3) artifact hypotheses (Slovic & Lichtenstein, 1971).

Misperception is taken to be a misunderstanding of the process that generates the stimuli received. This may be the result of human lack of the cognitive schemata capable of the efficient conceptualisation of the inferencing task in terms of a stochastic model of probability. It could result, too, from the inappropriateness of the use of probability theory as a description of the data-generating processes. The latter, whilst inconsequential in laboratory trials using the classic experimental techniques, such as poker chips and bags, is a possibility in agriculture where production outcomes are influenced by both pre-ordained actions (that is deterministic, for example, number of sheep retained for breeding) and chance events (that is probabilistic, for example, bad weather during lambing resulting in large post-natal losses).

The second source of error, misaggregation, is suggested to be the result of difficulties encountered in the aggregation of data (Davis & Olson, 1985). Limited computational capacity appears to hinder the normatively correct aggregation of data by humans in probabilistic inferencing tasks. This statement, however, assumes that the subjects are in fact attempting to apply a statistically "correct" form of data aggregation in the first place.

Prominent in the area of misaggregation has to be the recognition of the "base rate fallacy" with the consistent underweighting of base rates and the associated overweighting of "representativeness considerations" in probability inferencing. The relative weight afforded base rates is suggested to be influenced by (1) the degree of causality that can be attributed to the base rate reported, (2) the degree of specificity of base rate information relative to other information provided and (3) the general lack of vividness or saliency of base rate information when it is conveyed in conjunction with other "individuating" information (Bar-Hillel 1983).

The "artifact" hypothesis links conservatism in probability estimation to the observation that "subjects are capable - and optimal - when dealing with responses in the odds range from 1:10 to 10:1, but are conservative when forced, either by the accumulation of many data or by the occurrence of one enormously diagnostic datum, to go outside that range" (Slovic & Lichtenstein 1971, p. 697).

3.3.6. Inferencing by heuristics and the normative standard

Given the shortcomings of humankind's attempts to mimic the cognitive and computational ability of "statistical man", and the observation that life requires people to continuously make judgements, some would suggest a need to rephrase Edwards (1971) question as "What is he doing *when he is undertaking inferential tasks* ?" Many may answer "He's doing the best he can; *he's using heuristics* ". The utilisation of these rules of thumb appears consistent with Brehmer's (1980) observations of human preferences in their addressing of probabilistic inferencing tasks. However, the application of heuristics result in judgements that may deviate from those derived from statistically coherent methods.

In general, discrepancies between human inferencing and the normative standard resulting in "serious errors of inferencing" are seen to arise from the lack of adequate consideration of such factors as sample size, correlations, and base rates (Nisbett et al. 1983, p. 340). Davis and Olson (1985, p. 248) list four deficiencies which they consider to be consistently exhibited by humans in probabilistic inferencing situations: "(1) lack of intuitive understanding of the impact of sample size on sampling variance, (2) lack of intuitive ability to identify correlation and causality (3) biasing heuristics for probability estimation and (4) lack of capacity for integrating information".

A number of heuristics for probability estimation have been identified. Kahneman and Tversky (1973) suggest that people regularly apply a heuristic termed "representativeness" in inferencing tasks. In fact, they were able to show that people regularly made predictions on the basis of the predicted outcome's apparent similarity to the evidence on which the prediction was made. That is, an inferred future outcome was chosen because it appeared to represent the data (information) on which the judgement was made. This results in insensitivity to the reliability of the evidence and to prior probability of the outcome in inferencing tasks (the base rate fallacy), in violation of the logic of statistical predictions. Where subjects have been shown to infer on the basis of representativeness , over-confidence in the accuracy of their predictions and fallacious intuitions concerning statistical regression have been observed by Kahneman and Tversky (1972).

In addition to these heuristics, there are a number of features of human inferencing techniques which lead to information distortion such as "primacy effects" (Asch 1946, Anderson and Barrios 1961, Mynatt, Doherty and Tweney 1977, Wallsten 1981), "recency effect" (Anderson and Hubert 1963) and "value induced distortions" (Irwin 1953, Irwin and Snodgrass 1966, Delaney and Wallsten 1977).

Whilst these examples demonstrate that people, in certain situations, use statistically inept heuristics, there is evidence that in other situations heuristics employed have a fundamentally correct basis. To illustrate this, Nisbett et al. (1983, p. 345) examined the process of generalisation. They concluded that it was difficult to see how people could generalise about a given population from an exhibited sample "without the application of at least a rudimentary version of a law-of-large-numbers heuristic".

Given the existence of heuristic approaches to inferential tasks and the observation that these heuristics vary in their statistical credibility it appears valid to address the following questions. First, what factors influence the selection of heuristic procedures from the decision maker's repertoire? Second, is it possible though the structuring of information systems to enhance the chance of selection of statistically-orientated heuristics?

In relation to the first question Nisbett et al. (1983, p. 346) suggest that

> three factors - clarity of the sample space and the sampling process, recognition of the role of chance in producing events, and cultural prescriptions to think statistically - operate individually and, perhaps more often, together to increase people's tendencies to apply statistical heuristics to problems that require a statistical approach.

Further, they suggest that formal statistical training is apt to enhance the possibility that people will view probabilistic situations in a more statistically correct way.

The existence of these variables suggests that information systems may in fact be altered in such a way as to influence the selection of heuristics by producers who are required to undertake inferential tasks.

3.3.7. Cue salience and utilisation

A significant volume of work, based on a correlationist approach, has been published on interrelationships between cues in the judgemental process with the basic aim of the differentiation of factors determining cue weighting. Brief reference to a number of the factors influencing both the weighting and utilisation of cues follows. Such influences are at times partially responsible for the divergence of human inferencing from that of "statistical man".

Cues in agreement have been shown to be weighted equally and to be utilised in the integrating process, whilst disagreement between cues results in the focusing of attention on one cue and the incorporation of additional cues to resolve the conflict (Slovic 1966). The variability exhibited by a highly salient cue was shown to influence the weighting of the particular cue, with Uhl and Hoffman (1958)(cited by Slovic & Lichtenstein 1971) demonstrating a positive correlation between cue variability and cue weighting. However, this effect was not recorded with minor cues. Knox and Hoffman (1962) demonstrated that inferences could be influenced by changes in the scale of data presentation.

Significant was the subject's reluctance to make judgements over a range which was greater than that of the data presented.

In a 1971 summation of the work to date relating to the influence of the number of cues (data sources) on judgement, Slovic and Lichtenstein (1971, p. 687) concluded that

> .. there is a small amount of evidence that increasing the amount of information available to the decision maker increases his confidence without increasing the quality of his decisions and makes his decisions more difficult to predict.

Dorris, Sadosky and Connolly (1977) addressed the same question, examining the impact on inference quality of the amount of data and information supplied to decision makers, presented with inference problems for which statistical data was available. In this experiment, quantity of data, defined as the number of independent variables (data sources/cues), was differentiated from the amount of information, defined as the fraction of the dependent variable variance which could be explained by the set of data sources. This experiment led the authors to conclude that

> ... the ability of the human operator to utilize numerous input data is quite limited. Beyond five input data variables, performance may be depressed. With respect to the design of data input systems, these results suggest that redundant (intercolerated) data should be used when possible.
> (Dorris, Sadosky and Connolly 1977, p. 648)

It is of interest to note that the causal mechanism of data and information redundancy may be related to its role in the development of search patterns in a probabilistic decision environment (Simon and Newell 1971).

It has also been hypothesised that cues in a format or unit compatible with that of the required response will be considered more salient than cues requiring transformation (Slovic & Lichtenstein 1971). Such a hypothesis suggests that market reports in a foreign currency (for example, US dollar corn quotes) would not be considered as salient as quotes in domestic currencies. Similarly, time series market price data may not impact as much on the formation of variance expectations as would the appropriate calculated measures (from the same data) of variance compatible with the variance measures utilised in the decision structure to be applied. In fact, Conrath (1973) was able to demonstrate changes in choice behaviour by the manipulation of the format in which probabilistic data were presented. This effect was attributed both to the increase in saliency of a piece of data and to greater attention being paid to a particular dimension in the choice space to which the cue related.

3.3.8 Idiosyncratic influences on information evaluation

Whilst difficult to incorporate into generalised recommendations regarding the structuring of Management Information Systems (MIS's) appropriate to the Australian rural producers in aggregate, recognition of the impact of idiosyncratic influence on the integration of data is of value in understanding the complexities of judgement.

A consistently reported bias in information evaluation has been the observed over-confidence that individuals place in their own judgement. This appears to be partially explained by the selectivity people exhibit towards information, which results in greater weight being given to data of a confirmatory nature along with neglect of contradictory evidence. Koriat, Lichtenstein and Fischhoff (1980) were able to achieve a partial amelioration of this bias through mechanisms that increased the saliency of evidence which was contradictory to a particular judgement.

In a review of the literature on the psychology of individuals' usage and evaluation of certain types of information, Dermer (1973) concludes that the process of information selection and evaluation is both idiosyncratic and related to an individual's cognitive make-up. From the analysis of experimental work carried out in the field of accountancy, Dermer (1973) was able to show that people with a predisposition to avoid ambiguous situations placed a greater value on internal and non-behavioural information (for example,, financial and operational information), which is the most well-defined and certain of all information available, and less value on current and future internal behavioural information relating to particular decision situations. Work such as this, which illustrates the idiosyncratic nature of information evaluation, is significant to the evaluation of information systems in so far as it indicates that the measurement, apart from that by the consumer, of the utility of a particular type of information, e.g. current market prices, could well be invalid.

In a series of studies, in which auditors and executives were required to undertake inferencing tasks, Ashton and Ashton (1990) were able to demonstrate differences in responsiveness to evidence (data and information) relating to the positive/negative characteristics of the information and to the presentation format (sequential/simultaneous) of the information. It was concluded that the education, training and professional environment of auditors as opposed to that of business executives, were significant causal factors in this observation.

Davis and Olson (1985, p. 251) suggest that idiosyncratic decision behaviour can be traced to an individual's positioning along two continuums, descriptive of cognitive style. The perceptual processes involved in information gathering are seen to extend from one extreme of 'perceptive individuals', "who focus on the relationships among data items and attempt to generalize from them about the environment", to 'receptive individuals' who "focus on the details and attempt to derive specific knowledge about the environment from the available data". The second continuum mentioned by the authors is that of the variance between 'systematic' and 'intuitive individuals'. The former is more likely to follow a structured, deductive approach to decision making; the latter to be more inclined to use heuristics, trial and error methods, to act spontaneously and be more responsive to non-verbal cues.

In summary, individuals have been shown to react differently to data presentation formats, to engage in different inferencing procedures and to search for and utilise varying amounts of information. Such variations have been correlated with differences in measures of individuals' cognitive complexity (Zmud 1979).

3.3.9 Selection of inferencing techniques

The general characteristics of heuristic decision making as exhibited by Australian producers are described in the following terms by Watson (1983, p. 41);

> Under heuristic decision making the manager represents his environment largely through observation, and what cannot be observed is typically suspected as being unworkable or irrelevant. Heuristic thinking involves trial and error probing, breaking the perceived problem down into subproblems which are solved by rule of thumb, and 'satisficing', that is, being content with acceptable

> levels of goal attainment to avoid the extra effort of finding an optimum solution.

The reversion to heuristic forms of data integrating is seen by a number of authors as being a form of satisficing. Nakajima and Hotta (1988) suggest that the propensity to resort to simplifying heuristics, with their associated reduction in optimisation efficiency, is linked to the complexity of the task at hand. The more complex a task, requiring greater mental effort and abilities, the greater the tendency to trade reduced accuracy for reduced effort.

However, reversion to the application of heuristics may also follow the initial application of appropriate decision rules to complex multi-attribute problems where a decision maker is repeatedly exposed to the same or similar problems (Svenson 1979).

The selection of a "cognitive option" for the processing of information on which inferences are to be based is considered by Howell and Burnett (1978, p. 66) to be influenced by a range of factors including "response requirements (frequency estimation vs probability estimation vs prediction vs choice)", the type of "uncertainty event (frequentistic vs nonfrequentistic, internally vs externally generated, known vs unknown generators)" moderated by the "ease of event encoding and span of events over which judgements may apply". It is the contention of these authors "that man is both an able intuitive statistician and a pragmatic rule maker depending on what he is asked to do with the uncertainty information.". This work has led to the postulation of "a taxonomy of measurement tasks together with their implications for judgement data" displayed below in Table 3.1.

Support for the concept that probability inferencing is reliant on the aggregation of a number of cognitive elements is found in the Wallsten and Budescu (1983a, p. 153) description of the mental processes of an individual faced with a request to provide a subjective probability estimate.

> ..... rather an individual's opinion is more-or-less vaguely formulated, and upon being asked to evaluate the probability of an outcome, a person will search his or her memory for relevant knowledge, combine it with the information at hand, and (presumably) provide the best judgement possible. That judgement

> will depend on what is retrieved from memory, what aspects of the current information are utilized, and possibly on the sequential order in which this is all integrated into a unified opinion.

Howell and Burnett's (1978) approach, whilst requiring further validation, is of particular interest to the analysis of inferencing in an agricultural decision environment as it draws attention to the possibility of different cognitive approaches to inferencing being related to uncertainty measures dictated by the task, and inference outcomes being disproportionately influenced by various cognitive elements.

Consider the decision structure of stochastic cash flow budgeting. Certain critical elements are included as probability distributions (usually triangular distributions). This task would be described in the above taxonomy as a probabilistic estimation while the less critical elements (inputted as point estimates) would be considered to be a prediction. Alternatively, the distinction between a practiced internal event generator and known external event generator can be considered similar to the difference in the task confronting a producer estimating the outcome of crop yields (an outcome over which the producer has a degree of control through the controlled application of certain inputs , for example, water, fertilizer and seed) and the task of estimating the sale price of the crop at a given date (the outcome of which is significantly impacted upon by factors external to the producer's sphere of control).

Table 3.1

Summary of Task, Event, and Cognitive Element Categories Comprising The Taxonomy

	Event		Cognitive elements stressed				
Task	Kind	Generator	FR[a]	PGK	H	SB	CB
A: Frequency estimation	1. Frequentistic	Unknown external	(x)		[b](X)		
	2. Frequentistic	Known external	(x)	x	x	x	
	3. Frequentistic	Unpracticed internal	x				(x)
		Practiced internal	(x)	x		x	x
B: Probabilistic estimation	1. Frequentistic	Unknown External	x		x		
	2. Frequentistic	Known External	(x)	x	x	x	
	3. Frequentistic	Unpracticed internal	x				x
		Practiced internal		x	x		
	4. Nonfrequentistic	Practiced External		x	x		
	5. Nonfrequentistic	Practiced Internal		x	x		x
C: Prediction (short event span)	1. Frequentistic	Unknown External	x		x	x	
	2. Frequentistic	Known External	(x)	x	x	x	
	3. Frequentistic	Unpracticed internal	x		x	x	x
		Practiced internal	(x)	x	x	x	x
	4. Nonfrequentistic	Practiced External		x	x		
	5. Nonfrequentistic	Practiced Internal		x	x		x
D: Choice	(no present basis for distinction from C above; hypothesized greater involvement of utility considerations)						

[a] FR, Frequency record; PGK, prior generator knowledge; H Heuristics; SB, selective bias; CB confidence bias.

[b](x) designates secondary involvement.

Source: Howell and Burnett 1978, p. 66

Further, the taxonomy is of interest in the general debate as to relevance of various agricultural decision models. Normative models which treat outcome variance as the product of an unknown frequentistic external generator would, by extension, expect inferences as to input variables to be based on recorded past frequencies, in accordance with the dictates of Bayes's theorem. Producers who possess significant experience selling into a particular market could be expected to have some knowledge (or at least a belief in their analysis of the market). Such knowledge would result in the producer's perception of the market process being classified as an 'external known generator' within the Howell and Burnett (1978) taxonomy. Inferences in such a situation are reported to be influenced by the cognitive elements of "prior generator knowledge", "heuristics" and "selective bias" with a secondary involvement by "frequency records" of the disturbance process. Whilst not pursued in this thesis, this explanation of the disparity between human inferencing and Bayesian judgement appears to be of relevance to understanding primary producers' formation of expectations.

3.4 Verbal and Numerical Probability Encoding & Decoding

The communication of market information to primary producers relies almost entirely on audible and visible stimuli. For effective communication to occur these physical stimuli need to be received and decoded by the recipient so that there is a high degree of correspondence between the concepts or data originally encoded by the source and the decoded message registered by the recipient. The processes of data communication will be discussed at length in a later chapter. However, to remain consistent with the structure of this thesis, human constraints on the effective communication of risk (probabilities) are discussed here.

Where decision structures require point estimates or estimates of risk (specific measures of event probability) as inputs, producers wishing to avail themselves of such decision aids will be required either to form their own expectations as to the distribution of the particular variable or adopt probability measures communicated to them from an external source. To achieve the transfer of data to facilitate the former, or to provide the latter, agricultural information systems utilise both numerical and verbal forms of communication (here, verbal is taken to be either the written or spoken word) or a combination of the two.

Yet there appear to be grounds to suggest that the efficiency of risk communication may be influenced by the format of the communication, as the following observation of managerial behaviour by March and Schapper (1987, p. 1405) suggests.

> ....that individuals look at only a few possible outcomes rather than the whole distribution, and measure variation with respect to those few points; and that they are more comfortable with verbal characterisations of risk than with numerical characterisations even though the translation of verbal risk expressions into numerical form shows high variability and context dependence.

In fact, Kahneman and Tversky (1982) go so far as to state that the standard calculus of probability will be at times incompatible with the state-of-mind-dependent notions of probability communicated in natural language. This point is illustrated by the authors in the following quotation, in which the natural language expressions of event probabilities are shown to be characterised by sincerity conditions and test of validity.

> Consider, for example, the prediction: 'I think that the price of gold will be higher by 50% in six months than it is today'. Taken literally, this is a point-prediction, which should be assigned a very small probability of confirmation. But the prediction is not intended to be taken literally. Point predictions are normally understood as comparative statements, or as statements of the range in which an outcome is expected to fall, e.g., 'I think the increase in the price of gold will be nearer to 50% than to x% or y%' . The speaker and the listener normally expect to agree on the tacitly implied values of x and y. For example, the forecaster cited above will be considered remarkably accurate if the price of gold actually rises 53% in the next three months, although the forecast was not strictly true. Thus a speaker who asserts a numerical prediction is committed to a range rather than a point. The speaker is also committed to the proposition that the value is about equally likely to be above the estimate as below it, except when the nature of the prediction makes this impossible. Thus, a person who says 'I think the price of gold will rise by 50% in the next six months would be considered to be deliberately misleading

> if he or she also thought, but did not communicate, that the actual value was much more likely to be above the estimate than below.
> (Kahneman and Tversky 1982, p. 149)

3.4.1 Verbal communicators of risk

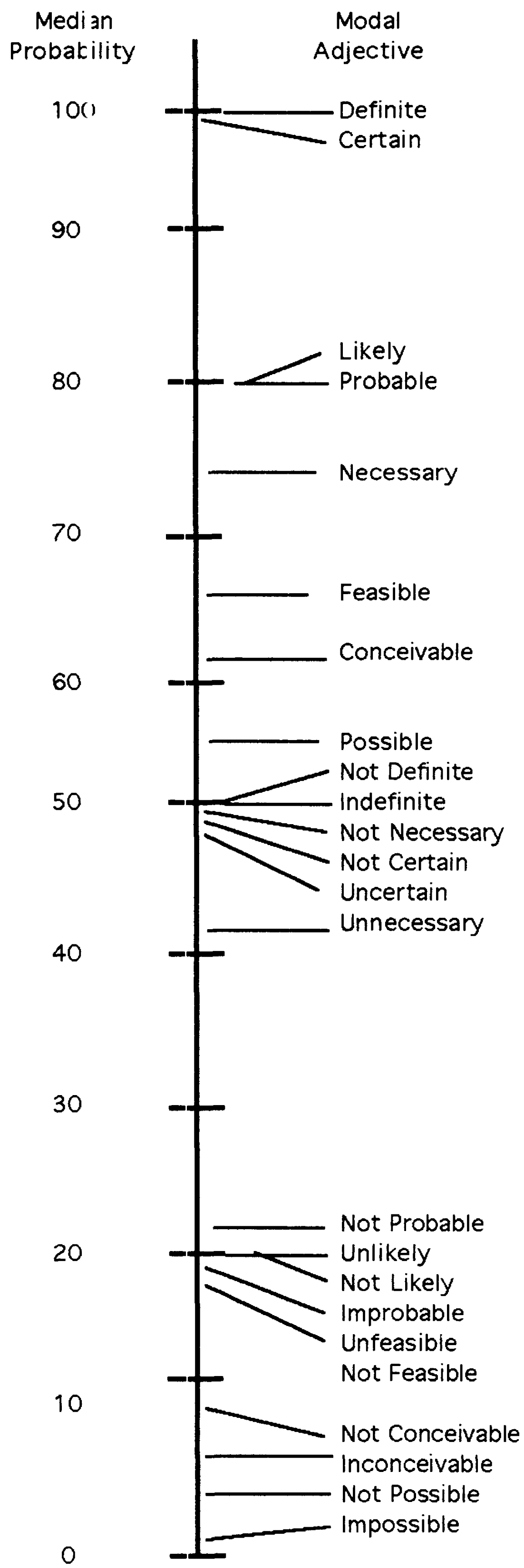
The efficient encoding and decoding of measures of probability in terms of both reliability and validity is considered essential for effective communication of probability estimates. "A probability encoding is said to be reliable if it is free of random error, or in other words is repeatable, stable, or consistent", while a probability encoding "is valid if it accurately represents the opinion of the person from whom it was elicited " (Wallsten and Budescu 1983a, p. 151).

There is abundant evidence to show a human preference for the utilisation of verbal characterisation of risk as opposed to numerical expressions of risk (Wallsten, Fillenbaum and Cox 1986). Yet the utilisation of the former practice has been associated with ambiguous communications, and is in sharp contrast to the numerical input requirements of most decision structures (Budescu, Weinberg and Wallsten 1988).

The cause of the vagueness associated with verbalisation appears to be linked to several stages of the communication process. First, Wallsten et al. (1986, p.362) suggest that the verbal encoding of probabilities conveys a vagueness of uncertainty not associated with comparable numerical encodings. Support for this statement comes from the comparison of both verbal and numerical estimations of the precise probabilities (estimates of spinner segments) in which the latter were "virtually errorless" leading to the assertion that "the vagueness can be attributed to the verbal expression and not to the perceived uncertainty".

The second major cause of vagueness appears in general to be associated with a breakdown in the validity of the decoded probability statements. On an individual basis verbalisation of risk estimates appears to be consistent and to exhibit a high degree of repeatability, with individuals being able to consistently rank both modal adjectives and probability statements while assigning numerical subjective probability estimates to the statements. That is, encoding of verbal expression of probability appears to exhibit a high level of within-individual reliability. This was illustrated by Reyna (1981) who studied the role of modal adjectives as qualifiers of probability statements (that is, in placing sincerity conditions on such statements). From this series of experiments it was concluded that such affirmative adjectives and their affixal negations (add 'un' or 'in') along with their lexical negations ('not') could be ordered on a unidimensional scale. Further, this rank ordering corresponded to the subjective probability estimates placed on probability statements incorporating such adjectives by the subjects in these experiments (see Figure 3.4). It is to be noted that the subjects were asked to express an opinion of the group of adjectives supplied by the author; it is not to be concluded that individual subjects would normally differentiate such a large number of categories when evaluating probabilistic environments.

Similar within-subject consistency of probability statement ranking was reported by Beyth-Marom (1982). However, significant between-subject inconsistency in the numerical translation (reduced validity) of 30 probability statements occurred as illustrated by the results reported in Table 3.2



Source: Reyna 1981, p. 645

Figure 3.4 Median Subjective Probability Values Assigned to Modal Adjectives

Table 3.2

<u>Range of Expressions</u>

No. Verbal expression	C_{25}-C_{75}		C_{10}-C_{90}		Median Rank
	Limits	Range	Limits	Range	
1. Not Likely	5-15	10	2-18	16	I
2. Very low chance	10-18	8	4-23	19	I
3. Poor chance	11-25	14	4-33	29	I
4. Doubtful	16-33	17	11-39	28	II
5. Low chance	22-34	12	15-38	23	II
6. Small chance	22-36	14	17-42	25	II
7. Can't rule out entirely	24-49	25	12-58	46	III
8. Chances are not great	28-41	13	22-52	30	II-III
9. Not inevitable	35-56	21	26-59	33	IV
10. Perhaps	36-53	17	28-58	30	III
11. One must consider	37-59	22	27-64	34	IV
12. There is a chance	37-60	23	28-67	39	IV
13. May	42-58	17	32-65	33	III-IV
14. It could be	42-57	15	34-63	29	V
15. Possible	51-58	7	42-61	19	IV
16. One can expect	51-63	12	42-69	27	V
17. Reasonable to assume	52-69	17	43-81	38	V
18. Likely	53-69	16	42-81	39	V
19. It seems	53-65	12	50-69	19	V
20. Non-negligible chance	53-67	14	36-77	41	V
21. It seems to me	54-67	13	50-73	23	V
22. One should assume	54-68	14	48-75	27	V
23. Reasonable chance	54-69	15	49-81	32	V
24. Meaningful chance	63-80	17	58-86	28	V
25. High chance	75-87	12	71-91	20	VI
26. Close to certain	75-92	17	58-97	39	VI-VII
27. Most likely	78-92	14	72-97	25	VI
28. Nearly certain	83-96	13	76-99	23	VII
29. Very high chance	87-96	9	83-99	16	VII
30. Certain	98-100	2	93-100	7	VII

(C_{25}-C_{75}) interquartile range of subject responses
(C_{10}-C_{90}) 80 percent range of subject responses"
Source: Beyth-Marom 1982, p. 261

There is strong evidence to suggest that this inconsistency in the numerical translation (reduced validity) is a function of the individual differences, event base rate perceptions, or perceived prior probability of the event being described, held by the recipient (Wallsten, Fillenbaum and Cox 1986).

The significance of verbalisation error in the probability inferencing process to decision outcomes has not been widely studied. However, in one contextually-constrained study of the potential for error inducement, Budescu and Wallsten (1990, p. 258) concluded that, whilst there was a tendency for bids in response to verbal communications of probability to be more variable than those based on numerical descriptors, "responses to verbal and numerical descriptors of common underlying probabilities tend not to be different". It is suggested that this observation may be related to the cognitive response of individuals asked to act on verbal descriptions of event probabilities. Reference is made by the authors to the capacity of the "v - μ model" (Budescu et al. 1988; Wallsten, Budescu and Erev1988) to provide a description of this cognitive activity. Basically, the model proposes that a probability phrase is perceived to describe well certain probabilities, while describing other probabilities either side of this restricted interval to a lesser extent, and excluding all other probabilities. This vagueness is resolved by the individual selecting a value from the restricted range of probabilities most representative of the phrase.

3.4.2 Price and probability groupings

A propensity to consider outcome variance in discrete groups rather than a continuous probability distribution has been reported (March and Schapper 1987). From the same series of experiments reported in Table 3.2 Beyth-Marom (1982 , p. 266) concluded that "subjects seem able to discriminate 7 levels of subjective confidence" to which most probability statements could be allocated. These groups, as per Table 3.2, correspond to the following subjective probability intervals : I: 10-35%; II: 10-40%; III-IV: 10-40%; V: 40-80%; VI: 70-90% and VII: 70-100%.

A similar encoding, by farmers, of prices into qualitative categories with verbal descriptors such as "good", "fair" or "bad" along with the tendency for a particular (numerical) price to subsume part of the variability normally associated with markets, has been reported by Ortiz (1980). It was further suggested by Ortiz (1980) that farmers tend to retain, in memory, past yields and prices in qualitative formats which relate to the propensity of a particular yield or price to generate a given level of income. Support for the supposition that prices remembered or utilised by farmers are in fact referencing a range of prices is found in the more frequent use of rounded or convenient prices than other prices by US dairy farmers, as reported by Williams (1953).

3.5 Search

Many of the data inputs required for agricultural decision making can be characterised as being passive, insofar as their acquisition requires active search. The motivation of search activity and the effectiveness of the search itself are hence considered to be important in the final composition of the data set for incorporation into particular decision structures. Further, to be effective the search pattern adopted needs to restrict the data yield to a volume and density which is capable of being processed by the decision maker, so as to avoid "information overload". As with the questions relating to cognitive ability, it is justifiable to question whether a producer's performances in the data search function of decision making are capable of approaching that of a normatively correct decision maker.

Numerous reports of search function deficiencies relative to the normative standard have been published. In a review of information search prior to general managerial decision making, Svenson (1979, p.86) observed that most decisions are made without complete search, hence concluding that "many algebraic models of decision making are inadequate" and that the choice of "less than satisfactory" decision structures is often influenced by the incompleteness of information. While, in reporting the results of a multinomial Bayesian task experiment, in which information was made available on a sequential basis at a cost per unit of information requested, Levin Samet and Barhlek (1975, p. 510) concluded that the subjects "were generally conservative in that they purchased more information than would have been recommended by normative procedures". Such laboratory trials may be considered partially analogous to the situation confronting a producer in that often the choice between alternative actions entails the acquisition of data and information over a period of time. Such results provide one example of normative deficiency exhibited by mortal decision makers. This can be contrasted to consistent observation of restricted search patterns and information filtering in situations of potential information overload (Davis and Olson 1985).

Initially in this section will be reviewed a number of human factors which reportedly influence the extent of data search undertaken prior to decision making. From this work it is hoped to gain an understanding of the corresponding limitations on the data sets and decision structures applicable to agricultural decisions so that recommendations as to the structuring of management information systems(MIS) can be made which reflect cognisance of such problems.

The second motivation for the investigation of search patterns related to the light that such tracing techniques can shed on the cognitive processes involved in problematic decision making.

3.5.1 Search motivation

Webester (1979, p. 246) suggests that the very act of seeking information indicates that the farmer considers "his own estimate of response to form an inadequate basis for decision."

The strength of this dissonance and the invoked level of search was shown to be positively related to the level of uncertainty associated with the problem and the importance of the outcome to the decision maker, with both factors interacting in an additive rather than a multiplicative fashion over a range of problem types (Lanzetta and Driscoll 1968).

Alternatively, Thornton (1962) suggests that managers engage in the collection of ideas and information by virtue of curiosity and that such actions may not be directly motivated by particular problems.

3.5.2 Search patterns

The information search pattern utilised by a decision maker may be determined by such influences as the pre-structuring of the decision (for example, adoption of a particular decision structure), the application of decision heuristics or be generated as a function of the presentation format of the information available. The significance of the presentation format to decision outcomes was discussed by Conrath (1973) who, on the basis of a series of investment decision experiments, attributed changes in management choice to the ability of variations in the presentation format of probabilistic data to concentrate the decision maker's attention on a particular dimension of the choice space.

In a reference to the behavioural description of search associated with problem solving, Davis and Olson (1985) note that the search for solutions in such cases appears to be based on an initial search in the locality of the current solution or the present symptoms. Failure of the initial steps leads to search in organisationally vulnerable areas. The initial stage has to be viewed as analogous to anchoring, a phenomenon observed by other authors in the formation of expectations (see 3.3.4).

This observation appears consistent with comments contained in a review of the theory of human problem solving by Simon and Newell (1971, p. 151) in which they concluded that humans undertook very limited trial-and-error search, preferring to examine 'promising areas' within the decision world. Search was considered to be directed by heuristic processes based on the perception of structures within the decision space. Within this context, structure is seen by the authors as "simply the antithesis of randomness, providing redundancy that can be used to predict the properties of parts of the space not yet visited from the properties of those already searched." Directed search rather than random search is based on this predictability.

This structured search in areas of perceived promise, with its associated contraction of the decision world, can be seen to restrict the cognitive demands placed on the decision maker.

3.5.3 Search completeness

Time availability is reported by Bock (1976) as a major stricture on the amount of information used by Australian farmers. The point of cessation of search is, in principle, simple to identify, that being the level of investment in search at which opportunity costs equal marginal costs. However, this is difficult to apply with the decision as to cessation of search being reliant on intuition and subjective judgement (Dillon 1977).

Asymptotic increases in the total information search have been reported in a range of decision process tracing experiments. This has led to the suggestion that there is a relatively limited amount of information that an individual will examine prior to decision making and that simple increase in available information volume may not lead to increased decision accuracy (Payne 1976, Olshavsky 1979, Klayman 1985, Nakajima and Hotta 1988)

3.5.4 Idiosyncratic factors

As with other components of the psychological processes involved with decision making, the idiosyncratic nature of pre-decisional search can be illustrated by reference to Long and Ziller's (1975) work on dogmatism. In this work a strong negative correlation is reported between the level of dogmatism exhibited by an individual and the amount of predecisional search undertaken.

Another example of the idiosyncratic nature of pre-decisional search is provided by the impact of perception of informational concreteness. "Particular individuals rely on concrete observable characteristics of evidence and neglect other information related to the process or context of evidence, leading to possible error judgements" (Davis and Olson 1985, p. 249).

Such a consideration of the constraints on problemistic search is relevant to the fifth level of problem conceptualisation, as defined by Humphreys and Berkeley (1983), in that the articulation of the factors involved in the constriction of the data search pattern is a prerequisite of the description of the principles guiding the closure (reduction) of the "grand world" to that "decision world" in which a particular problem is structured and solved.

3.6 Learning

Producers confronted with a range of cues (or data sources) must learn to integrate data from these cues if they are to formulate expectations or to make judgements as to the actual state of nature being described by various cue values. Limitations on human ability to adjust such integration techniques, so that inferences become a closer approximation of outcomes, have been studied in terms of human learning capacities.

Brehmer (1980) suggests that the learning process is more than just the construction of a mental picture of the world in that it involves the development and testing of hypotheses. Based on the observation of subjects' attempts at learning in a probabilistic situation, he concludes that a confirmatory strategy of hypothesis testing is the norm rather than the alternative (negatory) strategy of seeking information to refute the hypothesis. This leads to the biased selection of positive information or data as opposed to negative information or data; the former being perceived as being able to tell them what the concept is, the latter what it is not.

This view of learning has significant implications as to the ability of producers to improve their understanding of their multi-factorial decision environment on the basis of outcome feedback. Brehmer (1980, p. 228) notes that

> When we learn from outcomes, it may, in fact, be almost impossible to discover that one really does not know anything. This is especially true when the concepts are complex in the sense that each instance contains many dimensions. In this case, there are too many ways of explaining why a certain outcome occurred, and to explain away failures of predicting the correct outcome. Because of this, the need to change may not be apparent to us, and we may fail to learn that our rule is invalid, not only for particular cases but for the general case also.

This view of learning provides a plausible explanation as to why subjects fail to recognise the sub-optimality of inferencing based on deterministic models of a decision environment. With such reinforcement (or the absence of challenge) and the lack of an adequate stochastic schemata in their cognitive equipment, along with inferential tasks in which the probabilism is not manifest, the seeming dominanace dominance of deterministic modeling of decision environments by producers are not surprising.

3.6.1 Feedback and learning

Given recognition of human propensity to seek evidence of causality in the environment rather than view the tasks as being probabilistic in nature (Brehmer 1980) and a desire to improve producer's inferencing, it is valid to ask the question as to whether beneficial adjustment of cue aggregation techniques (learning) can be aided by alternate forms of feedback.

In an agricultural decision environment the salience of feedback appears to be further limited by a number of factors including: (1) significant delays between the allocation of productive resources and the sale of produce hampers the evaluation of decisions on the basis of realised outcomes; (2) single or minimal exposure to production decision/sale events provides inadequate sampling of outcomes in a probabilistic environment; (3) alterations in the decision environmental conditions between successive like decisions limits the relevance of previous outcomes to repeat decisions of a similar functional form; and (4) less than perfect correlation between cue (for example, market reports) and criterion (actual product price)recieved by individual farmers induces uncertainty in feedback. Further there is little or no provision, within the agricultural environment, of cognitive feedback, relevant to the relationships, "among cues, between cues and distal objects (or criteria), between cues and cognitions, and between cognitions and distal objects" (Doherty and Balzer 1988, p.165).

These characteristics of agricultural production systems along with the associated agricultural price cycles have been noted by Mauldon (1973, p. 33). He attributes the latter to the fact that the "lag between decisions and their outcomes are long in relation to the frequency with which errors are detected and control decisions made".

In addition to the above-mentioned characteristics of the agricultural decision environment, which limit the usefulness of feedback to producers, the provision of feedback appears to be of limited or restricted value to any individual attempting to gain knowledge of a multidimensional task for the purpose of inferring outcomes.

The nature of such learning tasks, is described by Bjorkman (1968) (cited by Slovic and Lichtenstein 1971, p. 706) who suggests that learning in correlation tasks within a probabilistic environment, requires the acquisition of knowledge about the functional relationship between stimuli and criteria (functional learning) along with probability learning. The latter relates to the understanding of the probability distributions around the elements of the functional relationship.

To further explore the nature of human learning it is useful to review the studies into multiple-cue learning tasks which are normally conceptually based on the "lens model" and assumed to be of relevance to a variety of "real world" situations (Slovic & Lichtenstein, 1971). Examples of such work are provided by the studies reported by

Hammond and Summers (1972) and by Hoffman, Earle and Slovic (1981). The experimental conditions present in such studies may be considered somewhat analogous to the situation confronting a producer who must formulate expectations of wool prices (often 12 months in advance) on the basis of various cues (for example, ABARE forecasts, AWC forecasts, current wool prices and last year's realised prices).

Slovic and Lichtenstein (1971, p. 708) summarised the findings of the literature published in this area in the following terms: "subjects can learn to use linear cues appropriately"; "learning of non-linear functions occurs but is slower and less effective than learning linear relationships"; "subjects can learn to detect changes in relative cue weights over time although they do so slowly"; "It is easier for subjects to learn which cue to use than to discover which functional rule relates a known valid cue to the criterion, learning both of these simultaneously is especially difficult"; "in a two-cue task, pairing a cue of low or medium validity with one of high validity is detrimental to performance (a distraction effect), while pairing a cue of low validity with another of medium validity is facilitative"; and "subjects can learn to use valid cues even when they are not perceived with perfect reliability".

An insight into the inadequacies of the standard feedback pattern in the aiding of learning is provided by Hoffman, Earle and Slovic (1981) who concluded that subjects involved in such experimentation have consistently been shown to exhibit a limited ability to learn multicue-criterion relationships, where the experimental program adopted the standard stimulus-response-outcome (SRO) feedback paradigm . In fact, Hammond and Summers (1972, p. 64) go so far as to suggest that SRO feedback is not only of

> limited usefulness in the acquisition of knowledge, outcome feedback may be detrimental to control, as well.

With the development of the concept of cognitive control as a distinct component of multi-cue inferencing tasks, Hammond & Summers (1972) provide an analytical framework for the attribution of suboptimal performance to either poor learning ("functional" or "probabilistic") and individual's efficiency in the application of their learnt cue integration techniques. In a revision of the data from a series of multi-cue probability learning tasks, clinical judgement tasks and interpersonal conflict experiments, all involving SRO feedback, the authors concluded that suboptimal performance continued despite subjects' increased knowledge of the task, suggesting significant inefficiency in the application of this knowledge, for example, poor cognitive control.

However, Hammond & Summers (1972, p. 64) suggest that cognitive control may be improved by the provision of an alternative form of feedback, for which they provide the following description.

> Feedback which contributes to control should consist of cognitive material - not response orientated material - which will enable the subjects to perceive not only that their judgement was in error, but why it was in error. Such cognitively orientated feedback must enable the subject to compare (a) the properties of his cognitive system with (b) the properties of the task system with which he is trying to cope. .... Of particular importance in this respect are two essential parameters: (a) differential cue weights and (b) the form of the function relating each cue and the criterion.

Support for the proposition that learning and performance in multi-cue inferencing tasks may be improved by manipulation of feedback is derived from the work of Hoffman, Earle and Slovic (1981). These authors report that, in experiments where subjects were required to predict numerical criterion values from three numerical cues, in treatments where feedback was limited to discrete-trial outcomes (for example, stimulus-response-outcome), non-linear cue-criteria were not learned; however, where appropriate feedback was provided subjects were able to learn such functional relationships. "Appropriate feedback" in this case referred to feedback that "provided information about the statistical properties of the task and the statistical properties of his or her judgement system" (p. 77). To distinguish between the two types of feedback the term "task characteristic" is used to describe the former and " response characteristics" the latter.

3.6.2 Noise and equipotentiality

Through the introduction of error (noise) into the feedback provided to subjects in their MFL task experiments, Hoffman, Earle and Slovic (1981) attempted to provide laboratory task analogues to "real-life" inferencing reliant on probabilistic relationships. They observed a serious impairment to subject's attempts to learn the relationships within a task where even relatively small error components were introduced. In their discussion of this result they draw a distinction between noise originating from feedback uncertainty with its associated impact on the certainty surrounding the value of the criterion, given the stimulus configuration, and a "second form of uncertainty, one which results from the fact that, under any compensatory aggregation rule, different patterns of cue values can imply the identical criterion value" (Hoffman, Earle and Slovic 1981, p. 96). The latter form of uncertainty (termed "equipotentiality") in a multivariate function results in uncertainty regarding the structure of the stimulus configuration, given the criterion value. The authors suggest that this form of uncertainty may be a major contributor to the retardation of learning in such situations such that, attempts to estimate the stimulus configuration of higher degree functions, say the inverted U-shaped function describing yield response to fertilizer applications, involves an additional complexity in that two separate application rates may exhibit the same yield response.

3.7 Summary

State of the art agricultural decision making still remains heavily dependent on the human resource for a significant part of its data/information processing. The task confronting the managers is one of the aggregation of data from their economic environment, storage of that data and the transformation of that data into information applicable to the problem at hand. Producers are seen to acquire market data/information, upon which they form expectations of future market conditions, these expectations subsequently being used as inputs in the decision process.

Chapter Two established the nature of the decision inputs required for a variety of problems and their associated decision aids/structures.

This Chapter has considered the data acquisition, storage, and inferencing capacities and limitations of humans. As such it has attempted to delineate some of the initial constraints, originating from human cognitive capacities, on the supply of decision information, encountered as we move back down the information supply chain.

As a continuance of this movement, the subject matter of Chapter Four deals with the features of producers' economic environment which facilitate or constrain the transfer of data to the producers' semantic memory.

Chapter 4

AGRICULTURAL INFORMATION SYSTEMS

4.1 Introduction

An attempt is made in this chapter to examine the process by which data/information is generated, transformed and communicated to the farm decision maker. Within the structure of the dissertation presented, the chapter is orientated towards the examination of the linkages between the general decision environment (specifically the market environment) and the semantic memory of the decision maker. The relationship of the subject matter to the total decision process is depicted in Figure 4.1. While it is convenient to consider the process as exhibiting a unidirectional flow, as depicted in this figure, from the outset it is necessary to recognise the potential for counter current flows of data/information (see Figure 4.2). Significant to this chapter is the understanding of the process of, and the potential for, the externalisation (that is segregation from the decision maker's cognitive activities) of parts of the judgement and decision making processes that occur with the transition from simple management information system (MIS) through to decision support systems (DSS).

It is from these related fields (MIS; DSS) of study that the conceptual basis of this chapter is drawn. The majority of the literature published in this area originates from the study of communication systems and from investigation of information and management systems within corporate or military structures. The holistic view of the data processing chain, with its emphasis on the relationships between the different aspects of data generation, summation, transmission and utilisation, adopted in the general MIS approach to this field of research is held by Barnard (1975, p. 292) to provide "some conceptual foundations to what might otherwise tend to be a rather amorphous subject area ...... ".

Two constraints must be borne in mind when reading this chapter, in which is made an attempt to draw an analogy between the MIS and DSS servicing agriculture and those described in the literature. First, this thesis is loosely constrained to the consideration of market information and, as such, ignores a large part of the management data set required for the on-going operation of an agricultural enterprise. Second, within the corporate structures generally described by such literature, there is normally a far greater degree of vertical integration than that found in Australian agriculture. This is of importance in that the questions of data/information ownership, the acceptance of decision structuring assumptions, decision responsibility and the control of information systems, are far more contentious in the stratified and atomistic ownership structure of agriculture.

This potential for structural constraints on the flow of information within agriculture was recognised by Sporleder (1983, p. 388).

> Some trade customs and exchange arrangements for agricultural commodities may complement collection or dissemination of information on market conditions while others hinder it. For example, vertical integration or certain types of cash forward contracting may improve private individual firm information flow but hinder availability of public information.

Purcell (1969, p. 1110) recognised the importance, to the general economics discipline, of research in the field of MIS and DSS, citing the mounting evidence that suggested an incapacity of the "price system" to function as an effective communication system, contending that " (1) the marketing economist must broaden his perspective to include analysis of the barriers to effective communication, whatever the origin of those barriers; and (2) the developing theory of communication can provide the tools needed to make such a re-orientation of our research efforts productive." The view that "price" is an inefficient communicator is supported by Buccola (1984, p. 713) who observes that

> In the real world of costly information and incomplete market development, price is not a sufficient statistic and cannot be used to solve for all information held by informed traders.

It appears that the potential for the systemic deficiencies within the information systems servicing the primary producer and resultant deficiencies in the decision data sets available to producers (the basic concern in this dissertation), is both significant and multi-faceted. Illustrative of the potential for such problems are the conflicting wants of managers and the desires of market researchers.

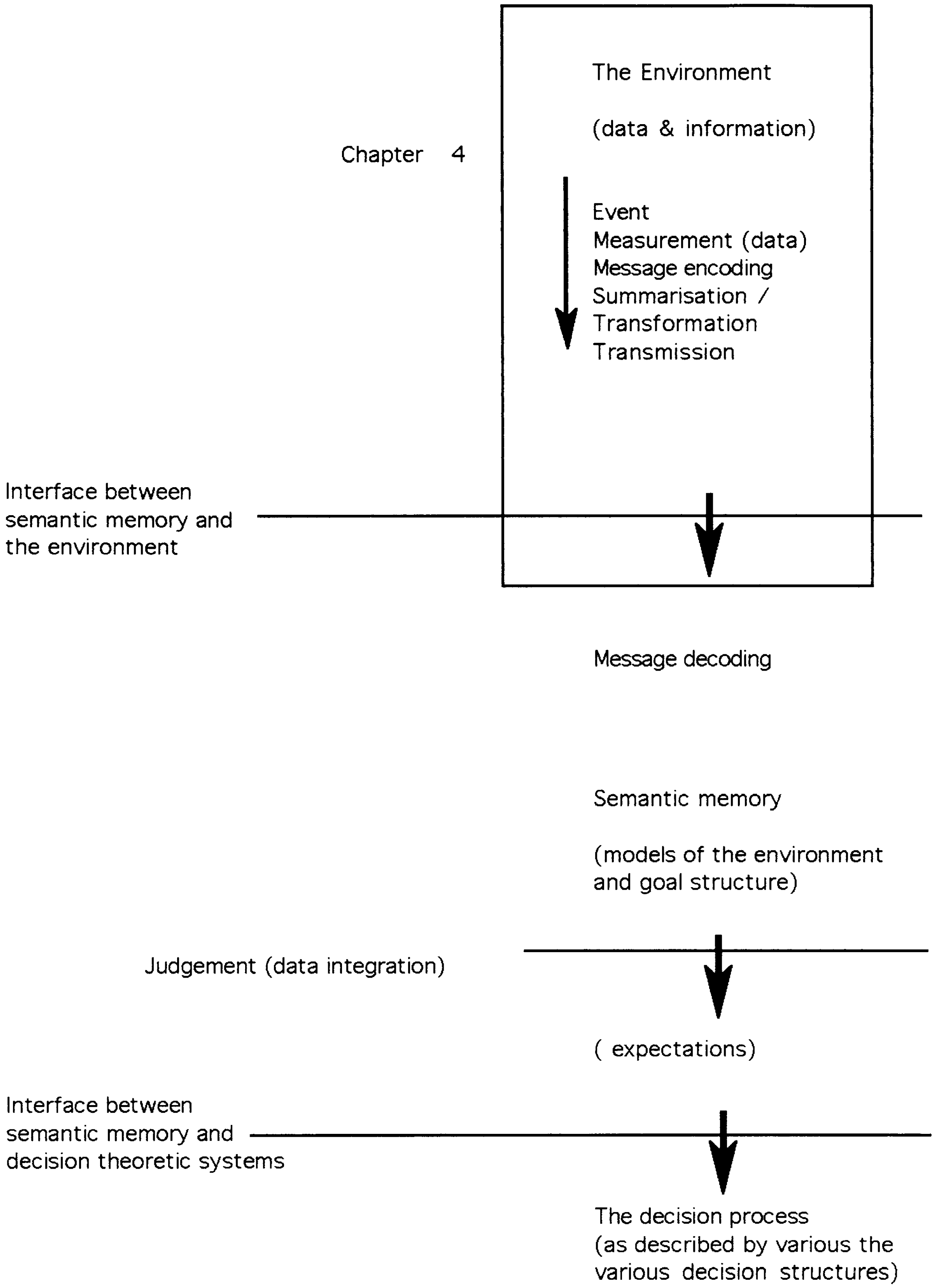


Figure 4.1 The Environment - Memory - Decision Process Interfaces
(adapted from Humpreys and Berkeley 1983)

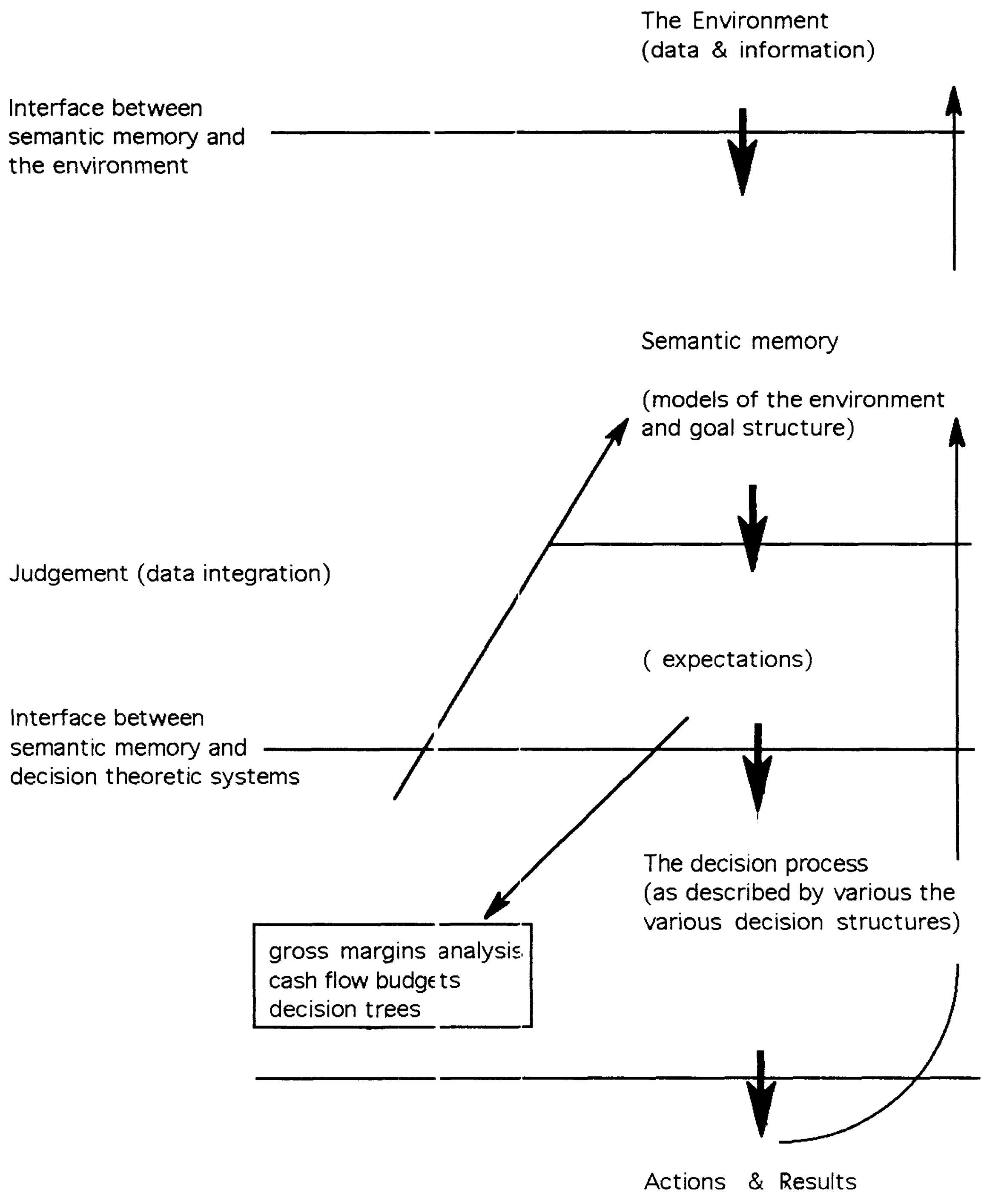


Figure 4.2 Counter Flows in the Data/Decision Process
(adapted from Humpreys and Berkeley, 1983)

The former require quick, low cost, timely and accurate information, presented with few statistical qualifiers, whilst the latter is described as wanting questions amenable to examination in a methodologically sound manner with adequate resources and being desirous of presenting findings "with qualifications and statistical evidence to support the conclusions drawn" (Davis and Cosenza 1985, p. 12).

Further, information/decision systems technologies are areas in which rapid change is occurring influenced by technological change (e.g. microcomputers) and the elongation of both marketing chains and decision structures . This has necessitated the development of information transmission networks and the substitution of information for traditional agricultural inputs (Sonka 1985). The potential significance of improvements to information systems, specifically those involved in market information delivery, is alluded to by Scandizzo, Hazell and Anderson (1983, p. 93) in the concluding remarks of a study into wool price stabilisation:

> We conclude that, in many cases, improved market information services may more economically provide the substantial part of the social benefits of price stabilisation.

The examination undertaken in this chapter of the process by which data/information is generated, transformed and communicated to the farm decision maker is structured around an initial consideration of information systems theory.

4.2 Information Systems

4.2.1 Definitions

Prior to entering the discussion of information systems theory it appears necessary to attempt to clarify some of the terms relevant to the area. This is not to suggest that the definitions cited are being put forward as being universally applicable. Rather they are being adopted to assist in the aggregation of material from several sources within this chapter.

First, it is advantageous to dismiss the concept of "fact" or "absolute truth" as such things do not exist. Rather, it is suggested that we receive messages descriptive of the environment "filtered through a changeable value system" (Thornton 1962, p. 45).

The term "data" will be considered to have a broader application than the strictest scientific definition. In the purest sense, "data" is taken to be actual observations of the environment, recorded in scalable units of a recognisable standard. Such data is the result of an enquiry process (Chavas and Pope 1984) and can be viewed as a collection of "nonrandom symbols which represent quantities, actions, objects etc."(Davis and Olson 1985, p. 201). Examples of such (orginal) data would include observations of realised livestock prices in terms of dollars per head or cents per kilo liveweight. The application of the term 'data', within this chapter, will be extended to include entities derived from original data, through such processes as aggregation, transformation or verbal summation etc, where such entities become inputs for further processing. An example would be the statistical manipulation of raw wool market data to generate measures of variance in wool markets for inclusion in applications of portfolio analysis. Similarly, estimates of enterprise gross margins utilised in decision analysis may be considered to be data. A further bifurcation of the term data to accommodate quantitative data (i.e. census data and statistical data) and qualitative data (i.e. assertions, customer opinions and observations) appears of use when considering the processes of data generation (Falvey undated).

Watson (1983) describes "information" as being transformed data which is accessible knowledge and which has meaning for a current inquiry process. The substance of such "information" is taken to be the reduction in ignorance achieved whilst the "form" of information is taken to be the manner of structure or organisation in which information (transformed data) is presented (Glen 1980).

Here the description of the "substance" of information conforms more closely to the cognitive science perception of information, that being a creation of the mind, as something conscious agents assign to, or impose on, otherwise meaningless events. This is consistent with Watson's (1983) recognition of the individuality of the recipient's cognitive evaluation of data as information.

The "form" of the information is allied to the "objective commodity" concept of information, that being the general perception of information common in an economics sense, in which information exists "independent of the interpretive activities of conscious agents" (Dretske 1983, p. 55). Changes in the "form" of information can result in the possibility that what one individual interprets as information in a given decision situation will be regarded by another individual as data (Watson 1983). To illustrate the point, wool auction data (individual lot prices) may be transformed into a market indicator, considered to be information by a market reporting organisation whilst, to a producer formulating an expectation of future market prospects, the current market indicator level is but one data input required for such an inferencing task.

From the preceding, and for the purpose of further discussion, the differentiation between "data" and "information" will hinge on the question of the need for further changes in "form" prior to elicitation of a reduction in ignorance in the recipient of the signal.

The following definition of knowledge is offered by Dretske (1983, p. 58); "Knowledge is defined as information-caused (or causally sustained) belief." In constrast, Barnard (1975, p. 291) applies the term "knowledge" to data which has been evaluated in a general way for future use, suggesting that to an economist knowledge is composed of the "stock of qualitative and quantitative generalisations about economic relationships". For the purpose of this chapter the internal nature of knowledge (that is, the individuality of beliefs) is considered to be the cogent feature. Thus, published economic relationships or the output of either DSS or expert systems (ES) (based on such relationships as those described by Barnard (1975)) will be considered to be "information" if accepted without modification by the decision maker. This implies commonality of output and currently held beliefs, or over-riding confidence in the validity of the DSSs or the ESs. However, should such material be used as inputs for some form of cognitive inferencing, it would be considered to be "data". In both cases the externality (relative to the decision maker) of the information or data excludes its classification as "knowledge".

Whilst the transmission of data/information through either space or time is taken to compose a "signal", the means of transmission (radio, press, electronic data transmissions, etc) is referred to as the communication "channel".

The term "message" will be used to represent the aggregate of the concepts that the generator (source) of a signal wishes to convey and the concepts that a recipient (target) is cognisant of as a result of the reception of such a signal. Where it is necessary to distinguish between the two types of message, they will be referred to as either "source message" (that is the concept which the source wishes to convey) or "received message" (the interpretation placed on the signal by the target).

The process of "communication" can then be viewed as the construction of a "source message" by the originator of the communication, the encoding of that message to generate a signal which is transmitted along a channel, the reception of the signal by the target, the decoding of the signal, followed by the cognitive processes of generating the "received message" (Purcell 1969).

4.2.2 Data Bases (DB); Management Information Systems (MIS); Decision Support Systems (DSS) and Expert Systems (ES)

A systems approach to the flow of information in an economic unit has evolved over a number of years, emerging as a distinct field of study in the late 1960s. Its origins were in the fields of accounting, computer science, decision theory, general management theory, operations research and organisation theory (King 1986). The range of descriptions of such systems cited in the literature appears to indicate that the terminology has been used to describe a continuum rather than a strict taxonomy of systems. Watson (1983) suggests that, at one end of this continuum, decision making is heuristic in nature whilst, at the other extreme, decision making is almost totally reliant on formal decision structures. In the former case, no external data or information is utilised with decision making being reliant on the farmer's own experience and observations. A farmer operating at the other extreme would be expected to continuously access external data and information and utilise formal structures for both data aggregation / evaluation and choice.

The term common to the majority of the work in this field is that of "system" which is taken, by Brien (1983), to encompass all elements germane to a specific problem area, this being consistent with Barnard's (1975) description of an "information system" as being the logical configuration of significant elements in a selected problem area.

The breadth of the problem area selected provides the basis for the classification of systems while Gum and Blank (1990) note that the concepts of "function" and "process" are critical to the definitions of such systems. This is illustrated by Gum and Blank (1990, p. 540) through reference to the standard definition of an ES(Expert System) the function of which they state to be "to duplicate as nearly as possible the problem solving techniques and rules of the expert". The processing units of an ES are described by Doluschitz and Schmisseur (1988, p. 174) as being comprised of a "knowledge base of domain facts (data by the definitions adopted here) and associated heuristics, an inferencing procedure or control structure for utilizing that knowledge base and a natural language interface." Here the term "knowledge" is to be considered more aligned to the definition of "information" adopted within this thesis.

At the other extreme are "data banks", which are described by Mason (1975) as having the function of data generation with the decision maker required to determine the meaning of the data. Within such systems the function is fulfilled through the process of observation, recording, storage and retrieval.

A function intermediate between DBs and DSSs is assigned to MISs by Eisgruber (1973) and Zmud (1979). The two most important processes of MISs are described, by Ackoff (1967), as the filtration and condensation of data. Brien (1983) stresses the importance of MISs in the facilitation of the transfer of information.

The extension of the functional role of basic systems (normally some form of accounting or production data base) has seen the development of higher level systems (e.g. DSS and ES) (Davis and Olson 1985, Doluschitz and Schmisseur 1988), resulting in a commonality of early stage processes. This is illustrated in Figure 4.3.

However, considerable divergence, both in the structure and the level of utilisation, in the theoretical description of management information systems in general and those observed in use by corporate entities have been reported by Wentz (1972). Factors contributing to this divergence were reported to include difficulties in recording detailed microdata, acceptance by line management, accessibility and analytical sophistication. In summary, the practical significance of an MIS is considered to be constrained.

> In short, an MIS moves the firm from suboptimization methods towards optimization techniques, by permitting more variables to be explicitly considered in a given decision situation. (Wentz 1972, p. 123)

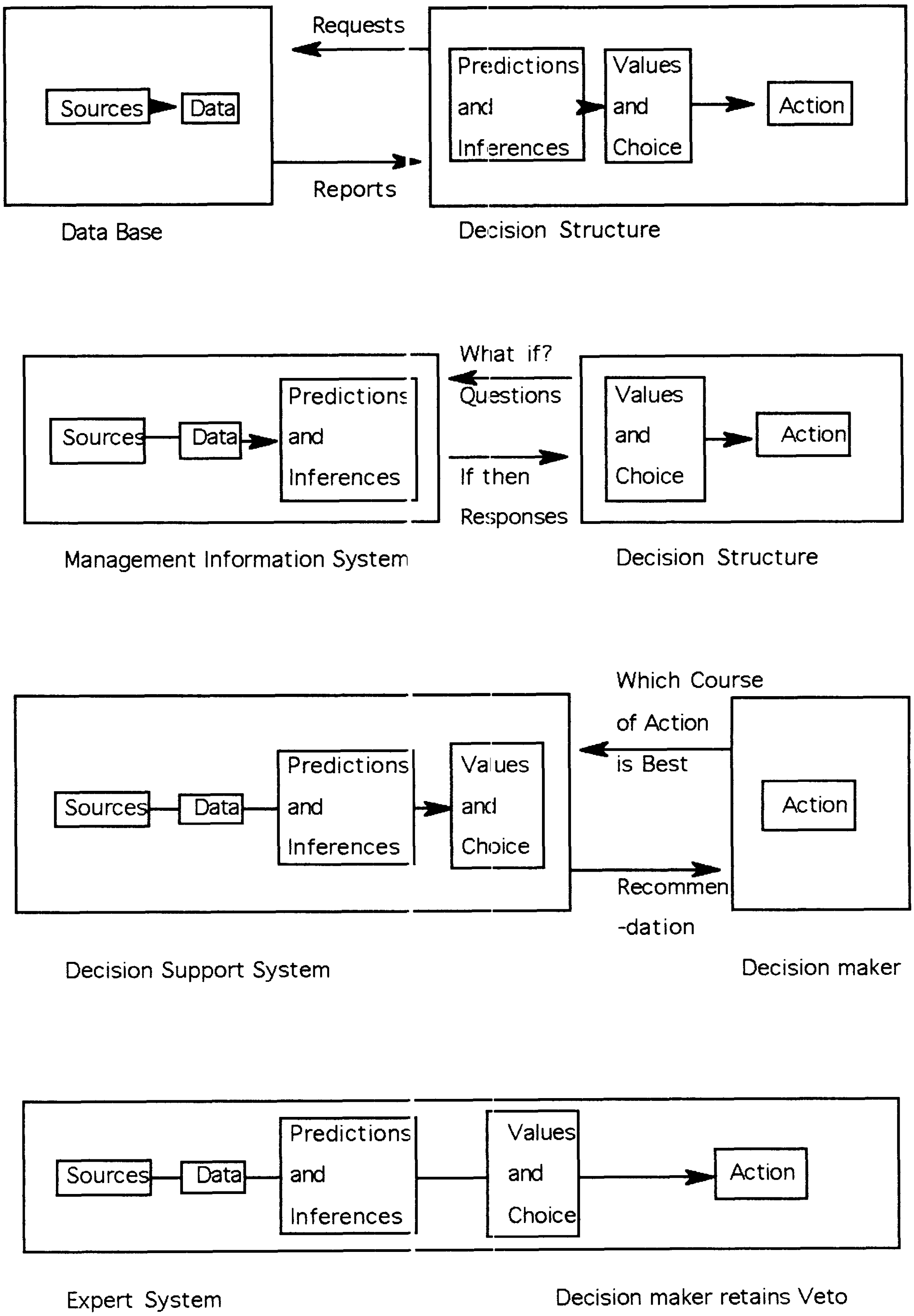


Figure 4.3 Data - Information - Decision Systems
Adapted from Mason 1975

Further, these unified structures appear to be at odds with the genesis of the data/information structures observed in agriculture. The latter appear to be quite diverse, with their origins, functions and processes being linked to specific stages of the production, marketing and consumption chain.

In an 'ideal' structuring of problem solving, Barnard (1975) suggests that problem delineation should be followed by selection of an appropriate theory or analytical framework and only then should the data requirements and potential sources be considered, resulting in problem-specific, integrated information/decision structures. With the exception of some programmable decisions, the costs associated with the development of such systems is prohibitive. In reality, producers are reliant on a number of diverse data and information systems/sources which exist in the economic environment and from which they attempt to draw data/information applicable to specific problems. This is, in essence, the reverse of the idealised problem-theory-data flow postulated by Barnard (1975).

Hence, whilst above (in Figure 4.3) the systems are depicted as single entities, the nature of Australian agricultural information systems can be more appropriately conceptualised as a confederation of systems, including commodity-specific market information systems, general and commodity-specific technical information systems, enterprise specific systems, etc.

Yet, there is a general commonality in the structures of the members of this confederation. This can be illustrated by comparing the structure of "market information systems" and the structure described in the generalized model of MISs. The specific functions and processes ascribed to "market information systems" by Falvey (undated) include (a) the improvement of market efficiency through the automation of clerical tasks, better stock control, better operational support systems, (b) improved effectiveness by proper management of the support system, and, (c) identification of international, national and regional issues, and the tracing of changes in demographic, economic, technological, supply, social, political and legal trends.

Further,

> Any market information system must fulfil the following criteria.
> 1) be able to move information from place to place.
> 2) store and retrieve information.
> 3) aggregate data into smaller and/or more accessible units.

4) analyse data to determine and measure relationships.
5) mix, and pass the data around to a variety of managers to identify possible links.
6) be able to recognise changing patterns or relationships.
(Falvey undated, p. 19)

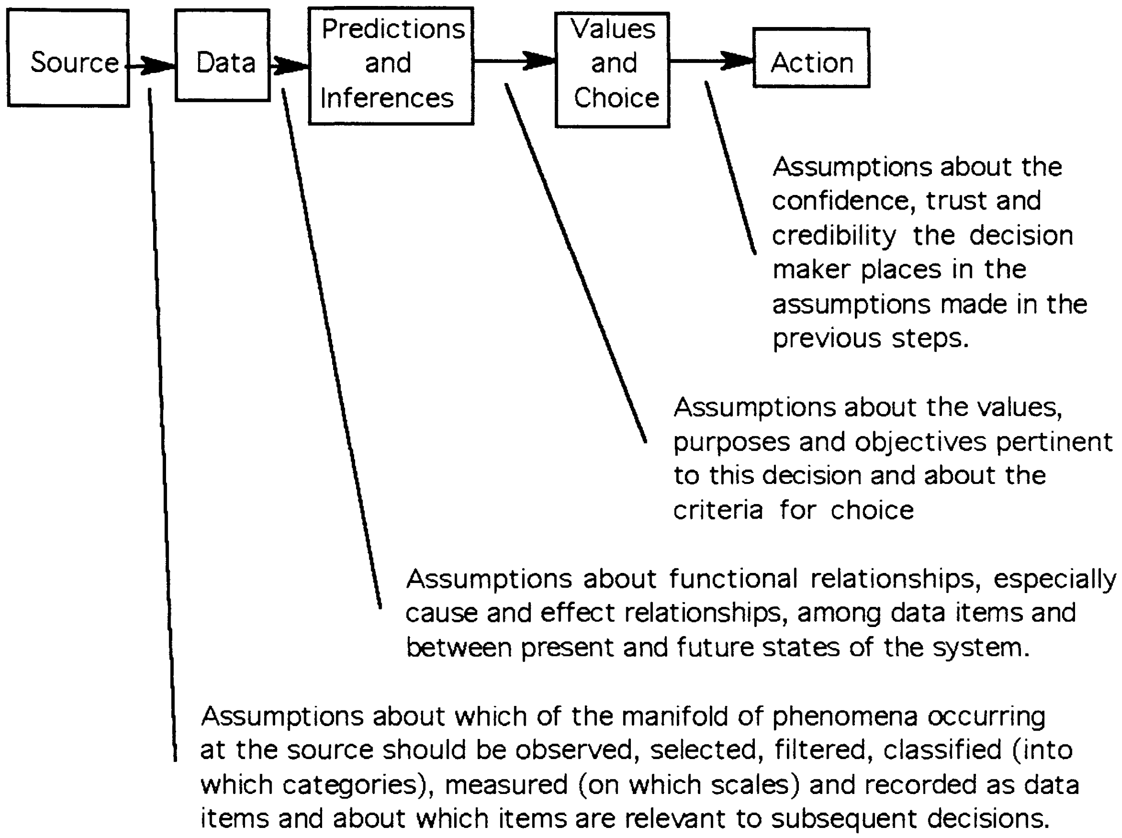
Falvey's (undated) "market information system" appears to exhibit the functional and process characteristics of a MIS whilst being constrained in the scope of data handled. The removal of the processes of data analyses, data transmission and relationships analysis from the description of such a system would suggest the positioning of the reconstructed system at the level of a "market data base". The addition of "choice" mechanisms would elevate the system, along a continuum, to the level of a "market decision support system".

4.2.3 Information processes

This section examines the underlying processes required to fulfil the functions of the various information systems. While the study of the efficiency and accuracy of processes such as measurement, data summation, transformation and communication comprise fields of independent study, it is necessary to recognise the impact the designated function of the system and, specifically, the type of decision (operational control, management control and strategic planning) has on the appropriateness and level of the processes undertaken.

As systems are expanded, with the consequent externalisation of parts of the data/decision process, various assumptions are made as to the nature of processes that the system attempts to replicate. These assumptions have been summarised by Mason (1975) (see Figure 4.4.).

Implicit in the acceptance of the need to make such assumptions is the recognition of the potential for the assumptions being either incorrect from the outset or being rendered so by alterations to either the decision environment or the decision structures utilised. The following section examine some of the attributes of the data/information processes described by Mason (1975) and the products of such processes.



(Source; Mason 1975, p. 13)
Figure 4.4 Process Assumptions

4.2.4 Data

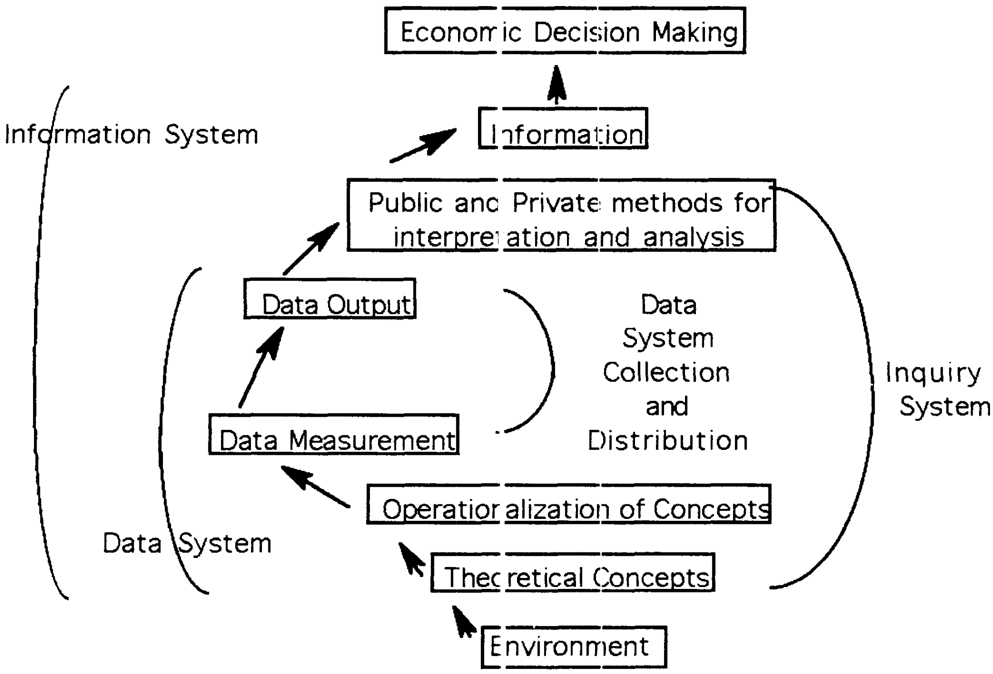
For primary producers to be able to respond appropriately to the changes in their economic environment they need to be able to recognise such changes when they occur. For change in the environment to be recognised, a corresponding change in the decision maker's perception of the environment must occur. Such change is brought about through movement in the concepts (variables) used to describe the environment. Hence, the validity of the variables used, and the accuracy of the data generated from observations of the decision world, will impact on the reception of environment held and the efficiency of decision making (Davis and Olson 1985).

The problems associated with the definition, representation and measurement of variables within the data systems and information systems supporting Australian agriculture appear to be a major aspect of the overall information problem (Watson 1983). Yet, it is necessary to be cognisant of the potential to overestimate the importance of data collection as warned against by Eisgruber (1967, p. 1541).

> Unless we develop an awareness of the fact that - viewed broadly - data collection can never be an end by itself, much effort will be wasted and much useful information will go begging. .

In a similar vein, Sporleder (1983) notes the impact of emerging data collection and dissemination technologies on the absolute amount of data available in agriculture, observing that the "massive amounts of data which are capable of being processed by modern computer networks should not be regarded as information of immediate assistance in decision making." (Sporleder 1983, p. 390)

Hence, it becomes critical to understand the interaction between agricultural data systems and their abundant output and the generation of decision-relevant information and its availability to the appropriate decision makers. The conceptual relationships between the "data system" and the overall information system was described by Rosaasen et al. (1983) using the Canadian domestic feed grain information systems as a model (Figure 4.5).



Adapted from Rosaasen et al. (1983)
Figure 4.5 The Data System

Given a motivation to improve decision making accuracy, it is considered appropriate to engage in the evaluation of such data systems and resultant data sets. Such systems are required to be able to: select the appropriate entity to be observed; define the entity (variable) to be represented; identify an appropriate scale for measurement of the variable; perform the actual measurements; and, where necessary, store, retrieve and process the data (measurements) at a later date (Watson 1983).

Data collection

In the broadest sense of overall farm management, Errington (1989) reports general consensus among professionals that the collection of quantitative data (numerical information), either via individual farm records or from external sources, is of critical importance to the efficient operation of agriculture.

As a result of the sale of produce, farmers will gain some information through their own participation in the market. It may be suggested that this information, by reason of the reduced need to make assumptions relating to product qualities, conditions of exchange, recording or transmission errors etc, will represent the highest quality data available to the producer. The significance of such data and the low level of ambiguity associated with it can be seen in the common use of "last year's realised prices" as anchor points for expectation formation (future price inferencing). Similar statements relative to technical data would also appear reasonable.

Yet, this data can be expected to have a number of limitations in terms of its ability to accurately describe the market, related to its generally limited sample size, its contracted temporal and spatial nature, and its post hoc nature. In addition, Mauldon and Schapper (1970) have noted significant data inaccuracy associated with problems in recording, allocation and valuing experienced during practical application of input-output recording systems to sheep enterprises on farms. Such limitations force producers to access data from various informal and formal information systems.

The primary role of such data/information systems (data bases, etc) is the generation of data by which relevant environments (market, production) can be described. The data/information systems may themselves may perform the functions of the development of variables, concept operationalisation and measurement or collect data from structures undertaking such functions. This is illustrated by the need, within the realm of marketing, to collect information (the function of research) from a variety of sources using a number of different techniques, if an in-depth understanding of the market is to be achieved .

Falvey (undated) identifies two basic forms of research orientated towards the generation of market data, a) quantitative market research (census data and statistical information); and b) qualitative research (group discussions to ascertain customer opinions, observations). The former is characterised as being highly structured and statistical and as being amenable to three different research approaches: a) survey or primary research; b) research utilising information developed for some other purpose such as internal sales and accounting records; or c) research into external data from the census, government reports, trade associations, experimental research, etc. (Falvey undated).

Where there is a need for the generation of "standard data" (normally restricted to technical data such as crop yields, or input output conversion ratios), Errington (1989) notes that there are three options available: a) individual experts; b) a panel of experts; or c) a field survey. To these, it is suggested, direct measurement through experimentation should be added.

Whilst qualitative research is characterised as being less structured, more expensive, requiring skilled interviewers, and generally of restricted and possibly unrepresentative sample size, it has been useful in the generation of hypotheses relating to future market conditions (Falvey undated).

The actual process of collection of quantitative market data is reported to be constrained by numerous factors, the sheer quantity of data in the relevant decision world being paramount. An inverse relationship exists between the numbers operating in a market and the potential volume of information available for collection (Smith 1965). The generation of agricultural data (at least in the UK) is viewed, by Barnard (1975), as being further constrained by the following factors: a) the atomistic and spatial structure of the industries; b) demands on family time associated with physical work which reduces record keeping; c) the diversity of agricultural institutions; d) the diversity of farm resources and structures; and e) environmental variations.

Additionally, Smith (1965) attributes some of the difficulties encountered in the gathering of market data to the bypassing of centralised markets, whilst noting the potential role of central clearing houses or Statutory Marketing Authorities (SMAs) in the collection of market information and its centralisation.

However, on an economy-wide basis, the costs associated with the collection of data are becoming less and, with the advent of data bases, the costs for accessing data (post collection) have also declined (Cotteill 1988). This suggests that there is a significant potential for overcoming some of the problems identified.

Apart from the technical problems associated with the generation of accurate data (i.e. data reliably reflecting the environment), Slovic and Lichtenstein (1971) suggest that unless the data utilisers have an understanding of the method utilised in data generation they may misperceive the conditional probability of the data. This potential for misperceiving the relative accuracy and the nature of the population sampled (reported) will reflect itself in either excessive or diminished confidence in the data and, subsequently, the level of ambiguity felt by the data users.

Data qualities

Any evaluation of such systems needs to address both the costs associated with the system and the quality of the output of the systems. The adequacy of the data (and, by extension, information available to decision makers), in terms of its utilisation in a particular decision structure, can be reviewed in terms of the following qualities: accuracy; relevance; and its comprehensiveness (Barnard 1975, Watson 1983). This requires a number of assumptions (noted in Figure 4.4) to be made about the decision process, specifically concerning the interaction between "source" and "data." Further, in discussing the adequacy of data, Einsgruber (1967) notes a tendency towards the recording of more accurate and more detailed information in every aspect of farm business and warns against the tendency to overestimate the accuracy with which measurements can be made, whilst also highlighting the problems associated with the incorporation of data with wide ranges of accuracy into decision structures.

A significant influence on the accuracy of data is the stability and appropriateness of the measurement standard adopted (conceptual obsolescence). The importance of stability increases with both the length of the data series and number of measurement sources which are to be aggregated. Bonnen (1975) notes some major problems with some US agricultural data series, where the conceptual bases of measurement have exhibited a large degree of obsolecence (e.g. "family farm" units). The contrast between such units and the more stable biological or physical units of measurement, such as tonnes of wheat or dollars per kilogram of beef, illustrates the point made. Such conceptual obsolescence may be a result of changes in the population being observed (e.g. smaller families) or arise from changes in the response demands placed on the data source (e.g. since the introduction of "across the hooks trading", DSSs for feedlot operations require estimates of market returns in c/kg dressed weight rather than $ /head).

Rosaasen et al. (1983), in a study of the information system servicing Canadian agriculture, pick up on the point of the stability and commonality of the conceptual basis on which observations are made. They state that the definitions of the concepts (variables) must be the same at every stage of the information system, as changes may result in misleading information being transmitted to the decision maker. To this can be added the requirement that there be a commonality of comprehension of the definitions of variables held by all participants in the measurement, communication and decision chain.

This concern with the problem of concept stability is also seen in Kohls and Downey's (1972) statement suggesting that uniformly applied and accepted quality standards are essential to the accurate and meaningful reporting of commodity prices. Further to the question of product description, variability in the conditions of exchange may significantly distort price data. Such inadequacies in product description are reported to have reduced the meaningfulness of price information to farmers in Australia (Bock 1976).

As the definition of variables being reported is tightened, through the introduction of product grading systems (e.g. over the hooks, fat score 2, 'C muscled bullocks' as opposed to 'bullocks'), the potential for variance in both grade price observations and *expost* forecasts may in fact be reduced (Freebairn 1973). However, in stochastic environments with limited opportunity for observation, the reliability of such observations may be restricted by limited sample size. The significant number of nominal quotes for various wool 'types' reported by the Australian Wool Corporation/Australian Wool Exchange is indicative of this problem.

A further reduction in the error rate of primary data may also be achieved by the reduction in any subjectivity associated with the collection of the data (Barnard1975), such that the utilisation of liveweight scales replacing visual estimation of liveweight in the marketing of livestock would be expected to reduce the occurrence of errors in the data yielded from particular transactions.

Davis and Olson (1985) note a number of additional sources of technical errors in various data collection mechanisms which have the potential to impact on the accuracy of data. These include: a) incorrect data measurement and collection; b) failure to follow correct processing procedure; c) loss or non-processing of data; d) wrong recording or correcting of data; e) incorrect history (master) file (or use of wrong history file); f) mistakes in processing procedure; and g) deliberate falsification. Suggestions as to the means of amelioration include: a) internal controls to detect errors; b) internal or external audits; c) addition of confidence limits to data; and d) user instruction in measurement and processing procedures, so that users can evaluate possible errors.

Pronouncements as to the other two attributes (relevance and comprehensiveness) by which Barnard (1975) considers the adequacy of data should be judged are, by their nature, case-specific. However, there are a number of common elements to the evaluation of the relevance of specific data sets. Dretske (1983, p. 56) makes the critical observation as to the need for a "lawful regularity between two events, statistical or otherwise" as prerequisite for one event to carry information about another. Even given this primal condition of relevance, data may lose relevance due to a number of causes such as delayed communication. All data has a strong temporal element, often referred to as timeliness of data or information. The significance and the case-specificity of data timeliness is recognised by Kohls and Downey (1972, p. 250) who state that

> If information is to be useful it must be timely. What is considered timeliness will vary with the different types of markets and different ways in which information is used.

Data may become out-of-date due to significant changes in the environment in which the observations were made, changes in the statistical basis of the measurement or data transformation and changes in the decision structures to which the data is to be applied. Message delay may also result in the obsolescence of data, yet the primary cause of message delay, within information systems both formal and ad hoc, is reported to be a function of the priority assigned to the message (Huber 1982a, p. 145):

> ... three variables that seem to affect message delay: (1) timeliness of the message, (2) work overload of the sending unit, and (3) the number of links in their communication chain.

Judgements as to the comprehensiveness of available data can be viewed in terms of the degree to which the "available data set" matches the "optimal data set". Both the size of the problem domain and the decision structure intended to be applied will influence the boundaries of the optimal data set. Changes to the scope of the idealised data set and hence source data bases can be expected to mirror the differences identified in the taxonomies of decisions and decision structures discussed in chapter two, such that the scope of the decision world and the intended decision structure (application) to which the data is to be applied consequently impact on both the scope and the architecture of the source databases. In addition, such databases must also have the capacity to accommodate ad hoc queries (Davis and Olson 1984).

In commenting further on the relevance and comprehensiveness of data, Barnard (1975) concludes that a comprehensive data set may include data which has already been seen, hence is considered superfluous and, as already seen, irrelevant, noting that more detailed data are not necessarily more comprehensive than less detailed data (nor are they necessarily more accurate or more relevant).

Whilst accepting this view in general it is important to note the role of redundant data/information already held by the target in accuracy-checking and the development of confidence source/communication channel reliability and for inter-source comparisons.

An alternative view (the cost-benefit approach) as to the question of whether or not the data available is of adequate comprehensiveness is seen in the examination of the marginal returns to additional data/information. However, there is often great difficulty in the judgement *ex ante* as to whether the available data is in fact an adequate description of the actual environment to which decisions relate. Hence, it is necessary to acknowledge that putting this principle into practice would be far from easy, (Barnard 1975, Dillon 1977). In practice, the producer must balance the costs, both financially and in time of gathering more data, of greater detail and accuracy, along with the costs associated with delaying a particular decision, against the additional benefits associated with a greater degree of decision accuracy. The latter is significantly influenced by the appropriateness of the decision structure applied. This analysis is further complicated by the fact that "units" are not of uniform value, such that the last piece of data/information may be of significantly more value than all previously gathered data/information. Bonnen (1975) further notes that, where information is a free good and where greater levels of uncertainty place increasing value on information, the assumptions of the neoclassical model become less applicable. In practice these decisions "inevitably rely heavily on intuition and subjective judgements" (Dillon 1977, p.173).

4.2.5 Data transformations

Bonnen (1975, p. 758) makes the observation that "decision makers rarely use raw data" and that there are a number of intervening acts, such as summarisation, various statistical transformations, interpretation, evaluation and filtration, which transform data into problem-specific information. It is this screening, editing, evaluation and problem orientation of data which is seen as the essence of the conversion of data into problem-specific information (Purcell 1969, Chavas and Pope 1984, Davis and Olson 1985). In fact, Gorry and Scott Marton (1975) suggests that most managers do not require additional data. Rather, that they have a need for new methods to understand and process data and information already available to them. The aiding of decision makers in these areas, with subsequent externalisation (from the decision maker's cognitive activities) of such functions as filtration and condensation, is considered to be the most important function fulfilled by MISs (Ackoff 1967).

Whilst this data transformation and the manipulation is seen as being problem driven, due recognition of the impact of the constraints of the available communication channels and of information transmission costs, as a motivator of data transformation, is required. The constraints on the transmission of large quantities of data imposed by channel capacities, such as the time availability constraints in the electronic media or the "seven plus or minus two" constraint of human receptors (Miller 1956, Silver 1981) (see

3.2), may in fact be the major impetus for the proliferation of such summation techniques as market indices used to convey market trends.

It is therefore necessary to distinguish between the communication constraint-driven transformation of data and the transformation of data associated with the functional disparity of DBs and MISs (see figure 4.3). Timko and Loyns (1989, p. 611) make reference to such a differentiation in the discussion of the impact of factual correctness and the importance of "information being presented in a form which potential users can understand" on overall information effectiveness. The discussion of the requirement for communication-induced transformations and communication induced errors is undertaken in 5.4.

In the case of data transformation associated with MIS functions, systems-induced errors may be associated with the need to make assumptions as to functional relationships, especially cause and effect relationships, among data items and between present and future states of the environment (Mason 1975) (see Figure 4.4). The need to make such assumptions about a range of cause and effect relationships escalates as the level of problem abstraction increases. Hence, it can be expected that data/information systems orientated towards "level 3" as opposed to "level 1" problems, as described in Humphreys' and Berkeley's (1983) taxonomy of decisions (see Chapter 2), will exhibit a greater potential for data transformation induced errors.

The structuring of MISs is further complicated by instability in the environmental relationships being reported. Where such systems are required to make predictions about future states of such environments, the system must be capable of detecting changes in the actual relationships occurring and evaluate the significance of such changes to the assumptions implicit in the MIS itself. For example, a MIS that incorporated wool supply and demand functions, with elasticities of demand and supply based on historical data, to aid in the formulation of price predictions, would need to recognise the fundamental change in the production environment brought about by the removal of the Reserve Price Scheme or the movement of the processing base to (lower labour cost) Asian countries. The significance of such problems can be expected to increase as the time horizon over which predictions are required is extended, the structural stability of the industry decreases and the rate of innovation in the industry increases.

In addition to the introduction of systemic error, Barnard (1975) stresses the need to address the potential for amplification of errors, noting the scope for accumulation of primary data errors as the statistical manipulations become more inclusive, for errors to become more complex as primary data is combined with other statistics and for errors to become more refined as a result of the data being manipulated in various mathematical and econometric models.

Data summarisation / modification

The literature pertaining to the subject of data/message summarisation (reducing the size of the message/data package while at the same time faithfully reproducing the message) and modification is found by Huber (1982) to be extremely sparse. Yet the former has the potential to greatly reduce the cognitive or logistical load on the units having to process the data and the latter may result in significant misrepresentation of the environment reputed to be portrayed. Here, 'modification' is taken to be a distortion of the message (data package) meaning and is said to be the result of either the cognitive limitations of, or the motivation of, the sender (Huber 1982).

Data summarisation can be achieved via various mechanisms: data can combined into a descriptive statistic; as such the descriptive statistic can then be compared to some standard; or statistical inferences can be drawn from data with such inferences being treated as data for further processing. In addition, quantitative data may be summarised through the process of verbalisation.

Huber (1982, p. 151) puts forward the following propositions as to propensity for summarisation to occur

> The probability or extent of message summarization is positively related to the perceived saving in transmission costs obtained from summarizing the message.
>
> The probability or extent of message summarization is inversely related to perceived cost of summarizing the message.
>
> The probability or extent of message summarization is positively related to the perceived workload of the receiving unit.

> The probability or extent of message summarization is positively related to the number of sequential links in the communication chain connecting the receive to the message source.

The capacity of summarisation to downgrade the information content of a given basic data set can be illustrated by reference to "data standards", adopted for comparative analysis purposes. A common and elementary form of data summarisation is the utilisation of means or averages which serve as "data standards". However, Errington (1989) notes that much data collected through national surveys contains important information on yield variability both between farms and over time, yet published standards still tend to refer only to estimated means for a given year. Hence, valuable information on the dispersion around these means, and hence the probability of obtaining significantly higher or lower yields, is lost when data standards are used as the means of communicating such basic data.

> What is required is a straightforward system for presenting some of the basic information on variability in a form that can be used by farmers,.. (Errington 1989, p. 23)

In a similar view to the work on summarisation, Huber (1982, p. 145) has developed a series of propositions relating to the propensity for message modification:

> The probability or extent of message modification is positively related to the increase in its goal attainment that the sending unit believes will result from introducing the modification.
>
> The probability or extent of message modification is positively related to the decrease in stress on the receiver that the sender expects will result from his or her modification.
>
> The probability or extent of message modification is positively related to the discretion allowed in choosing the message format.
>
> The probability or extent of message modification is positively related to the difference between actual message content and its expected or desired content.

> The probability or extent of message modification is positively related to the preceived ambiguity of the data on which the message is based.
>
> The probability or extent of message modification is positively related to the extent of the sender's work overload.
>
> The probability or extent of message modification is inversely related to the cost that the sender expects to incur as a result of making the modification.
>
> The probability or extent of message modification is positively related to the number of sequential links in the communication chain connecting the receiver to the message. (Huber 1982a, p 145)

Graphical representation

The use of graphs as a means of message summation is common throughout science and commerce. Wrigley and McLean (1990, p. 195) suggest that

> Business information is often communicated better in tables, graphs, and pictures than in words. Graphic aids bring clarity, force and interest to all types of statistical, financial and technical information because illustrations and graphs enable the reader to perceive trends quickly and understand the relationships between things.

The graphical aiding of perception has been extensively studied by Hoffman, Earle and Slovic (1981, p. 98) who comment that apart from the functions of data condensation, "graphical feedback eliminates the necessity for subjects to have to conjure up and test nonlinear functions" which has been shown to greatly aid learning in a multidimensional functional learning situation.

Whilst graphical style and information density influence the comprehension of information presented in graphical form, Evans (1968) reports that Australian farmers had little difficulty in understanding graphs of a quite complex nature. The same author notes that the level of secondary schooling attained by farmers was not a significant factor in determining the ability of farmers to read graphs.

Huseman, Galvin and Prescott (1991) note the power and ease of graphical presentation of qualitative and statistical information. However, they also note the ease with which graphs may be used to misrepresent information, citing the common ploy of manipulation of scales used on axes.

Market indicator series

There is general recognition of the need for market data summation, a primary function of MISs. A practical example of this can be seen in the numerous market indicator series published. This is a common feature of a range of markets including the bond, institutional stock and land markets, in addition to most agricultural commodity markets.

However, the degree of comprehension of the construction, limitations and the roles of such series appears to be limited.

Reilly (1989, p. 150) comments that

> A fair statement regarding security market indicator series - especially those outside the United States - is that everybody talks about them, but few people understand them.

The author's own discussions with a range of Australian producers indicates that this statement would be equally true if applied to the understanding of agricultural market indicator series.

The construction of market indicator series is influenced by a range of factors including sample size, sample representativeness, weighting, the computational procedure and the selection of base periods (Tomek and Robinson 1972). A wide range of computational mechanisms have been utilised to generate market indicator series, as illustrated in Table 4.1.

Kohls and Downey (1972) suggest that, given the impossibility of covering all transactions in a market, the problem becomes one of adequate sampling if one's aim is to obtain information which is representative of the market. The representativeness of a market indicator series will be influenced by the size and the breadth of the sample used to construct the series (Reilly 1989). Further, both market prices and market indicator series may also become unrepresentative of the supply and demand situation facing a producer as greater amounts of total supply bypass the central market (Smith 1965).

The representativeness of market indicators may also be compromised by the increasing utilisation of branding and grading within a market. Whilst the latter may improve the accuracy of the market data recorded, the need to aggregate across grades or brands, to achieve adequate sample sizes for the calculation of market indicators, often hides the reasons for differentiation. It is especially troublesome where the implicit assumption that individual commodity grades will move with the aggregate market is made in the discussion and use of an indicator series.

How ever efficient the construction of an "index number" is, a principal problem with the use of index numbers is in fact their subsequent interpretation. Tomek and Robinson (1972, p. 209) note that, whilst indices may be reasonably good indicators of relative price changes, they are "not good indicators of well-being or of relative income changes". The latter are often implicit in the general discussions involving market indicators.

Table 4.1

Alternative Stock Market Indicators

Type	Example	Formula
Price-Weighted Series	Dow-Jones Industrial Average (DJIA)	$DJIA_t = \sum_{i=1}^{30} P_{it}/D_{adj}$
		P_{it} = the closing price of stock i on day t D_{adj} = the adjusted divisor on day t
Value-Weighted Series Value	Standard & Poors Index	$Index = \frac{\Sigma P_t Q_t}{\Sigma P_b Q_b}$ x beginning Index
		P_t = ending prices for stocks on day t Q_t = number of outsanding shares on day t P_b = ending prices for stocks on base day Q_b = number of outsanding shares on base day
Unweighted Price Indicator Series	Uni of Chicago Series	$Index = \sum_{i=1}^{x} P_i$
		P_i = Stock price x = number of stocks in the series
Value Line Average	Value line Composite Average	Index = equally weighted geometric average of the percent changes in individual stock values

Source: Adapted from Reilly (1989)

Efficiency ratios and inter-farm comparisons

A common form of data transformation, in agriculture, has been the production of efficiency ratios such as returns on capital invested, returns per dry sheep equivalent and returns per hectare. Individual farm ratios are then compared with district or group averages, with inter-farm comparisons of gross margins also being common.

The use of such ratios has been strongly criticised by Mauldon and Schapper (1970, p. 279) who have suggested that

> .. [the information needs] of those who want statistical comparisons of key or efficiency ratios and of historical gross margins between different farms and between activities within a farm, could be met costlessly and punctually by a set of (almost) random numbers. This is because such comparisons and margins are of slight use in planning, budgeting and diagnosing strengths and weaknesses in farm management and are untimely, expensive and inaccurate.

Mauldon and Schapper's (1970) concerns relate to the inherent inaccuracies associated with the estimation of such ratios, the rejection of the implicit assumption that ratios based on last (or numerous previous) year's market outcomes or productivity will be relevant to the current planning period and the disparity between the calculation of average productivities, as in such ratios, and the planning (optimisation) need for estimates of marginal productivities.

4.2.6 Automation of decision structures

Mason (1975, p. 2) poses the question "where should the information system leave off and the decision maker begin?" Similarly in terms of primary production, it is valid to raise the question as to what parts of the data generation, data transfer, information evaluation and choice process should be either conducted by agencies external to the farm business or be automated under the control of the farm business or remain primarily a cognitive function of the individual producer?

The answers to these questions appear to be very subjective. However, it is possible to recognise several task characteristics which impact on the decision, such as the relative degree of structure observable in the problem, the probability of task repetition and the availability of qualitative data relevant to the problem.

Humphreys and Berkeley's (1983) decision taxonomy (see Chapter 2) provides a structure within which the conceptual scope and task complexity of various problems may be evaluated, thus characterising the automation task. However, the taxonomy cannot in itself answer Mason's 1975 question.

In this section an attempt is made to gain some measure of the potential for agricultural information/decision process to be automated. This is assessed through a review of the scope of commercially available agricultural computer packages and the reported utilisation of such automated decision structures. A later section of this dissertation reports on observations made by the author as to the actual utilisation of such programmes by a group of New South Wales farmers.

Data and inferences

First, a distinction between on-farm observation of production data and enterprise-specific market outcomes, as opposed to industry-wide market and production data, is required to be drawn. Differences not only exist in the theoretical concepts employed, their operationalisation and data measurement; it appears that there are significant differences in the ambiguity associated with both types of data. Again, discussion here will concentrate on market data and information; however, it is necessary to stress that this is only a subset of the data set required for agricultural decision making.

Currently, the vast majority of Australian agricultural commodity trade is computerised. This has been the result of the automation of the recording of the exchange function. The *raison det'er* for such systems has been the cost savings associated with computerisation of accounts, trans-shipment details and product description, and data exchange. As such, data collection and manipulation for market reporting and farm management purposes is peripheral to the basic task associated with such systems. An example of such a system is the "Australian Wool Industry Data Exchange".

The adequacy of these systems, as primary data sources for farm management, is constrained by questions of information ownership, commercial sensitivity and the general lack of any formalised data analysis within such data bases. This has resulted in the substantive analysis and reporting of such market data often being carried out by statutory authorities, as the market operators find it difficult to capture any commercial benefit from such activities. This is especially true where the statutory authorities have a requirement to access original market data for the purpose of levy collection. Such a situation has resulted in the significant automation (computerisation) and formal structuring of the processes of market data gathering and reporting.

The availability of these "free" market information systems, and the substantial costs which would be incurred should a producer wish to observe all markets of potential interest directly, results in the externalisation of the processes of theoretical concept formation, concept operationalisation, data measurement (observation) and data output. The dependence of producers on market data systems external to their enterprises, on this basis, appears a "rational" decision .

Even given access to the basic market data, an individual farmer would find it difficult, if not impossible, to interpret such bulk micro-data. This underlies the prominence of statutory authorities and commercial trading houses in the summation, transformation, interpretation and referencing of market data, as illustrated by the volume of market reports, market indeces, market graphs and commentary published by such organisations. Such material becomes the data input for various inferencing procedures used by producers. This has resulted in an imbalance in the effort directed towards the maintenance and investigation of the structures of federal government agricultural data bases contrasted with the "minimal amount of work undertaken in the area of database design for agribusiness" (King 1986, p. 458).

This externalisation and basic lack of knowledge has the potential to induce major errors in on-farm decision making where either there is a conceptual obsolescence in the data system or in the operationalisation of the DBs. Further, Bonnen's (1977) observation as to the need for conceptual and definitional consistency between data and analytical hypothesis can be extended to the recognition of the need for producer comprehension of the basis of market data observation and summation and a consistency of data/inferencing/decision structure conceptualisation.

> An analytical hypothesis or model and the data for its empirical test must have the same conceptual and definitional base. This is perhaps too logical and obvious to mention yet a failure to appreciate this fact lies at the heart of our apparent inability to understand and deal with the problem of the accuracy of information provided in agricultural economics. (Bonnen 1977, p. 399)

Whilst the process of market data generation and data summation (i.e. market description) is dominated by agencies external to the farm unit, the functions of prediction and inferencing (Mason 1975) are in general dissipated amongst a number of external agencies and the individual enterprise. The latter assumes the major role and bears the commercial responsibility for the efficiency with which it can undertake these tasks. Numerous econometric models, with varying capacities to formulate supply, demand and price expectations, have been observed with no evidence of automation of on-farm market prediction or inferencing being identified by the author. The processes involved in market outcome prediction at the individual enterprise level appear to be substantially holistic. However, this is not to deny the existence of formalised inferencing techniques for the formulation of price expectations (Turnovsky 1974, Fisher and Tanner 1978, Fisher 1982, Goodwin, Grennes and Wohlgenant 1990).

<u>On-farm computer application in agriculture</u>

In the American context the development of public agricultural databases is held, by Batte, Jones and Schnitkey (1990, p. 945), to increase "the potential for better decision analyses and improved allocative and technical efficiency in agriculture." Similar database developments associated with the capacity for direct data transfer to on-farm computers has occurred in Australia. Examples include the Computer Aided Livestock Marketing Service (CALM) market reporting service and "Elder Link" (a general data base maintained by a pastoral trading house). Whilst not currently widely accessed by producers, these systems are indicative of the potential to automate the acquisition of data.

<u>Automated choice</u>

The absence of any identifiable inferencing structures (in commercial use) truncates the integrated automation of agricultural decision structure, at the generalised data base level. This incapacity to formalise the processes of inferencing and prediction formation (a function assigned to MISs) appears to limit the automation of agricultural decision making to the mainly external functions and processes associated with DBs. However, on the basis of DSS accepting holistic market inferences, these being producers own estimates of market returns and subjective probability estimate, it is possible to further automate the decision process.

The inclusion of the functions of structured formation of values and the process of the identification of choice alternatives is seen by Mason (1975) as the factor distinguishing DSSs from MISs. These functions revolve around the questions of "what if?" and "if, then what responses will be observed?" The answers to these questions indicate the functional role of Decision Support Systems (DSS). The automation of such a system is largely dependent upon computerisation as the computational load is such that manual systems are ineffective.

Computers have, for some time, been considered to have significant application in the aiding of management units engaged in agricultural decision making, whether that assistance is in the form of automation of accounting functions (Batte, Jones and Schnitkey 1990) or "Expert Systems" (McKinion and Lemmon 1986).

Yet ,

> Various projections made nearly a decade ago forecasted that most commercial farmers would be using computers by 1990. These projections have proven grossly inaccurate, even though computer processing speed and software availability have improved remarkably. (Batte, Jones and Schnitkey 1990, p. 935)

Given that Australian agriculture is characterised by a large number of management units with limited resources, each with highly individualistic resource constraints and production goals, the processes of formation of choice values and response alternatives will be predominantly constrained to within-enterprise evaluation. Hence, the automation (computerisation), or aiding, of these processes will need to be applicable at "farm gate" level. However, most agricultural enterprises, with some exceptions, lack the capital or expertise to develop enterprise-specific automated decision structures. Therefore, where computerised automation has occurred it has, in general, been through the application of commercial packages.

A review of the listing of computer software available commercially in Australia, compiled by Reynolds (1992), indicates that the bulk of packages provide a degree of automation of enterprise-specific data storage and retrieval. Of the programmes listed for "Financial Recording & Analysis", 69 in total , the majority (77%) are based upon a cash book accounting approach. Of this group, 65% provided a budgeting capacity, with financial analysis restricted to cost centre (enterprise) allocation of transactions. Analysis beyond this level was very restricted, with only 16% of the programmes listed providing a form of gross margins analysis.

In terms of problem conceptualisation, these programmes indicate a capacity to automate farm management problems to a conceptual level of "one" under Humphreys and Berkeley's (1983) decision taxonomy. Further evidence of level one decision automation is provided by programmes for the calibration of boomsprays and metric/imperial measurement conversion programmes (Reynolds 1992).

The application of computers in Canadian agriculture also exhibits this dominance of financial recording over analysis, with 40% of the current Canadian software offerings being financial record keeping systems, and another 40% physical/production recording systems (Waldie 1989).

Of these financial recording systems Waldie (1989, p. 732) makes the following comments.

> There is no information of a usable form for management until the final steps are performed (balance sheet and income statement) .
>
> Put another way, financial accounting is reporting to other people (lenders, governments, etc) whereas management accounting is reporting to the manager.
>
> The bulk of software offerings to date merely automate the collection of aggregated information in a form that is of more use to people

outside the farm than for those inside it.

Only 8% of the programmes in the Canadian review provided any form of analysis or planning capacity (Waldie 1989). This measure is significantly higher in Australia on the basis of inclusion of "Cash Flow Budgets" and "Gross Margins" in the list of planning aids.

Extension of planning and analysis beyond this level of problem conceptualisation is extremely limited, with only one of the 69 Australian programmes listed by Reynolds (1992) provided any formal consideration of risk, specifically a price and yield sensitivity analysis. Nevertheless, there is a capacity, within the bounds of computational resources and the limitations of human inferencing, to conduct sensitivity analysis though the manipulation of cell point estimates within cash flow budgets. However, Dorris, Sadosky and Connolly (1977) suggest that decision performance is depressed where humans are required to integrate data over ranges in excess of five variables.

The lack of commercial whole farm financial software, entailing problem conceptualisation beyond Humphreys and Berkeley's (1983) level one conceptualisation, may indicate that the market is sceptical about further automation of agricultural decision making, given the breadth of the decision world involved. Even at this level of conceptualisation there is general contraction of the time horizon over which budgeting occurs, normally to a 12 month period. Such a reduction requires numerous resources (land area, major capital plant, flock structure, etc) to be treated as fixed, reducing the potential for optimising analysis.

Extension of DSS problem conceptualisation requires a corresponding contraction of the decision world, so that the choice criteria may be constrained and the problem remain manageable (McKinnon and Lemmon 1986).

The numerous feed formulation and feedlot analysis programmes, incorporating data bases containing feed and feeding standards, which also utilise objective selection criteria, illustrate the capacity to aid decisions at elevated conceptual levels. This automation is assisted as such intensive industries have the additional benefit of removing from the decision world a significant proportion of the environmentallyinduced production risk, hence simplifying the calculation of the optimal operating condition.

The development of DSS at higher levels of problem conceptualisation, within restricted decision worlds, such as "Stochastic-Computerised-Activity-Budgeting" for sheep enterprises (Mill and Longworth 1975), which incorporate risk optimising procedures, illustrates the theoretical potential for further automation. However, evidence of significant commercialisation of such approaches is difficult to obtain. Anderson (1976, p. 1) suggests that

> The difficulties of handling multiple sources of risk perhaps explains the paucity of 'fully-fledged stochastic (probabilistic) budgets in farm management.

Advances in this field have been made as illustrated by Brown, Turvey and Lowry's (1992) description of "B.E.A.R. Plus", a computerised farm management and extension tool for financial planning and risk management. This package automates the calculation of a range of business ratios and the probability of achieving specified returns, the risk analysis being dependent on the operator providing estimations of the normally distributed range of outcomes (price and yields) described by the expected, optimistic and pessimistic values. These values are entered into a formula that approximates the cumulative normal distribution, with the standard deviation being approximated as optimistic minus pessimistic, divided by two. Yet here again, as with Toft, O'Hanlon and Makeham's (1979) guide to decision making at the start of a drought, these DSSs are dependent upon the largely heuristic inferencing techniques to supply these estimates.

The primacy of the mental processes, conditioned by attitudes, values and goals, in the decision process, noted by Carry (1980), results in significant individual variance in decision making, especially in the process of choice. This individuality suggests that there may be great difficulty in the application of generalised ESs, with formalised objective (choice) functions, in agriculture.

ESs have been used in agricultural extension, described by Gum and Blank (1990), containing a data base and the capacity to structure that data in the form of knowledge relevant to the problem, an inferencing engine (a general problem solving structure) and symbolic reasoning capacity based on the application of strategies and heuristics in the manipulation of the symbols standing for the problem concepts. Here, the heuristic function is to limit the domain of search for solutions. The application of this level of automation has not only required the problem world to be constrained, it also requires a concerted effort to restrict the search for solutions to a domain of previously identified options.

The current application of ESs hence appears limited to narrowly defined problem areas, such as systems to aid producers in grain marketing decisions (Doluschitz and Schmisseur 1988) and in the field of education. The latter role is referenced by McGrann, Karkosh and Osborne (1989, p. 706), who conclude a description of an "Agricultural Financial Analysis Expert System" with the following remarks:

> ... verification efforts indicate that expert systems technology will be a valuable tool to enhance knowledge delivery by agricultural economists. Economics and finance are areas where expertise is often limited. Leading to inadequate use of data and analysis tools by producers, lenders and educators. Expert systems offer a significant delivery technology.

This potential offered by ES in the aiding of the dissemination of knowledge (extension) and learning experiences resulting from their application (Ozernoy 1988), particularly in the area of genetics, is seen by Pfeiffer (1989) to be the motivating force behind the embracing of the concept of ESs by agricultural scientists.

Hence, of the ESs reported in the literature, it is possible to suggest that in general, the limitations on the scope of the decision worlds which they can address at the moment restrict the application of such an approach to the automation of agricultural decision making to a very limited number of specific enterprises. Also such systems appear far from being able to provide rigorous optimisation of plans involving agricultural enterprises producing numerous products in a production and marketing environment exhibiting a high degree of variability.

The role of decision structures and data in the overall management decision process is summarised by Cull (1991, p. 3) in the following terms.

> In this era it is vital for the social and natural resource issues to be considered in any management decision. The data used, however, may be fairly subjective in the medium term, but the concept of the decision aid is that it is an aid, and not a precise tool.

Adoption of automated decision structures

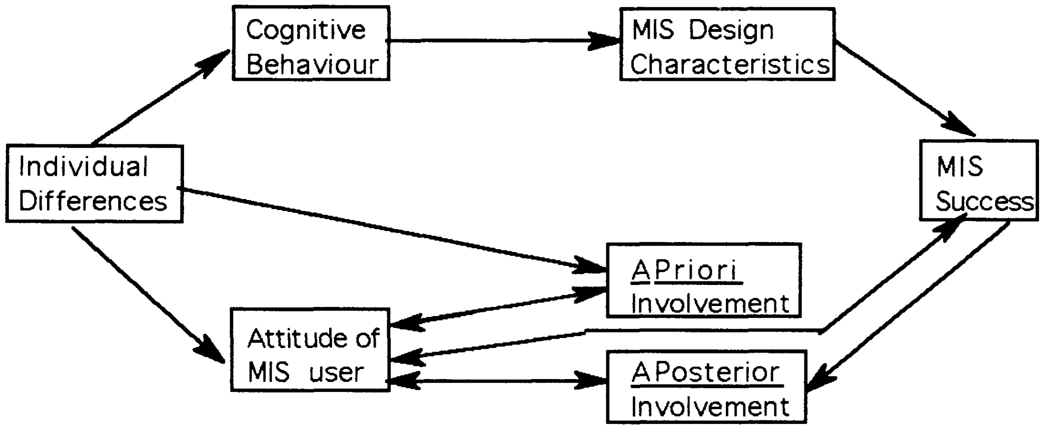
The utilisation of structured decision processes, on farms, is further restricted by the level of adoption of the already constrained "commercial" offering of computer packages. Without embarking on a comprehensive review of the literature pertaining to rural extension and innovation adoption, it is of interest to note some references specific to the adoption and utilisation of decision structures and the automation of the information/decision process.

Batte, Jones and Schnitkey (1990, p. 938) make the following observations relating to the adoption of computer technology by US farmers.

> Computer use within the firm is hypothesized to be determined by two sets of variables. The first set relates to farmers and firm characteristics that modify the firm's demand for information. Business size, farm type, and method of land control influence the rigour of information requirements. The manager's knowledge and skill also influence the demand for information.

The level of demand for, and use of, information, and hence the need for automation, is reportedly influenced by an individual's cognitive make-up, with intolerance of ambiguity influencing not only the level of demand (positively) but also resulting in a preference for 'factual data' over abstract or conceptual data (Dermur 1973).

From studies of the adoption and utilisation of MISs in corporate entities, Zmud (1979, p. 967) developed the following model of the interaction of individual cognitive characteristics and the success of MISs (Figure 4.6).



Source: Zmud 1979
Figure 4.6 Impact of Individual Differences Upon MIS Success

The individual differences considered important included "cognitive style" including such individual characteristics as being either: perception simple/complex; field dependent/field independent; or symatic/heuristic. Aso important were "personality" traits such as: dogmatism; ambiguity tolerance; extroversion/introversion; need for achievement; risk-taking propensity; evaluative defensiveness; and anxiety level. "Demographic/situational" variables were also reported to influence MIS utilisation.

Even given the physical adoption of computerised decision aids, the actual level of decision structuring induced may in fact be less than that exhibited by the package itself. As Steven's (1991, p. 24) observations as to the role of cash flow budgeting in farm management indicate;

> More frequently, the farm manager only generates the cash-flow budget after the decision about enterprise-mix has been made. Any further adjustments to the farm programme are made to satisfy constraints such as borrowing limits rather than to maximize profit.

Further, the adoption of the more specific ESs (i.e. those decision aids relating to limited decision worlds) available appears further constrained by the fact that

> Farm managers are reluctant to use more than one detailed farm management package. So a whole-farm decision support system must also be able to satisfy the manager's financial management needs of producing a cash-flow budget and balance sheet for the financier and a record of financial transactions for the accountant. (Stevens 1991, p. 25)

As with the adoption of any level of automation of the information/decision process, Lee and Nicholson's (1973) argument that the rationality of farmers' refusal to keep detailed records is unquestionable, unless the costs of recording are outweighed by the beneficial use the farmer can make of the records. This, along with Batte, Jones and Schnitkey's (1990) observations of American farmers, indicating that only 20% of the farmers reported management use of farm records, of which 85% used manual systems, suggests that farmers are yet to be convinced that positive net benefits flow from detailed enterprise analysis.

4.3 Forecasting

Any form of economic optimisation which entails the commitment of resources to the production of goods for sale in a future time period necessitates the formation of forecasts as to yield (physical output) and market outcomes. These forecasts may be wholly subjective, objectively derived or based on a combination of the two approaches.

The accuracy of, and the decision maker's confidence in, these price forecasts will have a significant impact on the validity of any decisions made and the decision maker's level of felt ambiguity, respectively. Further, it is suggested that significant variation in the degrees of accuracy of, as well as the confidence, in such forecasts held by the producer, and the rigours of the decision structure applied will result in significant cognitive dissonance. Observations by the author of farmers behaviour over many years indicate that this dissonance is a major contributing factor to the low levels of application of formalised decision structures in agriculture (there is no value in measuring sheep yards with micrometers). The significance of this lack of confidence in,and the subsequent under-utilisation of, forecasts by producers, is reflected in the observation by Goddard (1985, p.94) that;

> Improvements in the quality of forecasts may encourage more users to treat the forecasts seriously as an aid to their decision making.

This raises the question as to whether producers are justified in viewing agricultural commodity price forecasts, either supplied by agencies external to them or derived from their own inferences, as being so unreliable that it is of little value to apply intricate decision structures to such data sets (a recognition of the computer age maxim 'garbage in, garbage out').

In this section a limited number of forecasting techniques, and their application in agriculture, are reviewed. Concentration is on the techniques used by external agencies to generate price and global production forecasts.

It is to be noted that no formalised forecasting techniques, applicable at farm level, have been observed.

At the outset it is necessary to acknowledge the constraints on human inferencing, as described in Chapter 3, as these are seen to impact on the aggregation of current market signals and external agency predictions in producers' estimations of future price and production outcomes. The complexity of the data in such time series, "viewed as being composed of trends, seasonal, cyclical and random (irregular) components" (Tomek and Robinson 1977, p. 372), in addition to the identified 'inferencing constraints' which can be expected to impact on the aggregation of 'real time' market indicators (Wool Market Indicator, traded volumes, and specific bale quotes), suggests that producers may have significant difficulty in the estimation of product values, within the context of marketing decisions.

However, where the producer is required to provide future prices and production estimates (either in point form or with some measure of variability for input into particular decision structures) the inferencing task becomes infinitely more difficult as the number of cues increase (forecasts by brokers, ABARE and AWC), the weighting of those cues becomes problematic and, significantly, the cue - outcome relationships have the potential to become unstable. Further, both the time delay in the stimulis-response-outcome cycle and the disturbance in the relationships to be learned will greatly inhibit learning.

Such relationship disturbances are evident in Shepherd and Futrell's (1980, p. 111) description of the nature of seasonal price changes.

> Average seasonal price patterns are only a rough guide to the behavior of prices in any one year. Before average seasonal price movements can be of much use, they must be supplemented by a study of changing trends and erratic forces at work each year, separately for each commodity.

As also noted by Freebairn (1978), forecasts must be presented in a form which is easy for producers to interpret. Difficulties in data interpretation (inferencing) can be introduced by a range of factors, some as simple as measurement unit disparity between forecasts and decision structure or farmer's cognition (e.g. forecasts of cattle prices in cents per kg dressed weight when cash flow or gross margins are structured around dollars per head and the producers conceive of prices in cents per kg liveweight).

4.3.1 Forecasting techniques

Forecasting is defined by Goddard (1985, p. 86) as

> .. the process of providing information, before the fact, of the expected levels of economic variables of interest to decision makers.

However, differences in the interests of the various categories of decision makers who utilise forecast (producers, marketers, policy makers, etc) result in considerable variation in the forecasting requirements. Freebairn (1975, p.154) notes the importance of the "decision problem' (the decision world) and the "procedures of the decision maker" (the decision structure adopted) in the determination of "what variables to forecast and the forecast horizon, the time of release of forecasts, and the methods of presentation and dissemination of forecasts".

In addressing the question of the time horizon in forecasting (that is the span of the statement "before the fact"), Walker (1985) approaches the problem from the perspective of the intended application of the data. This allows the segregation of such data/information into what is termed "market news" and "market outlook". A similar differentiation is proposed by Smith (1965), who uses the analogous terms 'Situation' and 'Outlook'. The former are used in tactical decisions (e.g. the choice between options for the disposition of a marketable commodity either on hand or to which productive resources have been committed). The latter are applicable to strategic decisions concerning the allocation of productive resources. It is unreliability of the latter, market outlook, which is seen by Barnard (1975) as being the major deficiency in the British agricultural economy, a situation which appears to be similar to the Australian experience. The latter can also be considered to be of greater significance as, the longer the planning and forecasting period, the greater the managerial flexibility; that is, short term fixed assets become variable. Such longer term decisions are held to require forecasts of average prices over the period of the proposed investment, with multi-enterprise decisions potentially being adequately serviced by relative, as opposed to absolute, price estimates, with risk averse producers requiring information on likely price distributions as well as expected or mean estimates (Freebairn 1975).

On this basis the consideration here of forecasting techniques has been constrained to methodologies relevant to the production of market outlook data 12 months and more in advance of the fact, where possible. Further, this work concentrates on forecast techniques relative to the demands of producers and the potential decision structure available to them. This is at the exclusion of the policy maker and the marketer, who must be recognised as being the initiators of, and the financiers of, much of the Australian agricultural forecasting effort.

While Freebairn (1975) characterises the individual producer's decision problem (decision structures) as one of utility maximisation (of which profit maximisation is a special case) and evaluates forecasts in light of this presumption, the intention here is to consider how and to what extent the range of forecasts available to Australian primary producers influences the adoption of particular decision structures.

Wentz (1972, p. 367) makes the following statement germane to the process of forecasting.

> Predictions and forecasts depend on several assumptions. The first is that a relationship exists between the variable being forecast and one or more other variables that can be measured or estimated.

> The second assumption underlying predictions and forecasts is that the relationship between the variables will remain relatively stable over time and from one locale to another, or will alter in a way that can be anticipated. This is probably the shakiest assumption, for if anything is characteristic of the marketplace it is change. Were it not for change, there would be little need for predictions and forecasts.
>
> The third assumption - required only by the more rigorous methods of prediction and forecasting - is that the relationship between the variables can be approximated by mathematical forms which are sufficiently manageable and explicit to be of practical use to the analyst.

The literature on forecasting techniques describes a bewildering array of methodologies for deriving these relationships, which in turn generate multitude of models applicable in the agricultural context. Goddard (1985) provides a listing of the various forecasting techniques applicable to agriculture and some commentary on their requirements, advantages and disadvantages (see Table 4.2).

Table 4.2

Forecasting Methods

Model	Method	Requirements	Advantages	Disadvantages
Indicator Analysis	-Classification of economic time series according to whether they lead, lag or are coincident with variable to be forecast, using observed movements in leading time series to infer changes in future levels of forecast variables	-Historical time series for a variety of variables -Statistical analysis	-Relatively simple -Special and restrictive example of formal/informal model depending on links between lead and forecast variable being qualitative or quantitative -Not restricted by economic theory, choice of lead variable may be on statistical correlation	-Forecast accuracy depends on historical correlation between lead and forecast variable -Structural change not accounted for
Balance Sheet Methods	-Balance sheet of supply and demand is constructed from independent forecasts of the supply and demand for each commodity/country -Surplus/deficits of supply over demand plus pressure for change in prices, stocks or ag. policy	-Demand quantities assume constant prices related to population, income growth, income elasticities -Supply quantities based on trends adjusted for technical or policy constraints	-Simple analysis relative to formal model	Simplifying assumptions of constant prices, independence of commodity markets may invalidate forecasts

Table 4.2 Continued

Model	Methods	Requirements	Advantages	Disadvantages
Survey	-Survey of decision maker's intentions	-Regular surveys of producers/consumers plans	-May be extrapolated as direct forecast or combined with other information -Reduced specification problems in determining producer's expectation process	-Forecast accuracy will depend on the degree to which intended decisions are executed and on sampling proceedur -Forecasts likely to be more accurate the longer the decision lag, the shorter the forecast horizon the less the flexibilityand more costly decision revisions are.
Futures Market Price	-Use futures market as a basis of expected prices	-Access to futures prices	-Can be accurate in terms of bias -Easy to use	-Difficulty of replicating model forecasts and of evaluating sources of error
Formal Model	-Econometric Models -Input/Output Models -Programming Models	-Knowledge of technical realtionships, instutional arrangements, economic theory	-Model can be used to construct probability confidence interval forecasts as well as forecasts of mean or expeceted value -Formal model can be used to enforce objectively consistency on the forecasts -Offers opportunities to replicate forecasts, to evaluatesources of forecast error	-Assumptions made in the specification of the model may be overrestrictive when compared to informal models -Structural change over forecast period vis a vis historical period over which model is built not accounted for -may have large data requirements and high degree of complexity making them expensive to run.

1a : Forecast model : $\ddot{y}_{t+1} = a_0 + a_1 t + a_2 y_t + a_3 y_{t-1} + a_4 y_{t2}$ with a's being ordinary least square estimates for 1948/9 to 1965/6 sample.

1b : Forecast model : $\ddot{y}_{t+1} = b_0 + b_1 t + b_2 y_t + b_3 y_{t-1} + b_4 y_{t2}$ with b's being ordinary least square estimates for 1952/3 to 1965/6 sample.

1c : Forecasts published in September issue of Bureau of Agricultural Economics, *Trends in Australian Rural Production and Exports,* Livestock forecasts refer to year ending June 30.

1d : Forecast model. $Z_{t+1} = a_0 + a_1 t + a_2 Z_t + a_3 Z_{t-1}$ where *Z's* are two year averages of forecast variables and a's are ordinary least square estimates for 1946/7 to 1965/6 sample.

1e: From Gruen et al. 1967

2 Measured $\sum |\ddot{y}_t - y_t| / 8$

3 Measured $\sum |((\ddot{y}_t - y_t)/y_t) * 100| / 8$

4 Measured as number of turning point errors: number of turning points.

5 Computed as $((Z_t - Z_t)/Z_t) * 100$

6 If forecast is in the correct direction relative to the 1964/6 average level of the variable it is denoted by a 'yes', if not by a 'no'.

4.3.2 Forecast Accuracy

The significance of forecast accuracy, and measures thereof, to the application of forecasts in agricultural decision making led Wentz (1972, p. 379) to comment that:

> any forecast is a shaky basis for decision making if it is not accompanied by a statistical evaluation, including a confidence interval.

In fact, Jenkins (1982, p. 6) suggests that "a forecast without some measure of uncertainty is not of great value". The need to convey to decision makers the level of confidence that they can place in forecasts is also stressed by Fischhoff and McGregor (1982). However, these authors make the pertinent point that expressions of confidence are of little value unless the forecasters can assess the limits of their own knowledge.

Such expressions of confidence in forecast accuracy may be based on either the forecaster's subjective assessments or on more objective measurements of historical forecasting accuracy. The latter, of course, assumes both zero change in forecasting efficiency (no learning) and stability in the environmental relationships on which the forecasting technique is based and to which it relates.

Falvey (undated) notes the varying levels of success achieved in forecasting. However, the objective measurement of the relative accuracy of forecasting techniques is not an easy job. As to the user the important measure of the value of forecasts is the loss/gain function from their application within both the decision world of interest and the particular decision structure adopted, "the ultimate test is the translation of its predictive accuracy into improved decisions" (Vere and Griffith 1990, p. 109). However, such individual evaluation of forecasts is hampered by the availability of the information required and would, even if undertaken, be so idio-centric as to be of little value in the generalised evaluation of forecast techniques.

In general, the evaluation of forecast accuracy relies on evaluations of goodness-of-fit (quantitative accuracy) and tracking measures (qualitative accuracy) (Tomek and Robinson 1981, McIntosh and Dorfman 1992). Hence, test statistics such as mean forecast error (associated with a linear loss function), mean square forecast error (associated with a quadratic loss function), Thiel's inequality statistic, and the number of times changes in the direction of the variable are correctly and incorrectly forecasted (turning point errors) become, in fact, the fall-back position for evaluating and comparing forecasts (Freebairn 1975).

Whilst the application of summary statistics to compare forecasting techniques within a given time series (one which should be outside the data series from which the model in question was developed (Brandt and Bessler 1983)) has been common in the literature, Goddard (1985) stresses the idiosyncratic nature of model performance and its dependence on the variables and the time period over which such comparisons are made. Tomek and Robinson (1977. p. 342) note that,

> Experienced price analysts know that estimates of demand (or supply) functions frequently are sensitive to the time period selected for analysis, though few published comparisons are available.

Forecast accuracy/inaccuracy is the product of the net effect of the multitude of errors in forecasting that may be generated from the inappropriate application of forecasting techniques, inaccurate input data, or a lack of knowledge about, and variations in, the relationship between the explanatory variables and the forecast variable (model obsolescence), imperfect knowledge about the explanatory variables, etc. Errors in the anticipation of causal variables are considered by Freebairn (1978) to be the major contributing factor to errors in Australian agricultural prices and quantity forecasts.

Basic forecast accuracy/inaccuracy may be communicated using the measure of the range required to obtain a specific forecast confidence level. These ranges, required to achieve a 90% confidence interval, are estimated in the case of forecasts relating to the Australian wool industry to be in the order of: a) production forecasts ± 40,000,000 kgs, b) market clearances ± 50,000,000 kgs and 3) average prices recieved ± $0.90 per kilo clean, with the errors being random in nature (personal communication Bob Richardson 1993).

An example of specific model based forecasting inaccuracy is provided by the verification of The Bureau of Agricultural Economics (BAE) "Regional Programming Model" (RPM) procedures undertaken by Longmire et al. (1979). This work indicated a model predicted wool production of 570 mkg for 1975/76 against an actual production of 754 mkgs. This was contrasted with a range of actual yearly productions achieved in the interval 1969/70 to 1977/78 of between 680 and 926 mkgs.

Further measures of forecasting accuracy are provided by Freebairn (1975, p. 164) who conducted an evaluation of three Australian commodity price forecasting techniques, applied over the period 1966-67 to 1973-74. Due to sampling error and the period specificity problem, the results obtained specific to the wool industry, as presented in Table 4.3, are held by the author to only be "suggestive of forecast accuracy in a general context". The models reviewed included: "1) time series or naïve forecasts prepared by the author, 2) informal model forecasts prepared by the Bureau of Agricultural Economics and 3) formal model forecasts prepared by the Monash study and reported by Gruen et al.".

Just as the future for wool can not be assessed in isolation from other fibre markets (Tisdell and McDonald 1979), where producers are involved in multi-product enterprises they may be considered to be portfolio managers interested both in the accuracy of forecasts relating to all potential enterprises and in the ability to forecast future commodity price interrelationships (Shephard 1952, Reynolds and Gardiner 1980).

In many situations wool production is allied with lamb production. In an investigation of the accuracy of real saleyard price forecasting methods for lambs in New South Wales, Vere and Griffith (1990) report mean absolute errors ranging from 3% to 49% and turning point error ratio ranges of 3:5 through to 1:5.

Gellatly (1979, p. 92) evaluated forecasting techniques for the prediction of New South Wales quarterly beef production, one quarter ahead, noting that, of the methods reviewed, "the committee [a panel of industry participants] forecast has the highest simple correlation with actual values (0.4336)." He concluded that "the results indicate that the Committee's performance was not much better than that of a naive (no change) model".

The preceding cross section of Australian orientated forecasting techniques indicates a relatively low level of accuracy. This appears to be consistent with international organisational standards, Warr (1990, p. 365) commenting that, when compared with the no change predictive standard, World Bank commodity price projections "do not perform well".

The ability of futures markets to accurately predict future spot market prices has been a subject of some contention, with Hayward (1985, p. 81) commenting that

> The fact that supply and demand, or the 'fundamentals', can almost be irrelevant in the short run has led some economists and market observers to be critical of the futures market

From a study of US live cattle futures markets Martin and Garcia (1981) concluded that this instrument has performed the forecasting function poorly, yielding little additional information beyond that available from lagged cash prices.

Similarly, the efficiency with which the Australian live cattle futures market (period 1975 to 1979) and wool futures market (period 1968 to 1978) can forecast future prices was examined by Giles and Goss (1981, p. 10), these authors concluding that

> With one or two exceptions, the results support the view that lagged futures prices are unbiased estimates of delivery date spot prices for wool with lags from one to 12 months, and for live beef with lags from one to three months.

The significant declines in traded volumes in these markets subsequent to the above study need to be borne in mind when considering the significance of the results.

Furthermore, these results may be misleading if it is inferred that individual producers can rely on such instruments as means to reliably predict market returns on their own products. A number of factors will impair such transformations: a) differences in product description and contract terms; b) movements in basis (changes in grade premiums and discounts); and c) differences in prices units (wool is normally sold on the basis of cents per kg greasy whilst the futures contract is conducted on the basis of movements in aggregate market indicator). These factors can be expected to reduce the correlation between futures prices and individual producer's realised returns and also to impact adversely on producers' perceptions of the reliability of such instruments as price predictors of relevance to farm management.

Table 4.3

Evaluation of Naïve Forecasts of Wool Price and Production Levels in Period 1966/7 to 1973/4

Commodity	Unit	Average Level 1970/4	Forecast One Year Ahead[1a] Mean absolute errors[2]	Mean per cent errors[3]	Ratio of turning point errors[4]	Forecast Three Years Ahead[1a] Mean absolute errors[2]	Mean per cent errors[3]	Ratio of turning point errors[4]
Price Wool	c/kg	120	32.5	20.8	3:3	32.4	24.1	3:3
Production Wool	Mkg	800	92	12.3	4:1	82	10.5	3:1

Evaluation of Bureau of Agricultural Economics Forecasts of Annual Wool Prices and Production 1966/67 to 1973/4

Commodity	Unit	Average Level 1970/4	Forecast One Year Ahead[1c] Mean absolute errors[2]	Mean per cent errors[3]	Ratio of turning point errors[4]
Price Wool	c/kg	120.0	14.3	12.6	1:3
Production Wool	Mkg	800	38	4.7	1:1

Comparison of Naïve Model and Monash Model Five Year Ahead Forecasts of Wool Prices and Production

	Unit	Actual Average 1969/70 &	Naïve Model Forecast for 1970[1d] Forecast	Per cent error[5]	Correct direction[6]	Monash Model Forecast for 1970[1e] Forecast	Per cent error[5]	Correct direction[6]
Price Wool	c/kg	73.7	82.7	-12.2	Yes	107.4	-45.6	yes
Production Wool	Mkg	904	1002	-10.7	yes	870	3.8	yes

Source: Freebairn 1975

Table 4.2 continued

Model	Methods	Requirements	Advantages	Disadvantages
Informal Model	-Description of current state of the sector and a subjective assessment of future levels	Same as above but assumed form of processes generating forecast variable is implicit, method of reasoning qualitative	-Not constrained by explicit and formal constraints of a quantitative model (or restrictive assumptions) -Forecasts may be qualitative or or quantitative -Forecasts may include interval estimates and/or probability dist'ns as well as point estimates	-Greater importance of subjective judgement would seem to increase chances of personal biases affecting forecasts (eg. anchoring) -Difficulty of replicating informal model forecasts and of evaluating sources of forecast error -Accuracy will be influenced by degree of knowledge of forecaster (eg. quality of experience and ability to infer)
Time series model	-Quantitative relating of current and future values of a series to own past values -can vary from simple no-change to complex ARIMA models	-Historical time series on variable to be forecast	-Relative simplicity and ease of application of approach -Have no inherent causal relationships -Favourable comparative forecast accuracy of time series models.	-Difficult to pinpoint the causes of an inaccurate forecast and improve the forecast in the future

Source: Goddard 1985, p. 88

Finally, in a summation of the field of price forecasting, Tomek and Robinson (1977, p. 388) concluded that

> While we unquestionably have better tools of analysis available today than a generation ago, it is less certain that forecasts have improved to a corresponding degree.

The alternative to the provision of objective measurements of forecast accuracy as an aid to decision makers' formation of confidence intervals relative to a particular forecast is for the forecasters themselves to provide expressions of confidence in their own forecasts. However, as with the general population and general knowledge questions, forecasters have been shown to be over-confident in their own accuracy (Sjoberg 1982), a phenomenon that increases in magnitude as the level of knowledge increases. In a study directed towards this problem of forecast accuracy/confidence calibration, Fischhoff and McGregor (1982) observed that, whilst inaccurate, forecaster's assessments of accuracy were at least consistent and that, in addition, those forecasters who never expressed complete certitude were better calibrated (less over-confident).

However, in a cautionary note, Baker and Paarlberg (1962) suggest that whilst absolute forecast accuracy is of importance, there are many other problems, such as the efficiency of communication of forecasts and producers' perceptions of forecast accuracy, which have not been adequately covered and which influence the ultimate impact of forecasts on the economy. Such questions relating to communication efficiency are addressed in Chapter 5 and producers' perception of source and channel reliability in Section 5.6.

4.3.3 Learning from forecast errors

Within the constraints of human learning of relationships as discussed in 3.6, and on the assumption that there is actually a relationship between either a single or a number of forecasts and a producer's realised returns, the question as to whether forecasting techniques aid or hinder learning is pertinent.

Freebairn (1975, p. 158) suggests that

> By making explicit all the assumptions underlying the forecasts, the formal model forecasting procedure offers opportunities to replicate forecasts, to evaluate the sources of forecast errors, and to learn from these errors in improving forecasts in subsequent periods.

Further, it can be suggested that the formalisation of the interrelationships between the explanatory variables and the forecast variable should aid in the optimisation of producers' inferencing techniques. However, while this form of cognitive feedback as an aid to learning has been shown to be an advantage (see 3.6), this advantage will only be realised if the formal model's assumptions, its interrelationships and its errors are communicated to producers, along with the predictions derived. Additionally, Goddard (1985, p. 96) suggests that the provision of various forms of sensitivity analysis may increase the flow of information about the forecasting process, reasoning that the provision of such error information is necessary due to the "inability to monitor each individual user's loss function".

Jenkins (1982, p. 15) suggests that the utilisation of non-technical statements such as "2 out of 3 forecast errors, on average, will be less than 5 per cent of the value being forecast" is an effective means of communicating the potential for forecast errors to managers who, in general, do not like uncertainty. However, the provision of such sensitivity information, or the explanation of the assumptions underlying the forecast procedures is, in fact, a rarity, as most predictions are communicated as point estimates or trends, occasionally accompanied with descriptions of some major assumptions (ie. exchange rates, interest rates, estimates of demand volumes). Historical measures of forecasting accuracy appear never to be published for general consumption.

4.3.4 Producers' confidence in forecasts

The level of confidence that producers place in the forecasts that they receive from external agencies can be expected to influence the weighting applied to them during any inferencing process. Apart from the influence of the more objective measures of forecast accuracy, confidence in forecasts is also seen, by Vere and Griffith (1990, p. 104), as being influenced by the forecasting techniques adopted. They suggest that

> The strong subjective element in past News South Wales lamb market forecasts was a factor in their sceptical view by industry.

This ambiguity which farmers associate with official forecasts may be derived from the underlying inaccuracy of the forecasts themselves, conceptual misunderstandings and, in addition, inaccurate communication of forecast outcomes.

The degree to which this scepticism of official forecasts is reflected in the producers' confidence in their own predictions is of significant interest as this subjective uncertainty, along with the magnitude and direction of changes in expected price changes, is instrumental in determining the willingness of producers to alter production plans (Heady and Kaldor 1954).

4.3.5 Welfare gains from forecasting

Brandt and Bessler (1983) take the view that economic gain to be derived from forecasts will be evident in either rises in net revenue or low revenue variability. They also suggest that these gains will only be captured if the forecast accuracy is sufficient to allow the producers to incorporate the information provided into their marketing strategies.

While it is possible to suggest that economic gains from forecasting will be primarily dependent on the uptake of the forecasts by decision makers and the degree to which the forecasts aid more efficient allocation of resources, it is extremely difficult to derive any objective cost benefit analysis of forecasting. Estimates of the allocation of resources to commodity outlook activities in Australia place the costs involved in excess of some millions and perhaps tens of millions of dollars annually (Freebairn 1978).

In an exploration, based on a stochastic cobweb model of a single commodity, of the apportionment of the gains from increased forecasting accuracy, Freebairn (1976, p. 101) made the following concluding comments.

> the potential for welfare gains from providing agricultural producers with more accurate commodity forecast prices stems from the increased efficiency with which resources are allocated to alternative production activities. Realization of the potential gains will depend on

> the extent to which additional research activities can be used to generate additional information concerning the future demand for and supply of commodities, the extent to which the additional information is conveyed to producers, and to the extent which producers are able and willing to incorporate the additional information in forming the forecast prices on which they base their decisions.

With regard to benefit apportionment, the same author notes that the

> Distribution of the aggregate benefits between producers and consumers differ between models and situations. Important considerations include the elasticities of supply and demand, the source of the forecast error, and decision procedures adopted. (Freebairn 1978, p. 304).

Further, with regard to the scale of benefits to be expected from more accurate forecasts:

> Estimates of the benefits that would arise from decision makers using more accurate price and quantity forecasts suggest that they will be small rather than large. Using decision theory models, estimates of benefits of halving the errors of forecasts now assumed to be used by many decision makers would increase economic returns by no more than a few per cent of the gross value of commodity production. (Freebairn 1978, p. 311)

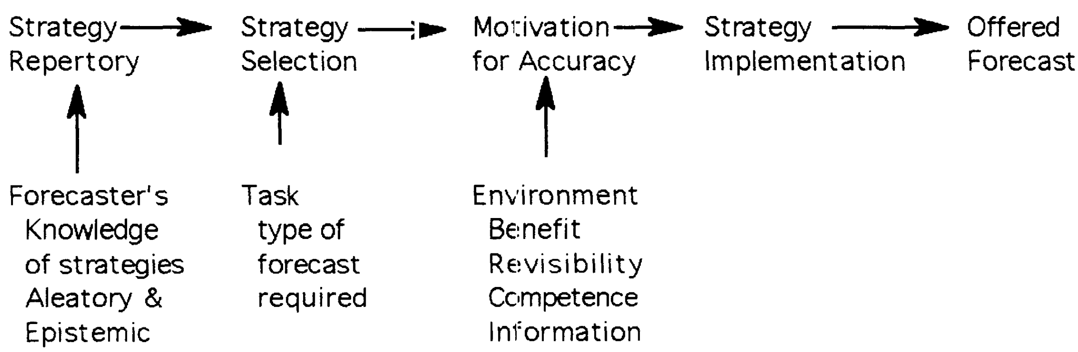
The preceding can justifiably be criticised as being far too narrow in the perspective of benefits attributed to forecasting, especially if the importance of forecasting in governmental policy formation is acknowledged (Klein 1984). However, this aspect is considered peripheral to the intent of this study.

4.3.6 Decision structure and forecasting method interactions

Historically, there has been a void between the academic endeavour concentrated on forecasting and practical decision analysis in agriculture, such that forecasting has often been seen as an end itself. Given a recognition of the intermediate role of human inferencing and its moderation of official forecasts prior to data entry into enterprise decision structures, it is valid to ask whether form or structure of external forecasts can influence the subsequent decision process.

While the area is relatively unexplored, evidence of such an interaction can be found in the application of decision trees in forecasting (Ulvila 1985) and in the "Contingency Model of Judgemental Forecasting" (Beach, Barnes and Christensen-Szalanski 1986) (Figure 4.7).

The latter attempts to model the influences on the selection of inferencing structures (judgemental forecasting methods) which are viewed as being on a continuum ranging from aleatory reasoning (the logic of gambling - modern probability theory) and those that use epistemic reasoning (which involves the application of knowledge about the unique characteristics of specific elements and the framework of knowledge, including the causal network and set memberships). Forecast outcomes are seen to be influenced by the repertory of forecasting techniques available, the type of forecast required (i.e. the application to the forecast relates) and the environment in which the forecast is made. Whilst developed to study the selection of inferencing techniques, the model appears, at least superficially, of interest relative to the question of forecasting technique selection by external agencies. In fact, the need for professional agricultural economists to select from a range of forecasting techniques is noted by McIntosh and Dorfman(1990), who describe an analogous continuum of techniques ranging from judgemental through structural models to objective methods.



(Source : Beach, Barnes and Christensen-Szalanski 1986, p. 151)

Figure 4.7 Contingency Model of Judgemental Forecasting

4.4 Summary

The atomistic nature of Australian agriculture has generally resulted in individual firms relying on market data generated by bodies external to the sphere of control. They gather data and information from external sources for the purpose of decision making and to satisfy their innate curiosity, involves the answering of series of fundamental questions relating to the events to be monitored, the way in which the events are to be measured and the ways in which the data generated may be summarised. Problems with concept obsolescence and other quality factors may result in the data ultimately available to producers, for both inferencing tasks and as inputs to particular decision aids or structures, being of a sub-optimal standard.

Past the point of data generation, aggregation and summation, producers appear to revert to their own capacities, yet there is some scope at the lower level of problem conceptualisation, or within constrained decision worlds, to automate or externalise parts of the decision process. However, the potential for this to occur appears to be constrained by several factors such as the absence of suitable computing software.

A significant gap in the potential for the automation of the decision process is evident in the absence of a formalised inferencing structures applicable at the farm level. In the formation of market expectations producers are left to their own cognitive capacities, generally requiring a reversion to heuristic, or the blind acceptance of externally generated forecasts. Not only are the latter of such a generalist nature (for example, the prediction of seasonal market indicator averages) , of little more accuracy than the naive no change model and viewed with such high levels of ambiguity that they appear to be of little direct use to individual producers.

This external sourcing of data/information and, in limited cases the output of MIS and DSS involves and act of communication, the efficiency of which will ultimately impact on the quality of the decision making. Chapter 5 presents a limited review of communication theory, highlighting the potential for data corruption originating in the communication process. As with previous chapters the emphasis is on the constraints inherent in the process and their impact on the quality of the final data set.