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Gareth EDWARDS-JONES*
Ian DEARY
Joyce WILLOCK

*Rural Resource Management Department
SAC, West Mains Road, Edinburgh, EH9 3JG Scotland UK
Tel.: (+44) 0131667 1041 – Fax : (+44) 0131 667 2601 – E-mail: ESA020@ed.SAC.ac.uk

Abstract
The potential for integrating psychological variables in predictive models of farmer behaviour is examined. Traditionally such models have been based on the assumption that farmers behave as if maximising profit. The Edinburgh Study of Decision Making on Farms is used as an example of a study which has demonstrated the complex relationship between the psychological, social and agricultural variables which actually determine farmer behaviour. On the basis of the results of this study it is postulated that little benefit may arise from integrating economic and psychological variables in models for national level land-use assessment. However, as the geographic scale of the model decreases, and/or the focus of the model moves towards predicting small scale behaviours then the inclusion of psychological variables would seem to offer greater benefits. Before such models can be developed three main areas of work need to be addressed. First, the representation of groups of farmers in typologies based on psychological variables needs to be explored. Second, the relationship between the psychological make-up of farmers and the different levels of financial gain available subsequent to their behaviour requires clarification, and third the computational form of any integrated model remains to be determined.

Keywords: farmer behaviour, decision-making, modelling, psychology, adoption dynamics

Résumé
Modèles de comportement des agriculteurs : l'inclusion de variables psychologiques permet-elle d'améliorer les prévisions ? *Le présent article examine les possibilités d'intégrer des variables psychologiques dans des modèles de prédiction du comportemnt des agriculteurs. Classiquement, ce type de modèle fait l'hypothèse que le comportement de l'agriculteur a pour objectif la maximisation des profits.*
Les auteurs ont utilisé les résultats d'une étude conduite par l'Université d'Edimbourg, intitulée « Edinburgh Study of Decision Making on Farms » pour mettre en évidence la relation complexe entre variables psychologiques, sociales et agricoles qui déterminent le comportement de l'agriculteur.
A partir des résultats de cette étude, les auteurs postulent qu'intégrer des variables économiques et psychologiques à des modèles grande échelle d'utilisation des sols n'apporterait pas d'avantages notables. Mais pour des échelles plus fines il apparaît que l'inclusion de variables psychologiques est intéressante pour prédire des effets de petite ampleur. Avant de pouvoir mettre au point ces modèles il sera nécessaire de poursuivre les recherches dans les trois domaines suivants: a) la représentation des agriculteurs selon des typologies basées sur des variables psychologiques; b) l'étude de la relation entre le portrait psychologique de l'agriculteur et les gains financiers associés à son comportement; c) la structure informatique à donner à un modèle intégré.

Mots-Clés : *comportement des agriculteurs, décision, modélisation, psychologie, dynamique d'adoption*

Introduction

Traditionally models seeking to predict the adoption of policies and technologies by farmers have combined a variety of biological, physical variables, e.g. farm size, farm type, soil type, agro-ecological zone, with some financial variables, e.g. market prices, availability of credit, asset:debt ratio (Harvey and Rehman, 1989). These models have not generally been strong in representing the social side of farming systems. Rather they tend to represent all the complexity of the social aspects of farm households within one objective function. That is, they assume that farm households are utility maximisers, and they assume that an acceptable proportion of household utility can be represented by considering financial matters, particularly profit. Whilst such approaches may be acceptable for simulating business decisions within a market situation there is a considerable body of evidence which suggests that very few farmers behave as profit maximising businessmen. For example, it is well known that socio-economic variables such as age, education and stage in family cycle may impact adoption decisions (Akinola, 1987; Dewees and Hawkes, 1988; Gasson and Potter, 1988; Voh, 1982). It is perhaps less well recognised by agricultural economists, that a suite of psychological and socio-cultural variables may also impact on farmers' decision-making and behaviour (Sing and Ray, 1980; Salamon and Davis-Brown, 1986; Fishbein and Ajzen, 1975; Bentler and Speckart, 1979; Gorsuch and Ortberg, 1983; Locke *et al.*, 1978).

In this paper we seek to examine the contribution psychology can make to understanding and modelling farmer behaviour[1]. In particular we seek to examine whether or not the inclusion of psychological variables in models concerned with predicting farmer behaviour is possible and practicable. In order to achieve this aim we will reflect on the experiences gained during a four-year study undertaken in Edinburgh, the Edinburgh Study of Decision Making on Farms (ESDMF), which brought together agricultural economists, modellers and psychologists in an effort to understand and model the interaction between personological (the combination of socio-economic and psychological variables) and observed farmer behaviour. The paper will proceed with a brief review of the methods utilised and results gained in the ESDMF, and will continue with a discussion of the advantages and disadvantages associated with utilising psychological methods within the policy assessment context. It must be stressed that the results of the ESDMF presented here are only summary in nature, and are presented in order to aid later discussion. Further details of the results are available in McGregor *et al.* (1995, 1996), Willock *et al.* (1994, 1995, in press).

[1] The definition of the notion of "behaviour" we adopt is that : Behaviour is the actions actually carried out by an individual, as opposed to the actions which they state they would carry out. Thus, the behaviour of a farmer is defined as those actions which they have actually undertaken on their farm. In an environmental sense this may mean the recreation of habitats, the reduction in pesticide use etc. Thus, the outcomes of behaviour are verifiable through observation.

1. The Edinburgh Study of Decision-Making on Farms (ESDMF)

1.1. Aims and Data Collection

The Edinburgh Study of Decision Making on Farms was a four-year study which sought to understand and model the general process of farmer decision-making. In particular it sought to examine the importance of the interaction between psychological variables (such as personality type, intelligence, attitudes and objectives) with behaviour. A review of the data collected as part of the study is presented below. These data were collected via questionnaires which were mailed to a random sample of 718 farmers in the eastern part of Scotland between January and June 1994. Respondents were asked to complete initial questionnaires prior to attending an evening meeting where a further set of questionnaires relating to

farming attitudes, objectives, behaviour and personal characteristics was administered. In order to gain information on the psychological characteristics of the farmers, they were also asked to complete a range of psychological tests. These are discussed further in section 1.3.

1.2. Analytical methods

As it was the intention of the study to develop quantitative models relating behaviour to a range of personological variables, it was necessary for the relevant data to be collated on reliable scales in order to be indexed. While many scales existed for some psychological variables (e.g. Intelligence Quotient), none existed for measuring farmer attitudes, objectives and behaviour. For this reason it was necessary to devise and test suitable quantitative scales on which farmer attitudes, objectives and behaviour could be identified and measured (Willock *et al.,* in press). Using these scales required farmers to complete an extensive questionnaire where they scored their response to various statements on a five point Likert scale (e.g. 1 = strongly agree, 3 = no opinion, 5 = strongly disagree)[2]. Multivariate analysis of these results enabled farmers' attitudes, objectives and behaviour to be classified into one of several domains (see Willock *et al.,* in press for more details on this process). For example, four domains of behaviour were identified (production oriented, environmentally oriented, stressed and emergent behaviour). The degree of expression of each behaviour was defined by the scores assigned to a series of activities that defined each behaviour (further details in Appendix 1). Measuring attitudes, objectives and behaviour in this way had the advantages of being quantifiable and replicable, whilst also enabling statistical analyses and numerical modelling.

Having decided on how the data would be collected it was necessary to identify the type of modelling which would be conducted in order to explain the relationships between the dependent variable (farmer behaviour) and the independent variables (personological and farm structural variables). This required identification of both the type of conceptual model which would be used, and the statistical technique to be used in modelling. One well-known conceptual model used in social science, the Fishbein Ajzen expectancy-value model of reasoned action, provides a theoretical framework for examining the influence of attitudes and goals on volitional behaviour. Fishbein and Azen (1975) proposed that attitudes affect behaviour indirectly through the mediation of the intention to act and/or through the influence of significant others on that intention. Although widely used, critics of this approach suggest that the theory is inadequate in three areas. First that some attitudes may directly influence behaviour (Bentler and Speckart, 1981). Second, that there is a « crossover » effect between attitudes and significant others, i.e. they may have common antecedents, for example the cognitive aspect of the attitude may already include the expectations of significant others (Oliver and Bearden, 1985). Third, the model can be improved by including other variables such as a moral norm, habit, or personality or environmental variables known to influence behaviour (Fazio, 1990).

An alternative framework which avoids some of the shortcomings associated with the Fishbein Ajzen model is the transactional model of behaviour which has its origins in systems and stress research (Lazarus and Folkmman, 1984). In this model attitudes are considered to influence behaviour directly as well as to mediate behaviour through goals and objectives. In a transactional model the transaction is between an individual's response to the problem and that individual's environment, where the independent variable(s) can be either

[2] This approach has the advantage of permitting respondents greater flexibility of response whilst also providing a suitable range of responses to permit meaningful statistical analysis. The disadvantages of a Likert scale over a more simple response structure (e.g. Yes or No) is that is requires more time to develop and to complete. In long questionnaires this may lead to potential respondent fatigue. However, overall we believed the advantages of a Likert scale to greatly outweigh any disadvantages.

psychological or environmental (Deary *et al.*, 1996). The effect of the antecedent variables are mediated by the cognitive response of the individual and the outcome of the transaction is the resulting behaviour. In this fashion a model based on traits (stable characteristics of the individual) or states (temporary conditions) may be developed. Generally, transactional models are assessed for fit by the correlation values between the measured variables and the variables' contribution in a multiple regression analysis, but it is argued that a more valid test of the model is the use of structural equation modelling (Bentler 1995; Valerand *et al.,* 1992). Structural equation modelling allows a pre-stated hypothesis to be tested using a mixture of factor analysis and multiple regression. In doing this the method estimates a series of separate but interdependent, multiple regression equations simultaneously. The likelihood of the model hypothesised actually occurring is then tested by the programme for its goodness of fit to the covariance matrix of the measured variables using a number of testing procedures. Obtaining a well-fitting model is not necessarily proof that the hypothesis is correct and it is equally likely that another model will fit just as well. For this reason it is necessary to postulate and test a few competing models then the best-fitting one may be used to confirm the specific hypothesis. When undertaking such a modelling process it is necessary to be aware of potential model selection bias, and further that the goodness of fit indices may be biased by this process.

1.3. Review of psychological variables collected from farmers

In addition to the easily documented aspects of a person, such as sex, age and education, decades of research in differential psychology have identified a series of other stable aspects of the person that have strong predictive validity with regard to job success and other important life outcomes. As many of these variables as possible were collected in the survey, in order to enable their ability to explain farmer behaviour to be assessed. A brief description of the more important psychological variables included in the survey is given below.

The first variable assessed was mental ability, or intelligence. This has a proven association with occupational success and impinges on decision-making in many ways (Neisser *et al.*, 1996). It was decided to assess two of the key aspects of intelligence, namely fluid and crystallised intelligence. To assess fluid intelligence, a non-verbal measure is necessary. Therefore, Ravens Progressive Matrices (RPM) were employed (Raven *et al.*,1992). It is well known that the RPM achieves about as well as can be done in a single test, a good approximation of fluid general intelligence. Results on the RPM are markedly affected by age, with young people performing better than older people. Generally speaking, scores on the RPM - and fluid intelligence - age like any other physical ability. The second type of intelligence which was assessed is known as crystallised intelligence. To assess this the national adult reading test was used (Nelson and Willison, 1991). Importantly, crystallised intelligence does not age in the way fluid intelligence ages. Generally speaking it is highly stable with age until about the 60s or 70's. It is often taken to represent concepts such as acquired knowledge, wisdom and higher level things such as acquired strategies. In an occupation such as farming, it was recognised that both of these types of intelligence might be important. Fluid intelligence would help with novel problems where previous knowledge would not help; however, it was also recognised that many farming problems are more easily dealt with if one has seen them several times before and had a stored series of strategies with which to meet them.

A further set of variables pertained to the personality of the farmer. In the last decade there has been much converging consensus regarding the number and type of personality dimensions which are most important in influencing behaviour (John, 1990). This has come together in what is known as the five-factor model of personality (Costa and McCrae, 1992). Therefore, human

temperamental variation is seen to express itself principally along five dimensions. The first is neuroticism, a tendency toward negative emotions such as anxiety, depression and guilt. The second is extroversion, a tendency either to be outgoing and sociable or to be more introverted and solitary. The third factor is openness, a tendency toward or against the embracing of new ideas, cultures and so forth. The fourth dimension is agreeableness; on the one hand this indicates a tendency towards affection and co-operativeness and on the other hand towards independence and hostility. The last of the five dimensions is conscientiousness which contrasts a tendency towards plannfulness and tidiness versus a tendency towards disorganisation. It was conceivable that many of these variables would have importance in farming. For instance, it is well known that farming is a stressful occupation. Therefore, one might expect individual differences in farmers' neuroticism levels to have an impact on the degree of stress felt with regard to farming. To take one more example, one might expect the farmers' level of openness to influence the degree to which they were embracing new ideas in farming.

The coping skills of farmers were also assessed. Again, theories of coping have coalesced recently in an agreement that there are two or three major coping strategies along which people vary. These are 1) task-oriented coping, a way of coping which involves planning and implementing ways to alleviate the stressful situation; 2) emotion-oriented coping, a tendency to express emotion such as anxiety, grief and anger in response to stress; and 3) distraction-oriented coping which involves indulgence in activities unrelated to the alleviation of the stressful situation. The instrument used to assess these coping strategies was the Coping Inventory for Stressful Situations (Endler and Parker, 1990). As with personality, one can easily foresee ways in which various coping strategies would be important in dealing with decisions in farming. For instance, it might be seen as more dysfunctional to engage in emotion-oriented coping with regard to the stressors involved in farming.

The above variables are all very general, with none of them devised specifically for the farming or business situation. This is both a strength and a weakness. It is a strength because, if they were to be successfully included in models of farmer behaviour it would indicate that the most general aspects of the person were important in specific activities. It is a weakness, because it is quite conceivable that more specific aspects of the person would have a more proximal and powerful association with some of their business-oriented behaviours. Therefore, it was decided that some aspect of a person's business decision-making should be involved. In a changing business like farming it was thought to be important to assess the degree to which each person was innovative in their processes or whether they tended to work with what was to hand and put up with and adapt rather than innovate. The scale which best assesses these tendencies is the Kirton Adapter-Innovator inventory (Kirton, 1987).

The final psychological variable collected was an outcome rather than an antecedent or mediating variable. This was the General Health Questionnaire (GHQ), which assesses non-psychotic psychological distress. In particular, the GHQ assesses mild to moderate degrees of anxiety and depression (Goldberg and Williams, 1991). This scale was assessed because, apart from specific farm business behaviours, we also attempted to model the process of farm stress and the GHQ provides a widely-validated assessment of generalised stress (McGregor *et al.*, 1995).

It is well known that farmers hold attitudes on a number of farm-related topics (Cougheneur and Swanson 1988, Schroeder *et al.*, 1985). There is also some evidence which suggests that farmers espouse a number of goals related to their farming, only one of which is economic success (Gasson 1973, 1974, Gilmore, 1986). Both attitudes and objectives may be important factors in decision-making and behaviour and it was necessary to collect information on them during the survey. This was done through the construction of a number of novel questionnaires designed to elicit relevant information on these variables.

	Farmer Sample			Normed population	
Variable	Mean	Std Dev	N	Mean	Std Dev
Personality					
Neuroticism	17.35	6.79	246	17.60	7.46
Extraversion	26.57	5.25	246	27.22	5.85
Openness	22.54	5.44	246	27.08	5.82
Agreeableness	28.52	5.10	246	31.93	5.03
Conscientiousness	32.96	5.43	246	34.1	5.95
Coping with stressful situations					
Task coping	60.52	7.74	246	58.56	9.96
Emotion focused coping	39.11	9.39	246	39.21	11.54
Avoidance coping	37.34	10.50	246	38.10	9.59
Distraction coping	16.15	5.53	246	17.53	5.51
Social diversion coping	14.11	4.12	246	13.31	4.13
Adaptor/Innovator Personality					
Kirton Adaptor/Innovator Inventory (KAI)	94.80	11.98	242	95	17.9
Intelligence					
(NART) Verbal Intelligence	33.94 (average of 16 errors)	9.97	216	22 errors	
(Raven std matrices) Non-verbal Intelligence	34.71	8.45	222		

Table 1: A comparison of the results from the personality tests undertaken with the sample of farmers in Scotland with results from a normed population in the UK

Farming Attitudes Scale Factors (EFAS)	Farming Objectives Scale Factors (EFOS)	Farming Implementation Scale Factors (EFIS)
1. Attitude geared towards achievement and motivation	1. Business objectives	1. Production oriented behaviour
2. Attitudes towards legislation	2. Environmental objectives	2. Environmentally friendly behaviour
3. Pessimism regarding the future of farming	3. Quality of life objectives	3. Stress behaviour
4. Openness to new farming ideas	4. Status objectives	4. Developing or « emerging » farmers
5. Financial risk taking	5. Off-farm employment goals	
6. Attitude towards chemical use		
7. Attitude towards policy decisions		

Table 2: Factors derived from the Edinburgh Farming Attitudes Scale (EFAS), Edinburgh Farming Objectives Scale (EFOS), and Edinburgh Farming Implementation Scale (EFIS) which represent domains of attitude, objective and behaviour held by the sample farmers.

These were termed the Edinburgh Farming Attitudes Scales (EFAS) and the Edinburgh Farming Objective Scale (EFOS) and measured attitudes and objectives respectively (Willock *et al.*, in press).

In addition to collecting information on potential explanatory variables, data on the outcome variable, namely farmer behaviour, was also needed. Information on the behaviour of the farmers was obtained through the use of a third questionnaire, The Edinburgh Farming Implementation Scales (EFIS) (Willock *et al.*, in press).

2. Results

The analysis sought to examine relationships between personological and farm structural variables with actual farmer behaviour (as measured with the Edinburgh Farm Implementation Scale (EFIS) described earlier). Prior to presenting some exploratory models relating behaviour and personological variables a brief summary of the psychological profile of the sample is presented.

2.1. Psychological Profile of Farmers compared with the General Population

The psychological profile of farmers in this survey only differed from that recorded from a normal population for one variable, and that was intelligence (Table 1). The population of farmers in the survey had a slightly higher than average intelligence as estimated by the NART test than the normal adult populations tested to date (Nelson and Willison, 1991)

One aspect of farmers' psychological profile which has been given much attention recently is that of stress, and it was widely reported that farmers had higher suicide rates than other professions (Jones, 1994). However, in the group surveyed here only 10 % (26) of the sample were psychologically distressed according to General Health Questionnaire evaluation. In the UK studies have found 22 % of the population would appear to be distressed by these criteria. Most of these will be transient and only about 12 % have persistent high scores, so it appears that stress levels in farmers are similar to those in the general populace.

2.2. Attitudes, objectives and behaviour

The three farming-related questionnaires (EFAS, EFOS and EFIS) were analysed by multi-variate analysis and it was discovered that farmers held seven types of attitudes, they had five types of objectives and expressed four types of behaviour (Willock *et al.*, in press). Each of these factors is explained by the score given to between 6 and 12 individual items relating to the general theme named by the factor on the relevant questionnaires. The factors derived from EFAS, EFOS and EFIS are presented in Table 2 and the items which defined these factors are presented in Appendix 1.

2.3. Correlations between personological variables and farmer behaviour

Analyses of the interrelation between the variables revealed significant correlations between achieving attitudes, business, quality of life and status objectives and business behaviour (Table 3). Similarly, environment-oriented behaviour was significantly correlated with an attitude towards chemical use, environmental objectives, status and off-farm objectives. Stressed behaviour was related to *not* being business-oriented, having a pessimistic attitude and a poor response to legislation. The relationship between the behaviours and farm structural and demographic variables is presented in Table 4.

Production-oriented behaviour was correlated with a range of structural and demographic variables including education, amount of training, having an arable farm, and larger revenue (Table 4). In addition, the correlations between

Factor	Production Behaviour	Environmental Behaviour	Stressed Behaviour
Attitude geared towards achievement and motivation	0.20**	0.04	0.18**
Attitude towards legislation	0.07	0.03	0.16*
Pessimism regarding future of farming	0.06	0.04	0.21**
Openness to new farming ideas	0.43**	0.26**	0.01
Financial risk taking	-0.14*	0.00	0.09
Attitude towards chemical use	0.11	0.19**	0.08
Attitude towards policy decisions	0.11	0.08	0.04
Business objectives	0.18**	0.12	0.05
Environmental objectives	0.16*	0.22**	0.00
Quality of life objectives	0.30**	0.12	0.05
Status objectives	0.14*	0.16*	0.05
Off-farm employment goals	0.14*	-0.35**	0.04

Table 3: Correlation between the domains of attitude and objectives held by the sample farmers and three behaviours exhibited by the farmers. * indicates significance at 0.05 level; ** indicates significance at 0.01 level

Variable	Production Behaviour	Environmental Behaviour	Stressed Behaviour
Acres	-0.07	0.22**	-0.11
Age	-0.05	-0.03	0.13
Assets	0.08	0.22*	0.08
Debt	-0.01	-0.06	0.31**
Diversification	-0.06	0.52**	-0.13*
Education	0.25**	0.18**	-0.07
Farm Type	0.03	0.04	0.02
Full-time employees	0.14*	0.15*	-0.12
gfm/acre	0.09	0	0.02
Land type	0.33**	-0.16*	0.07
Liabilities	0.17	0.06	-0.16
No. of children	-0.08	-0.01	-0.04
Other on-farm work	0.08	0.06	-0.16*
Other off-farm work	0.03	0.04	-0.04
Own off-farm work	-0.11	0.18**	-0.22**
No. Partners	0.01	0.06	-0.07
Part-time employees	0.00	0.26**	-0.01
Revenue	0.21**	0.05	-0.04
Size change	0.11	0.15*	0.04
Subsidies	-0.12	0.10	-0.10
Succession	-0.06	-0.05	0.05
No. supported	0.03	-0.07	0.02
Training	0.18**	0.15*	-0.02
Variable costs	0.10	-0.01	-0.09

Table 4: Correlation between three behaviours exhibited by the sample farmers and a range of farm structural and family demographic variables. * indicates significance at 0.05 level, ** indicates significance at 0.01 level.

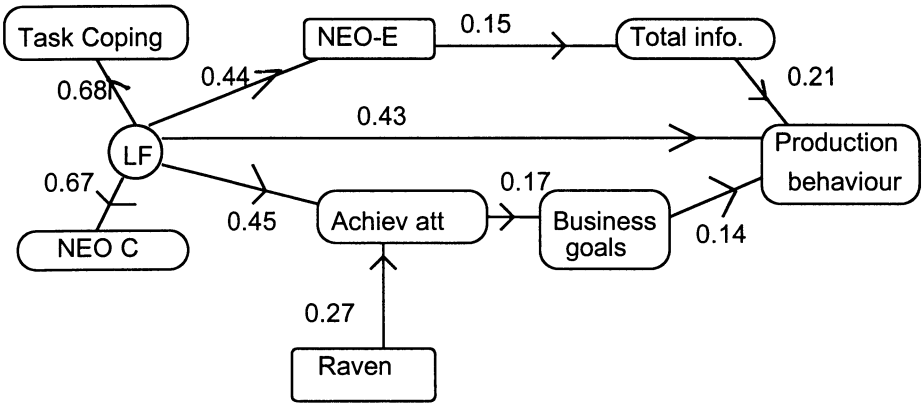
this behaviour and the psychological variables would suggest that production-oriented farmers are generally conscientious, open-minded, gregarious individuals, who regularly assess information derived from a variety of sources (Table 5). This is in contrast to environment-related behaviour which is correlated with the structural variables farm size, assets, diversification, education and being within a less favoured area (LFA), having off-farm work and part-time employees (Table 4) and the psychological variables extroversion, task coping, intelligence, information gathering and an open and innovative personality (Table 5).

Education and personality were important in affecting both production and environmental behaviours. Personality traits are also shown to be strong contributors to farmers' behaviour. The business-oriented farmer is an outgoing information seeker, open to new ideas, who conscientiously applies business practices. Interestingly, in this sample, it is the environment-friendly farmer who is most innovative and has the highest cognitive ability, while retaining the openness, information-seeking and conscientiousness traits of the business farmer. This is contrary to the findings of Pample and van Es (1977) who observed that the environment-oriented farmer was less likely to use innovative techniques.

It is apparent from Table 4 that stressed behaviour was strongly correlated with debt, the absence of diversification or off-farm work, and from Table 5 with the psychological variables neurotic personality, emotion focused coping and psychological distress. These results suggest that the « financially stressed » farmer typically has a neurotic personality, uses emotion focused coping, and is likely to be psychologically distressed. Whether this is due to an unusually high level of debt, or personality type would have to be determined separately.

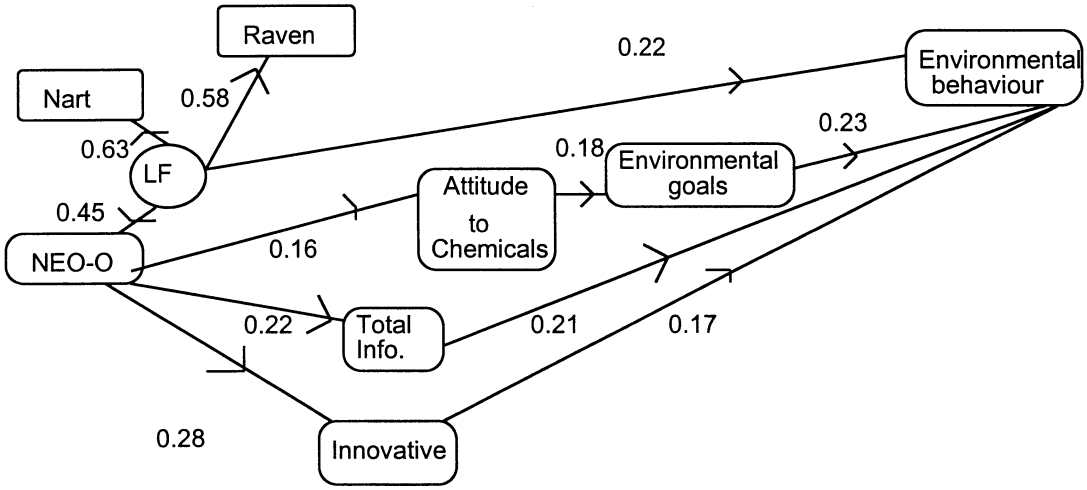
Variable	Production Behaviour	Environmental Behaviour	Stressed Behaviour
N E O			
Agreeableness	-0.09	0.01	-0.02
Conscientiousness	0.30**	0.04	0.12
Extraversion	0.28**	0.22**	0.06
Neuroticism	-0.14*	-0.09	0.21**
Opennness	0.19**	0.22**	0.01
Coping Inventory for Stressful Situations			
Avoidance	0.12	0.03	0.02
Emotion	-0.09	-0.06	0.19**
Task	0.26**	0.15*	0.12
Raven (fluid intelligence)	0.09	0.17*	-0.05
Nart (crystalised intelligence)	0.09	0.13	0.06
General Health Questionnaire - Innovator	-0.10	-0.05	0.31**
Kirton Adaptor Inventory	0.10	0.25**	-0.00
Total Info.	0.24**	0.22**	-0.03

Table 5: Correlation between three behaviours exhibited by the sample of farmers and the scores obtained by the farmers for various psychological variables. * indicates significance at 0.05 level, ** indicates significance at 0.01 level.



NEO E = score on the extraversion personality factor, NEO C = score on the conscientiousness personality factor, Task coping = score on Coping Inventory for Stressful Situations, Raven = measure of fluid intelligence, Achiev. Att. = item score from attitude questionnaire for achieving attitude, Business goals = item score for business-oriented objectives, Total info. = total amount of information gathered and used by farmers, LF = latent factor. This is a hypothesised variable relating four real variables (achieving attitude, task coping, NEO C and NEO E). It signifies some relationship between the measured variables which was not captured in the data analysis. The inclusion of latent factors in SQM may increase the goodness of fit of the model, and also highlights knowledge gaps. Production behaviour = independent variable relating to the self reported behaviour characterised as being oriented towards increasing production

Figure 1: A structural equation model relating a range of independent psychological variables to the dependent variable, production-oriented behaviour. Lines indicate a relationship between variables. Arrows indicate the hypothesised direction of the interaction. The numbers alongside the pathways indicate the standardised residuals solution as calculated by the EQS programme, the square of this value represents the proportion of variance explained by the two variables.



NEO O = score on the openness personality factor, Raven = measure of fluid intelligence, NART = measure of crystallised intelligence, Attitude to chemicals = item score from attitude questionnaire, Environmental goals = item score for environmentally related goals, Total info. = total amount of information gathered and used by farmers, Innovative = score on Kirton Adaptor Inventory, LF = latent factor. This is a hypothesised variable relating three real variables (Raven, Nart and NEO-E). It signifies some relationship between the measured variables which was not captured in the data analysis. The inclusion of latent factors in SQM may increase the goodness of fit of the model, and also highlights knowledge gaps.
Environment behaviour = independent variable relating to the self reported behaviour characterised as being oriented towards enhancing the environment.

Figure 2: A structural equation model relating psychological variables to environment-related behaviour. Lines indicate a relationship between variables. Arrows indicate the hypothesised direction of the interaction. The numbers alongside the pathways indicate the standardised residuals solution as calculated by the EQS programme, the square of this value represents the proportion of variance explained by the two variables.

2.4. Development of models

As described earlier, models developed within a structural equation modelling programme (Bentler, 1995) were developed to test a range of hypotheses concerning the interaction of psychological, structural variables and behaviour. Two of the models developed are described here. The first of these models relates the contribution of personological variables to production-oriented behaviour (Figure 1), and the second to environment-friendly behaviour (Figure 2). These models are presented here as examples of potential types of analyses which integrate psychological variables and farming behaviours. However, it is interesting to note that the personological variables explain between 20-30 % of the variation in the farming behaviours examined. Further information on these and other models is available in Willock (1998).

3. Advantages and disadvantages of incorporating psychological variables in models for *ex ante* policy assessment

Previous sections have discussed the methods and results of the Edinburgh Study of Decision-Making on Farms, which sought to incorporate psychological variables in explanatory models of observed farmer behaviour. The current section draws on the experience gained in this project and presents a theoretical consideration of the advantages and disadvantages of utilising psychological variables in future models which seek to predict the rate of adoption of a voluntary practice or policy, and/or a new technology amongst a population of farmers.

3.1. Are traditional models of farmer behaviour adequate?

If models which include psychological variables are to be useful in applied situations, then their utility needs to be proven. One measure of this utility would be if they explained either a larger amount of variation in observed behaviour (the dependent variable) than other models, or alternatively they explained some of the variation not explained by other models. The descriptive models developed by the ESDMF explained a relatively large amount of the variation, between 20 and 30 %. Clearly however a large amount of observed variation remains unexplained by these models. Comparing the explanatory power of these models with that of traditional models aimed at predicting farmer behaviour is not a simple task, largely because traditional linear-programming based models are extremely difficult to validate. However, evidence from Norton and Scheifer (1980) and Moxey *et al.* (1995) suggest that linear programming based policy assessment models have a percentage absolute deviation (PAD) of between 0 and 14 % (Table 6) (PAD is defined as the average absolute deviation between the predicted and the observed areas divided by the average actual value (Norton and Schiefer, 1980). This would suggest that there may be a role for incorporating other variables within these models in order to increase their explanatory powers. Support for the inclusion of psychological variables in these models comes from Norton and Scheifer (1980) who state that some of the principal causes of errors in regional or sectoral models include:

1) aggregation over a large number of producers
2) errors in the specification of the objective function
3) errors in the specification and estimation of commodity demand functions
4) errors in the treatment of factor markets

5) insufficiently detailed seasonality of input specification

6) other omissions of behavioural and technical constraints

7) errors in production coefficients and estimated resource availabilities and other technical parameters.

In theory, the inclusion of psychological variables within such models should reduce errors associated with 2) and 6), and depending on the model structure perhaps in 1).

So in summary, traditional models for predicting farmer behaviour do not explain all of the observed variation in farmer behaviour, and at least two of the reasons for this could be related to the exclusion of psychological and socio-cultural variables. However, even though the integration of psychological and economic models appears theoretically advantageous, actually assessing the potential of such an integration is difficult, if not impossible, to undertake given existing data sets. It is possible, however, to make some suggestions as to the situations where including psychological variables in models of farmer behaviour may be more or less useful. One way to examine this is through a consideration of the spatial scale addressed by the model.

Model name	Country	References	Concept	PAD
CHAC	Mexico	Bassoco & Norton (1975)	Production	13.4 %
-	Philippines	Kunkel *et al.*, (1978)	Acreage	9.1 %
-	N. E. Brazil	Kutcher & Scandizzo (1979)	production	8.2 %
MOCA	Costa Rica			7.0 %
	El Salvador			12.0 %
	Guatemala	Cappi *et al.*, (1978)	production	7.1 %
	Honduras			9.3 %
	Nicaragua			8.7 %
NELUP	U.K.	Moxey *et al.*, (1995)	land use	10 - 14 %

Table 6: The percentage absolute deviation (PAD) for a range of linear programming models developed for agricultural policy assessment. Partly derived from Norton & Scheifer (1980)

3.2. Spatial scale and the importance of psychological variables in models of farmer behaviour

There may be little benefit in integrating psychological variables in models which seek to predict land use at a gross scale (such as the Land Use Allocation Model, Harvey and Rehman, 1989) because at the national scale there is a large difference in financial return available from all possible enterprises, and in many situations enterprise choice may be constrained by bio-physical conditions. Here it is probable that the financial variables and the constraints of land use may dominate any decisions farmers could make. Linear programming (LP) probably allows for these constraints to be represented relatively accurately, and by applying the law of large numbers, the economists' view that utility can be modelled through the proxy of profit maximisation is probably a workable assumption.

However, consider the converse situation to a national scale model, where two identical sized farms (or parcels of land) are located close together and are subject to similar bio-physical conditions. If these farms were given to separate managers who had access to the same financial resources, then traditional LP programmes would predict similar land-uses for these farms. However, it is debatable if this is what would be observed. While both hypothetical farmers may, on the basis of financial returns, adopt an arable based enterprise, the exact details of the farms may vary in terms of crops, varieties, rotations, inputs and other aspects of land management such as the condition and extent of hedgerows, woodland, conservation headlands and the creation of

pasture for horses and other « companion » and « hobby » animals. Here it may be suggested that differences in the management of the land would be related largely to socio-cultural and psychological variables. One example of a real situation similar to this is the relationship between people and their gardens. Within housing developments in almost every town a wide range of land uses is evident in gardens, ranging from the wholly grass-based garden, through flowers to vegetables (or some combination of all three). This is despite the individuals who own these gardens sharing similar bio-physical conditions and having broadly similar access to resources.

So in theory, when considering the management of land parcels which are similar in terms of bio-physical conditions and where their managers have access to similar resources, two hypotheses may be postulated. First, traditional LP-based models would not predict any differences in land use between the parcels. Second, any observed differences in actual land use and management would be due to the psychological and socio-cultural make-up of their managers. If the above arguments are accepted as true, then the integration of psychological variables within models of farmer behaviour would probably bring greatest benefits when either the analyst is interested in homogenous resources managed by different people, and/or in relatively small scale changes in land management. A good example of such a situation which contains elements of both of these situations would be the uptake of an agri-environment policy within a region, eg Environmentally Sensitive Areas in the UK. Indeed, studies have suggested that psychological variables are important in the adoption of agri-environment schemes (Gasson and Potter, 1988).

3.3. Appropriate modelling scales: groups or individuals?

One of the major advantages of modelling farmer behaviour is the potential to extrapolate from a sample to the whole population. A pre-requisite of such extrapolation is that farmers be grouped according to some relevant characteristic, and that farmers within a group be more similar to each other than to farmers in other groups. While economists generally group farms on the basis of physical and structural variables, it remains unclear if meaningful typologies of farmers can be developed on the basis of sociological and psychological variables. Several sets of discriminating variables may be suggested as inputs to any farmer classification scheme. These range from the relatively common and familiar « age », « education », « stage of family cycle » through to the less familiar, « Intelligence Quotient » (IQ), « degree of innovativeness », « personality type » and attitude. However, to date there has been no agreement as to which variable, or group of variables, is most important in determining different farmer behaviours. It may be argued that to date agricultural economists have been utilising variables such as « age » and « education » as proxies for more fundamental psychological variables such as « openness », « intelligence » and « innovativeness ». If this is the case then typologies based on the fundamental psychological variables may be more meaningful and robust than any based on proxies. Indeed, having accepted the requirement to include non-financial variables in predictive models of farmer behaviour, one of the main advantages of utilising psychological variables is that they remove the need for less reliable « proxy variables ». The only point for debate here is whether or not collecting the fundamental data is cost-effective. Assessing farmer age is cheap and easy, and if this proves to be a good proxy for « openness », or any other psychological variable, which is complex and expensive to assess, then the continued use of proxy variables may be justified.

Much work remains to be done in this area, and while in theory it may be possible to represent individual farmers in relatively small-scale models which could be overlaid onto maps of the land they manage, this may not be either cost-effective or ethical. For example, within the ESDMF a significant and positive correlation was discovered between farmers' score on IQ tests and

gross farm income per hectare (gfm/ha) (McGregor *et al.*, 1996). Regardless of other differences, individuals with higher gfm/ha may be expected to respond differently to a change in circumstances, such as a change in policy, than individuals with lower gfm/ha, and IQ may be a good indicator of this response. Calculating IQ is relatively simple, and could easily be done at a local and regional scale. But would collecting and representing such data on computer models be ethical? Recent debates in psychology about cultural and racial differences in IQ suggest there is a broad field for dispute in this area (Herrnstein and Murray, 1995, Neisser *et al.*, 1996).

3.4. Moving from descriptive to predictive models

One issue of concern for agricultural scientists relates to the actual structure of any predictive model of farmer behaviour. The types of models developed as part of ESDMF are descriptive in nature, they seek to explain patterns in data rather than predict changes in some output variable. As such the ESDMF models reflect much of the work undertaken to date on the relationship between socio-cultural variables and farmer behaviour, nearly all of which is descriptive in nature. This body of work is in contrast to many economic and biological models which explicitly seek to predict change in output variables according to changes in inputs.

In this situation where farmer behaviour is a function of complex interactions between a wide range of variables ranging from the financial to the psychological, it is debatable whether or not standard linear programming is an appropriate modelling paradigm. Rather a simulation technique may be more appropriate, where for each farmer (or group of farmers) a distribution is derived which represents the probability of displaying any given behaviour, e.g. the adoption of a certain policy. Given the nature of the data to be manipulated by such a model, a rule-based approach has been suggested as being one possible structure for such models (Edwards-Jones and McGregor, 1994) and a prototype of one such model has been developed (Edwards-Jones *et al.*, 1998). However, much more work remains to be undertaken in this area.

4. Discussion

This paper sought to investigate whether or not benefits would accrue from incorporating psychological variables within models which seek to predict farmer behaviour. Four main points have arisen in the discussion so far. Firstly, psychological and socio-cultural variables appear to play an important role in determining the behaviour of farmers, and personological variables explained between 20 % and 30 % of observed variation in environment-oriented behaviour of Scottish farmers. Secondly, LP models of farmer behaviour are not often tested in a rigorous manner, but those for which data are available suggest they leave a relatively large proportion of the observed variation unexplained. Some of the reasons for these errors may pertain to the absence of psychological and socio-cultural variables being present in the model. Thirdly, socio-economic variables traditionally collected and used by agricultural economists may not be fundamental, rather they may be indicators of relationships which can be explained at a more fundamental and robust level by the collection and use of psychological variables. Fourthly, there is probably an interaction between the financial gains which accrue from a behaviour and the psychological variables related to that behaviour. Thus if the financial rewards are large enough, all farmers, regardless of psychological profile, may well adopt that behaviour. For this reason, the inclusion of psychological and socio-cultural variables in large scale models which seek to predict gross changes in land use may not be overly beneficial. However, as the geographic scale of the model decreases, and/or the focus of the model moves towards predicting small scale behaviours then the inclusion of psychological variables would seem to offer greater benefits.

The Edinburgh Study of Decision Making on Farms has proved that relevant data can be collected from farmers in order to develop models of behaviour based solely on psychological and social variables. More work is needed on the integration of such psychological models with economic-based modelling approaches. Areas on which particular attention needs to be focused centre around three main issues. First, the necessity and practicality of developing typologies of farmers for inclusion in large scale models. Second, the relationship between the psychological make-up of farmers and the likelihood that they will adopt a certain behaviour at different levels of financial gain. Finally, the computational form of any integrated model itself needs to be addressed. It has been suggested that a simulation approach may be more appropriate than an LP for the implementation of such models.

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Appendix

Items from the questionnaire which define the factors for attitudes, objectives and behaviours presented in Table 2.

Attitude Factors

Seven domains of attitude were identified in the ESDMF. These domains were defined in accordance with an individual having high scores on a set of items on the Edinburgh Farmer Attitude Scale (EFAS). The items in the questionnaire that defined each domain of attitude are given below.

1. Achievement/Motivation

It is important to have the best livestock / crops / pastures.
Farm production is the thing to take most pride in.
It is important to read about farming practices.
It is important to pay attention to market prices.
Farm land should be fully productive.
It is important to keep up with new farming policies.
It is important that farmers be respected in the local community.
A farm is a business to be run efficiently.

2. Legislation

Legislation in farming involves too much paperwork.
Farming policy changes are not easy to understand.
The Government interferes too much in farming.
There is too much paperwork in farming.
Filling-in grant forms is anxiety-provoking, because errors can be penalised.

3. Pessimism regarding the future

It would be nice to give up farming.
Young people should not be encouraged to farm.
Farmers in Britain are demoralised.
Other employment would be better than farming.
Prices of crops and stock are bound to fall in the future.

4. Openness to new ideas in farming

It is important to have the occasional member of the public visit the farm.
It is important to keep up with new farming policies.
New machinery/ideas in farming have not improved upon
traditional techniques.
Modern record-keeping systems are unimportant in farming.
It is important to visit other farms to look at their methods.

5. Financial risk taking

Successful farmers take financial risks.
In starting a new farming venture one should be willing to take out a loan for most of the capital required.
It is appropriate to take financial risks in farming.

Short-term loans are a good thing for farming.
To farm successfully one must be in debt.

6. Attitude towards chemicals

It is important to reduce nitrogen application by using non-chemical methods.
It is important to reduce pest control chemicals by using effective rotations.
« Green » groups are useful.
Organic farming is not a fad.

7. Policy

There is insufficient information on policy changes.
There is no clear overall strategy in agricultural policy.
Even advisors can't tell you what the current legislation is.
Farmers are sometimes informed about legislation too late to put it into practice.

Objective Factors

Five domains of objective factors were identified in the ESDMF. These domains were defined in accordance with an individual having high scores on a set of items on the Edinburgh Farmer Objective Scale (EFOS). The items on the questionnaire that defined each domain of objective are given below.

1. Business-oriented goals

It is important to utilise your resources.
It is important to have the best livestock / pastures.
It is important to make the largest possible profit.
Keep buildings/fences/dykes in good repair is important.
It is important to keep debt as low as possible.
Having up-to-date equipment and machinery is important.
It is important to try new varieties of livestock / crops.

2. Environment-oriented goals

Improving the quality of the farm generally is important.
It is important to use chemicals sparingly.
It is important to leave the land as good as you received it.
It is important to prevent pollution.
It is important to get all you are due from current legislation.

3. Quality of life values

Improving the living standards of family life is important.
Improving the quality of my life is important.
It is important to have other interests outside farming.
It is important to spend time with the family.
It is important to plan for retirement.

4. Status values

It is important to stay in farming whatever happens.
It is important to pass on the farm to a member of family.
It is important to have the respect of other farmers in the community.
It is important to enter and win at shows.

5. Off-farm employment goals

It is important to have other skills outside farming.
Off-farm work is necessary to stay in farming.
Having a successfully diversified farm is important.
It is important to have investments.

Behaviour

Four types of behaviour objective were identified in the ESDMF. These domains were defined in accordance with an individual having high scores on a set of items on the Edinburgh Farmer Implementation Scale (EFIS). The items on the questionnaire that defined each behaviour are given below.

1. Production-oriented behaviour

Do you monitor farm business performance?
Do you use targets in managing the farm?
Do you keep production records?
Do you use new farming methods?
Do you keep financial records?

2. Environment-oriented behaviour

Do you use fertilisers, sprays, chemicals?
Do you manage the farm business to maximise profit, above all else?
Do you regularly control vermin on the farm?
Have you taken any active conservation measures in the last five years?
Have you ever considered joining a conservation group?
Do members of the public occasionally visit your farm?
Have you inserted / replaced fences / dykes / hedges / etc. in the past five years?
To what extent have you diversified the farm business?

3. Stressed behaviour

Is it difficult to meet your farm business financial commitments?
Is it difficult to meet your personal financial commitments?
Is it easy to manage the farm business to suit yourself?
Has farm business debt changed in the last five years?
Is it difficult to find time to meet friends and family?

4. Developing farming behaviour (not discussed in this paper)

Do you have any definite plans to change the size of the farm business in the next five years?
Has the number of acres farmed for the farm business changed in the last five years?
What change has your income from the farm business shown over the last five years?
Have you made any large investments in the farm business in the past five years?
Do you discuss new farming policies with family?