Economics and animal welfare in extensively managed sheep production systems

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Abstract

Recent CAP reforms may require adjustments to the inputs of extensive sheep farming systems such as labour, supplementary feeding or veterinary treatment. Such adjustments might aim to maximise farm business profitability or minimise the costs of cross-compliance and may have consequences for animal welfare. These consequences must be understood so that they can be incorporated in the decision making process. This will help farmers meet consumer demands for higher standards of animal welfare, aid support under the Rural Development Measures and ensure minimum standards enforced through legislation including cross-compliance. However, identifying and quantifying the different elements of animal welfare in systems of different intensity is very difficult. To address this issue we used adaptive conjoint analysis (Green and Srinivasan (1990)) to rank alternative management practices for UK sheep farming systems in terms of impact on animal welfare. Scores were obtained by asking respondents (sheep farmers or sheep welfare specialists) via a computer-mediated survey to choose between alternative policies as defined by 5 attributes (labour, housing, veterinary treatment, feeding, gathering). The financial impact of these policies on the farm business was also assessed. Although there was a negative correlation between welfare score and financial impact, it was concluded that welfare could be improved within the context of viable farm business management by careful choice between strategies that fit individual farm circumstances.

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Introduction

This work forms part of research project AW1012 "Improving sheep welfare on extensively managed flocks by understanding the economic and husbandry influences on flock welfare" funded by the UK Department for Environment Food and Rural Affairs (Defra). The aim of this project is to identify a hierarchy of welfare responses and actions that should be targeted by both policy directives and economic activity to allow an economically sustainable extensive sheep production system to be developed. The work was prompted by the inevitable consequences of economic growth that cause capital to become more plentiful relative to labour. The result is that capital tends to be substituted for labour in all productive processes, including agriculture (Harvey, 2001). This effect led for example to a 3.2% decline in the total farm labour force in the UK between 2002 and 2003 while sheep and lamb numbers remained static (Defra, 2004). Such change may have implications for animal welfare and these are likely to be more acute in extensive farming systems where particular welfare challenges exist and means to monitor and control such challenges may be difficult to implement. Changes in agricultural policy will increase emphasis on this issue. Decoupling of subsidy from production will mean that farmers have to decide what to produce in the context of what the market will pay (Marsh, 2004). This will create more opportunity for the food market to reflect consumers' increasing demand for high standards of animal welfare via appropriate incentives and sanctions (Policy Commission on the Future of Farming and Food, 2002). Decoupled subsidy payments may also be conditional on meeting minimum standards of animal welfare (cross-compliance) or be used to provide incentives to raise standards (Scottish Executive, 2004).

Project AW1012 has four main objectives (Stott, 2003):

1. To establish a hierarchy of welfare criteria for sheep in extensive sheep farming systems.
2. To match this with a hierarchy of actions that shepherds can take to influence the welfare of the sheep in their care.
3. To provide quantifiable data linking input costs (for example labour) associated with the hierarchy of welfare actions and corresponding flock outputs.
4. To put all the findings into a decision support framework to provide the whole-farm perspective necessary to explore the practical implications and provide knowledge transfer relevant to a particular region or system.

This paper is concerned with objectives two to four.

Methods

Farmer Focus Groups

Data and opinion for this project were obtained mainly from four farmers' focus groups. The farm of one farmer from each focus group was chosen to be a 'focus farm'. The focus farm acted as a venue for meetings, a source of specific data where necessary and as a case study for exercises and discussions etc. Groups were located in the Lake District, Peak District, Mid-Wales and Scottish highlands, covering a range of extensive sheep farming regions. These groups were taken through stages in a series of four meetings to collect information and opinion. Further details are available on the project website: www1.sac.ac.uk/sheepwelfare.

Adaptive Conjoint Analysis (ACA)

To achieve objective 2 it was necessary to devise a consistent way for members of the focus groups and others to score shepherds' actions in terms of their perceived impact on the welfare of the sheep in their charge. There is much work underway in developing on-farm welfare assessment systems (see Spoolder et al., 2003 for a review). These can be broadly categorised into animal- (e.g. body condition score, disease state etc.) or resource-based measures (e.g. stockperson, environment, genotype etc.) (Main, 2003). The former are the subject of objective 1 (welfare criteria) in this project. Resource-based measures were unsuitable for the remaining objectives, which focus on welfare actions, as resources vary between regions and systems. We needed a 'common currency' to measure the effect on welfare of a wide range of actions undertaken by shepherds within the context of specific farming systems and environments. A computer-based ACA exercise was therefore designed and implemented using proprietary software (Sawtooth Software, Evanston, IL).

ACA is based on the principles of conjoint analysis used in marketing research to probe consumer perceptions of novel products and to help understand purchasing behaviour (Green and Srinivasan, 1990). More recently, ACA has been used to elicit stakeholder opinion in the fields of human (Fraenkel *et al*, 2001a,b) and animal (van Schaik *et al*., 1998; van der Fels-Klerx *et al*., 2000) disease. The product or service under investigation is described in terms of key attributes (e.g. colour in the case of a car) each of which can hold various mutually exclusive levels (e.g. red, blue, green etc.). Respondents register their relative preference (utility) for certain attribute levels by making comparisons with other attribute levels. By using a computer-based technique, questioning can adapt to reflect individual priorities and so minimise the interrogation necessary to extract utility scores. By suitable scaling (see Metegrano, 1994 for details), individual responses can be pooled to produce an average utility score for each level of each attribute. By adding the utility scores from one level of each attribute, a score can be obtained for the whole 'product' described in terms of its component attribute levels (e.g. black, 2-doors, diesel engine, etc.). Products that differ in one or more attribute levels can therefore be compared in terms of their relative utility to the potential consumer. This makes it possible for example to set an improvement in consumer utility (e.g. 4-doors rather than 2-doors) against marginal cost of production and hence specify products that offer best potential value for money. This paper describes how this idea was adapted to address objectives 2 to 4 in this project.

A list of the attributes and levels used in our ACA exercise is shown in Table 1 along with the utility scores resulting from our survey. Attributes and levels were chosen based on hierarchies of welfare concerns expressed by the focus groups (SAC et al., 2004).

Table 1: List of attributes and levels for ACA survey with associated welfare utility score

		Score
	Labour Attribute	
1	One shepherd per 400 ewes	43.86
2	One shepherd per 600 ewes	31.43
3	One shepherd per 900 ewes	2.67
4	One shepherd per 1400 ewes	-20.41
5	One shepherd per 2000 ewes	-57.55
	Housing Attribute	
1	Housing for all ewes over lambing period	21.33
2	Housing for only high risk ewes over lambing	8.05
3	Housing only for sick ewes/lambs at lambing time	2.23
4	No housing for any ewes/lambs over lambing time	-31.61
	Disease Control Attribute	
1	Routinely treat ALL common ailments across whole flock	46.97
2	Routinely treat only a SMALL NUMBER of common ailments across whole flock, but treat individual animals when sick	5.09
3	Treat individual sheep when they are sick, but administer NO routine veterinary treatments	-52.06
	Feeding Attribute	
1	Scan/condition score and feed all sheep in appropriate batches	49.62
2	Feed set amount to whole flock	2.88
3	No supplementary feeding except for snowstorm feeding.	-52.50
	Gathering Attribute	
1	Gather flock only three times per annum for treatment/sorting	-23.34
2	Gather flock only six times per annum for treatment/sorting	21.86
3	Gather flock only nine times per annum for treatment/sorting	1.48

There were 5 attributes with 5, 4, 3, 3 and 3 levels respectively. This gave a total of 540 alternative 'products', named 'profiles' in this exercise as they reflected alternative sheep management strategies rather than marketable products. A total of 38 farmers independently completed the ACA exercise. Of these, 34 provided consistent results (correlation > 0.6, see Van Schaik et al., 1998) that were therefore used in the analysis reported here.

Enterprise budgeting model

To examine the financial impact of each alternative welfare profile on the business, a linear programming (LP) model (Barnard and Nix, 1979) was constructed and solved using an 'excel' spreadsheet (Microsoft Corporation, 1997). The objective of the LP was to maximise returns to labour from sheep production in a typical extensive sheep management system under the constraints implied by each of the 540 alternative ACA profiles.

The effects of each attribute on the components of gross output (i.e. lambs sold per ewe, ewe replacement rates and all associated prices) were estimated by the focus groups. Two independent teams (except for 'gathering' where only one team was available) were asked to fill in a gross output schedule for all levels of a single attribute. An example schedule is given in the appendix. Each team contained 5 or 6 representatives drawn from all four regions. If any team felt that significant regional differences applied then they were asked to note these. Every team had the same default scenario (levels 3,2,1,1,2 respectively for attributes in the order listed in Table 1, see appendix for details). Their task was to adjust the default values (agreed by farm management specialists on the research team) according to their alternative attribute levels. A single team's results were used to represent each attribute level in the LP model rather than an average to ensure consistency. In future a further focus group meeting will be used to verify the assumptions chosen. The gross output components for each profile were taken as the average of the gross output components of all constituent attributes. From this set of component averages, a gross output was calculated that represented the profile concerned.

Each LP was constrained by the regular hours worked each year by a single shepherd. This was set at 1794 hours per year (Nix, 2002). It was also constrained to a maximum number of ewes dictated by the labour attribute level (Table 1). The regular labour required per ewe per year was based on the average of the average and premium labour rates given by Nix (2002). This was 3.38 hours. However, some of this time would be provided by casual workers or by working overtime, particularly at peak periods such as lambing. The figure of 3.38 hours was therefore adjusted downwards by the casual labour requirements (see on) associated with each attribute level.

Labour requirement at lambing time (March) was set at 0.85 hours/ewe (Nix, 2002) for ewes lambing indoors. Ewes lambing outdoors were assigned 0.9 of this figure. The proportion of ewes lambing indoors was assumed to be 1.0, 0.45, 0.10 and 0.0 for levels 1 to 4 respectively of the housing attribute (Table 1). The overall labour required at lambing time for a particular profile was compared with regular labour available and any shortfall met by casual labour. The cost of casual labour was set at £7/hour, reflecting minimum overtime rates for adult workers (SAC, 2003). A charge of £1.73 per housed ewe was made to reflect the opportunity cost of building space used. This figure was based on the annualised capital cost of making appropriate sheds available (SAC, 2003) for 0.3 of the year.

The treatment costs per ewe associated with the three levels of the disease attribute (Table 1) were estimated at £1.03, £2.65 and £4.63 respectively, based on a typical disease spectrum, product prices and level of incidence (P.Goddard, personal communication). In the case of housed ewes at level 3 (routinely treat all common ailments) an extra £1.80 was added to cover costs of vaccination against abortion and lambing sundries. Labour required for these alternatives were estimated from the total number of treatments associated with each level (7,13 and 19 respectively plus an extra 2 for housed ewes at level three). Each treatment was assumed to require 0.75 minutes per ewe (P.Goddard, personal communication). Labour for disease control could be provided either from regular hours and/or by hiring casual labour. This resource allocation was made by the LP so as to maximise return under each profile. A similar choice was not made available for labour at lambing time because of the seasonal nature of the demand. The only other veterinary cost was £60/shepherd to cover the costs of calling out a veterinary surgeon. Although focus groups indicated that vets are rarely called to treat individual sheep, typically there would be a need to call a veterinary surgeon at some time for advice, diagnosis or treatment of an acute problem.

Single bearing hill ewes would require about £2.63 of concentrate feed (at £250/tonne, SAC (2003)), while twin bearing ewes need about £4.73 (L.Mitchell, personal communication, assumes hay available and ewes fed for 6 weeks pre-lambing). If ewes are scanned, feed can be allocated accordingly (feed attribute level 1, Table 1) according to the profile average scanning rate obtained via the focus group exercise. Otherwise feed costs were assumed to be the average of the single and twin rates (level 2, Table 1) or negligible (level 3, Table 1). Scanning cost £0.50 per ewe and required 0.05 hours/ewe extra labour (A.Waterhouse, personal communication) (either regular or casual). Costs of hay were assumed fixed across all profiles at £0.39/ewe (SAC. 2003).

We estimated that it would take a gang of 3 people with dogs about 3 hours to gather a flock of 900 ewes, giving a rate per ewe of 0.01 hours. The labour required for the 3 levels of gathering (Table 1) was based on this estimate. Casual labour was used for this activity in the LP, at the wage rate given above. No alternative to casual labour was provided due to the need for a gang to undertake this work.

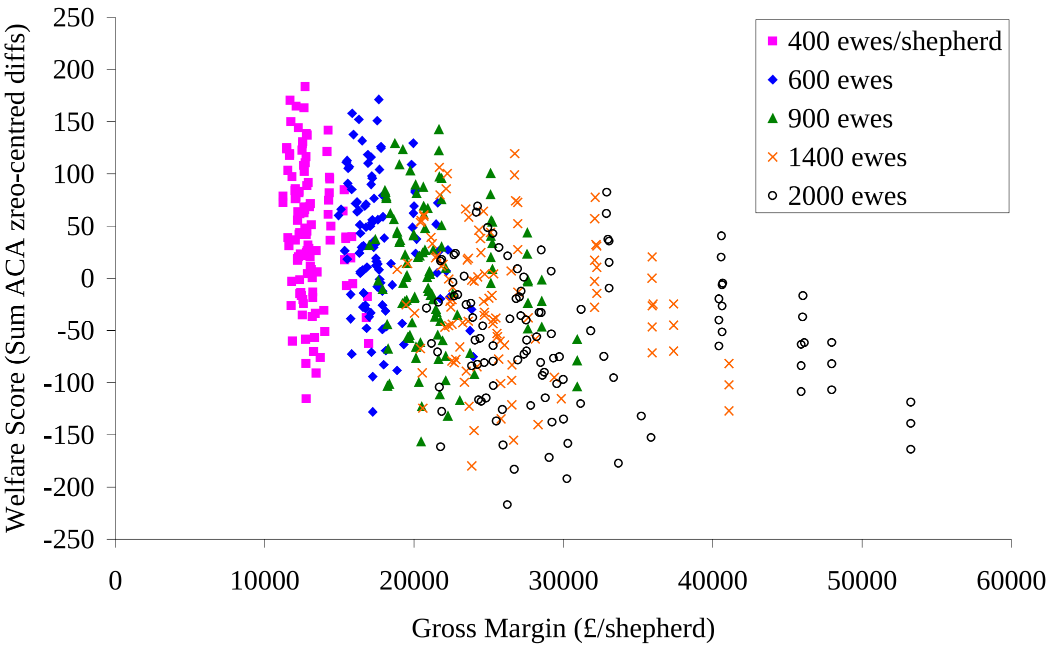
The LP calculated a farm 'gross margin' for each profile based on the average physical and financial assumptions for the relevant set of attribute levels. The gross margin included casual labour costs and the opportunity cost of lambing sheds as described above but otherwise followed the usual format set out in SAC (2003). Aspects of the gross margin calculation not covered by the attribute levels were based on figures in SAC (2003) for hill breeding Blackface ewes producing store lambs with limited inbye land in the Grampians and Southern Uplands of Scotland. These were wool sales (£1.28/ewe), Sheep Annual Premium (£13.01/ewe), LFA supplement (£4.34/ewe), ram replacement costs (£1.28/ewe) and sundry variable costs (£3.61/ewe). Fixed costs were subtracted from each profile gross margin to give a net farm income (NFI). These were based on the average of 2000/1 and 2000/2 for Scottish specialist sheep (LFA) farms reported in SAC (2003). Machinery and miscellaneous fixed costs were assumed fixed at the average farm size for the sample (618 ewes). However, land rents, property repairs and imputed rent on tenant's improvements were assumed to be proportional to the flock size implied by the labour attribute. Regular labour costs were set at £10,038 to reflect minimum wage rates including employer's national insurance and liability insurance (SAC, 2003).

Results

The maximum welfare score of 184 was obtained using a profile with attribute levels 1,1,1,1 and 2 respectively (Table 1), i.e. 400 ewes/shepherd, housed at lambing, all common ailments treated, scanned and fed accordingly and gathered 6 times per year. Maximum gross margin (£53,276) and NFI (£11,077) was obtained with profile 5,1,3,3 and 2 respectively. Thus the housing and gathering attributes were common to both welfare and income maximising profiles while all other attribute levels were at opposite extremes. The lowest welfare score of -217 was associated with profile 5,4,3,3 and 1. The lowest gross margin (£11,244) was with profile 1,3,1,2,1 and the lowest NFI (£-21,354) with 5,3,1,2 and 1. The correlation coefficients with welfare score were -0.46 (significant, $p<0.01$) and -0.09 (significant, $p<0.05$) for gross margin and NFI respectively.

The relationship between gross margin and welfare score for all profiles is plotted in Figure 1. Although a decline in welfare score is clearly apparent with increasing gross margin, for most gross margins/welfare scores there is a wide range of alternative profiles. In general, the higher numbers of ewes per shepherd offer the highest gross

Figure 1: Relationship between welfare score and gross margin



margins but at lower welfare scores.

The relationship between NFI and welfare score for all profiles is plotted in Figure 2. Here a peak of welfare scores is observed at intermediate NFI with lower score profiles at either side. This middle ground is occupied by profiles with labour attribute levels of 900 ewes/shepherd or less.

The overall average gross margin and average NFI were £21,845 and -£10,080 respectively. The range in the average gross margins for each attribute level indicates the relative financial impact of that attribute (Figure 3). The labour attribute was clearly most influential in this regard. However, because of the way fixed costs were allocated (see above) the labour attribute was much less important when measured by NFI (£3,175). The financial importance of other attributes was the same, whether measured by gross margin or NFI. The average importances of each attribute can also be measured in terms of animal welfare. This is done by expressing the range of

Figure 2: Relationship between welfare score and NFI

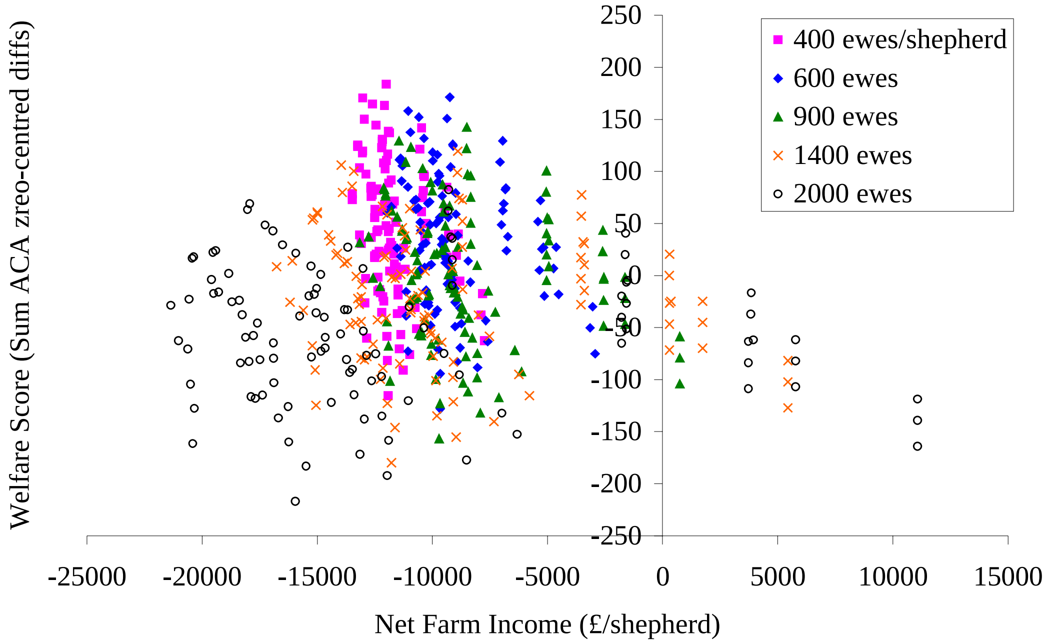
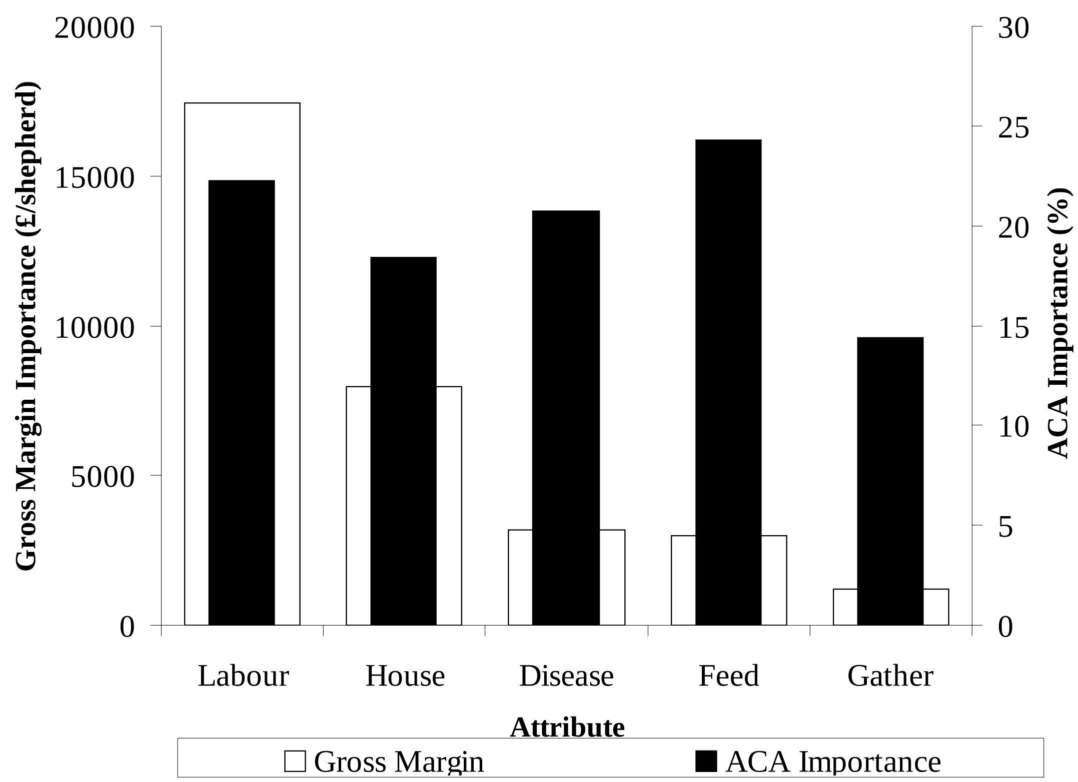


Figure 3: Average importances of each attribute in financial (gross margin) and animal welfare (ACA) terms



utility scores allocated by each ACA respondent for each attribute as a percentage of the total possible score (100 times the number of attributes) (Metegrano, 1994). The average of this relative importance score across all respondents gives the average ACA importances shown in Figure 3. The feed attribute scored highest in this respect, closely followed by labour, then disease, housing and finally gathering.

Discussion

Average NFI over the two years from 2000 to 2002 for specialist Scottish sheep (LFA) farms was £1,863 (SAC, 2003). This is considerably higher than the average NFI calculated here (-£10,080). However, our LP included casual labour in the variable costs. On most farms, such labour is likely to be provided by the farmer and spouse. Cost of labour provided by farmer and spouse is excluded from NFI but not management and investment income (MII). The published MII figure for such farms is -£9357 (SAC, 2003) suggesting that our LP provides average financial returns in line with current experience.

The welfare scores used in our study reflect the aggregate opinions of participating sheep farmers. Although their scores are based on considerable practical experience, it could be argued that their views are biased by such experience and/or by their vested interests and peer group influences etc. We therefore repeated the ACA exercise independently with 22 non-farmers (veterinarians, veterinary students and other specialists). In agreement with farmer preferences, the two most important attributes as identified by the non-farmer respondents were feeding followed by labour. Although some differences were found in the rank order of the remaining three attributes between the farmer and non-farmer respondent groups, this was not statistically significant ($p>0.05$). Within both groups there was considerable variation between individuals. This highlights the potential value of ACA as a way of establishing a consistent and quantifiable consensus that can be used to test relative values and so aid resource allocations to activities that are otherwise difficult to prioritise. As animal welfare is ultimately an issue of consumer preference (McInerney, 1997) it seems appropriate to develop the technique in ways that allow consumers to express their relative preferences for alternative animal husbandry practices.

Gross margin for any welfare profile depended on the values of parameters averaged over all associated attribute levels. This meant that the influence of any one attribute was damped by the others i.e. attribute levels were generally treated as independent and additive. Possible interactions between attributes were mostly ignored. In practice, some substitution between inputs is likely to the benefit of animal welfare and farm profits. For example, where ewes are scanned and fed accordingly and labour input is high, treating individual animals only when sick may work well. However, in some circumstances, if disease prevention is neglected, disease may catch hold rendering animals unresponsive to other inputs. This problem was partially countered by building interrelationships into the LP model. For example, labour requirements per ewe were fixed regardless of labour attribute level, thus when labour input was relatively high, slack regular labour could be allocated to other attribute activities thus saving casual labour costs. Also, disease costs were calculated on a per ewe basis so total disease treatment/prevention costs were influenced by the labour attribute. Sheep housed at lambing incurred additional disease attribute costs and required more labour.

As might be expected, high welfare scores were associated with high inputs. The only exception was the gathering attribute where the intermediate level was best for welfare. Unfortunately, except for housing and gathering, the high input/high welfare options did not provide sufficient financial advantage to offset their extra costs under the assumptions made here. Lowest input and hence lowest welfare attribute levels tended to offer the best financial outcome thus the highest financial profiles were little different from that with the lowest welfare score. At the gross margin level, the relationship with welfare score was linear, suggesting no diminishing returns to welfare score and hence no intermediate level of input that would offer reasonable financial rewards and yet most of the welfare score. However, when fixed costs were included maximum welfare score was associated with intermediate levels of financial return. This was caused by the method of allocating fixed costs that favoured the high input/high welfare labour attribute levels. The result highlights the importance of fixed cost control and the influence it may have on animal welfare. Unfortunately, this relationship will vary with business circumstances making it difficult to model typical scenarios and make general recommendations. Data published for English cattle and sheep farms in the LFA regions (Defra, 2002) suggest that 'small' farms (about 300 ewes) operate with lower fixed costs per labour unit compared to medium sized farms (about 750 ewes) of the same type. No doubt this is a necessary survival strategy but it may have important implications for animal welfare. Such implications will be worth further investigation as reform of agricultural policy alters the differential pressures on farm structure and policy makers seek to better target subsidy on farms that wish to provide higher standards of animal welfare (SEERAD, 2004).

Figure 3 demonstrates clear differences between the relative importance of the attributes for welfare compared to their financial importance to the farm business. The feeding attribute gained the highest overall score for welfare but was of relatively small financial significance. The financial dominance of the labour attribute is due to the direct association between the attribute levels and stock numbers (gross output). Although this dominance is wiped out at NFI level by assuming that fixed costs associated with land rent are directly proportional to stock numbers, this can be overcome in practice by more intensive use of existing land. The observation is in line with Harvey (2001) who stresses the need to reduce labour inputs in agriculture and with the trend towards larger flock sizes (and hence lower labour inputs) in the UK (Stott, 2003). As the welfare score for labour is almost as high as that for the feed attribute, there is a particularly strong conflict between welfare and financial importance associated with this attribute.

Conclusion

This study identified a significant negative correlation between economics and perceived animal welfare in a simulation study of typical extensively managed sheep production systems of the UK. However, the correlation was weaker when fixed cost estimates were included and considerable variation in welfare score was observed at most farm income levels. This suggests that welfare can be improved within the context of viable farm business management by careful choice between strategies that fit individual farm circumstances.

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Appendix - Example gross output schedule used by two focus group teams to evaluate the impact of one ACA attribute (feeding). Figures shown in column one are the default values provided by the research team.

	Feeding policy		
	Ewes scanned/condition scored and fed according to nutritional need	Flock given flat rate of supplementary feed	No supplementary feed provided except for snow storm feeding
Mortality rate in ewes (%)	6		
Cast ewes (%)	17		
Number of ewe deaths	54		
Number of cast ewes sold	153		
Number of replacements required:	207		
Scanning rate	135		
Lambs reared per 100 ewes	120		
Value of replacement shearlings/gimmers	£55	£	£
Cast ewe value	£20	£	£
Lambs produced	*1080*		
Number of lambs sold as stores	693		
Number of lambs sold fat	180		
Number of lambs sold for breeding (ewe lambs)			
Number of lambs kept as replacements	207		
Check lambs produced:	*1080*		
The estimated value of:			
Store lambs	£22	£	£
Fat lambs	£32	£	£
Ewe lambs	£50	£	£

Written instructions given to the focus group teams to accompany the above table:

Flock details:
The flock has 900 ewes that are cared for by one full time shepherd with additional labour when required e.g. for lambing and gathering.
The flock is scanned and ewes fed according to nutritional requirements, ewes carrying twins and other high risk sheep (approx. 45% of the flock) are housed at lambing time. All common ailments are treated routinely and the flock is gathered 6 times per year for treatment and other management actions.

Your task:
The inputs and output of the flock are detailed below.
Please estimate how these will be affected by a change in the feeding policy, e.g. any reductions in lamb output, that might arise if a flat rate supplementary feeding policy for all sheep (i.e. sheep not fed in groups according to nutritional need) was operated or if supplementary feeding was only provided in snow storms, BUT ALL OTHER THINGS REMAIN CONSTANT e.g. labour availability.