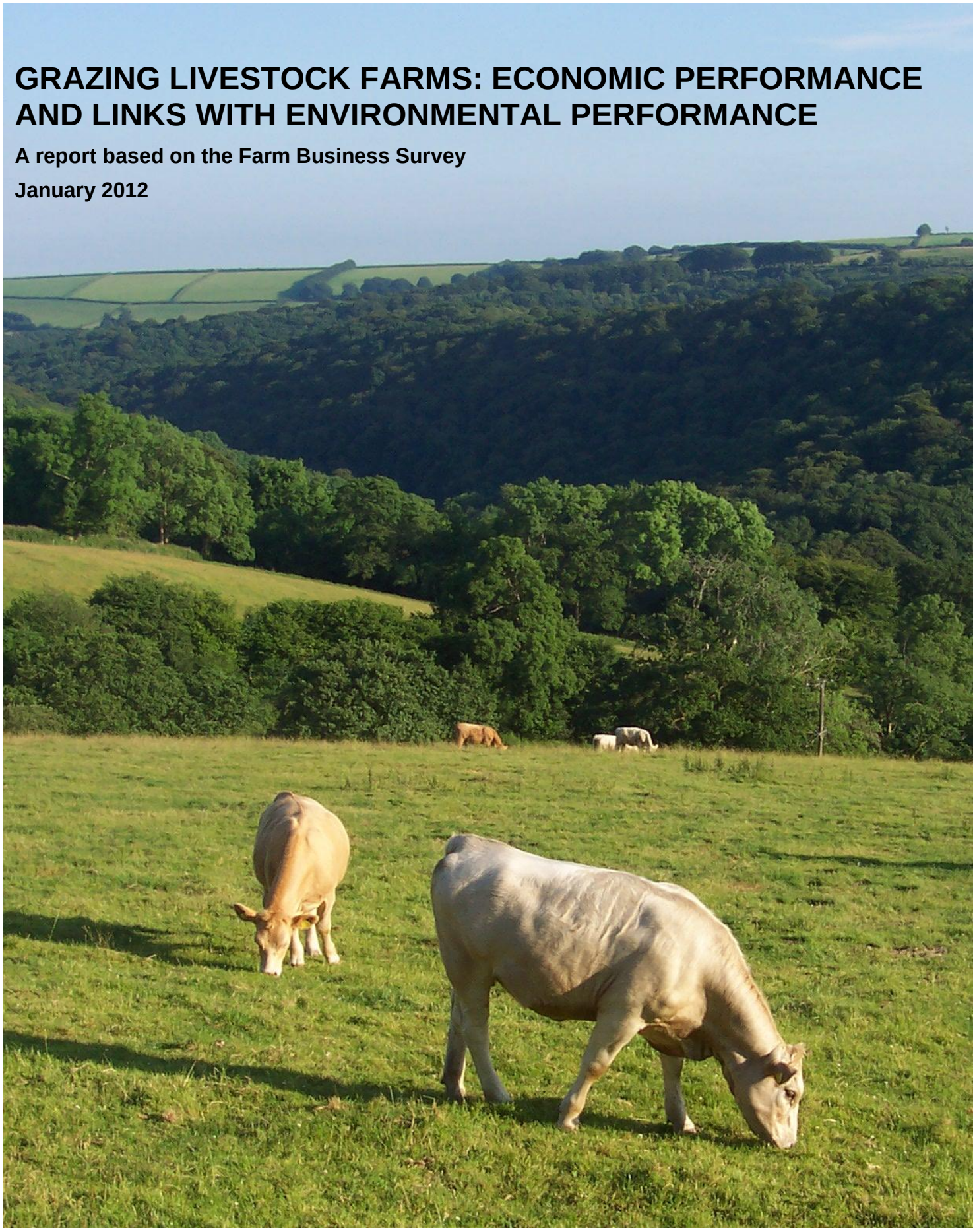
GRAZING LIVESTOCK FARMS: ECONOMIC PERFORMANCE AND LINKS WITH ENVIRONMENTAL PERFORMANCE

A report based on the Farm Business Survey

January 2012



Defra Agricultural Change and Environment Observatory Research Report No. 30

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Summary

1. ‘Efficiency’ in this report refers to economic efficiency, i.e. the farm’s efficiency at turning economic input into output (in this case mainly the value of livestock). The report covers all grazing livestock farms, whether upland or lowland, but doesn’t include dairy farms, unless the dairy unit is smaller than the main beef or sheep enterprise.

2. There is a high level of variation in efficiencies of grazing livestock farms. Under 5% of the variation in farm business output is related to large-scale geographic factors (e.g. regional differences in soil and climate). Over 70% is related to other between-farm differences in efficiency, such as differences in management ability and local geographic effects (e.g. small-scale variation in land quality), whilst around a quarter represents year-to-year variation in the performance of farm businesses.

3. A number of factors help to explain the variation in efficiency between farms, including the following:
   Debt: low efficiencies are strongly associated with high debt.
   Tenure and farmer age: owner-occupied farms perform no better than tenanted farms, despite not having rent included within their costs. The economic performance of owner-occupied farms decreases for older farmers. Younger tenant farmers have lower performance, which may be because they are on farms that are less economically viable.
   Area: for a given level of farm inputs, farms with bigger areas tend to have higher farm business outputs, but the impact on agricultural outputs is less marked, in contrast to the situation for cereals farms.
   Specialisation and diversification: lowland farms benefit from specialisation into beef or sheep. A small number of farms have diversified into other livestock, usually horses; these have lower agricultural efficiencies, but comparable efficiencies when the farm business as a whole is considered. Diversification outside agriculture is associated with a modest increase in farm business efficiency
   Unpaid family labour: even if ‘unpaid’ labour is costed at its full economic value, farms with greater proportionate use of family labour perform better in terms of agricultural outputs, but there is no significant relationship with farm business output.
   Contract work: greater use of contractors for field operations (silage making etc.) is associated with better agricultural performance.
   Livestock production: those farms that finish their own lambs, particularly those in the uplands, perform better. However, this probably reflects the quality of land and it does not necessarily follow that other holdings would improve their performance by finishing lambs.
   Organics: the performance of organic farms relative to conventional ones varies from year to year.

4. For the agricultural cost centre, there is strong evidence of increasing returns to scale provided a cost is imputed for unpaid family labour; i.e. economically larger farms are more efficient on average. However, for the entire farm business returns to scale are approximately constant after adjusting for family labour costs.

5. Economic performance is strongly related to membership of agri-environment schemes. In terms of agricultural output, ELS gives little reduction, classic schemes give a slight reduction, whilst HLS causes a marked reduction in agricultural output. For farm business performance the situation is reversed, with all schemes being associated with increased output, with the most demanding schemes giving the biggest advantage. Those farms carrying out extensive agri-environment works without payment tend to have lower farm business efficiencies.

6. Business management practices are linked to economic efficiency, particularly at the Farm Business level. High performing businesses are likely to:

    - use management accounting practices, including benchmarking
    - have a PC and use the internet for submitting forms electronically
    - use business management exercises to plan ahead
    - put in practice actions to bring about environmental improvements
    - show a high level of interaction with customers
    - adopt risk management strategies

    Those farms using technical advice obtained from events and demonstrations tend to have high performance for both the farm business and agricultural cost centre.

Grazing livestock farms: economic performance and links with environmental performance.

A report based on the Farm Business Survey

1. Introduction

The first of Defra's three priorities, as set out in the business plan announced in November 2010[1] is to 'Support and develop British farming and encourage sustainable food production'. Sustainable food production can only be achieved if the economic performance of individual farms allows them to remain viable and competitive. The first objective of this report is therefore to examine how economic performance varies between grazing livestock farms, and to examine the characteristics of the best performing farms.

In examining the economic performance of farms, a key issue that has stimulated much debate over many decades is the degree of association between performance and farm size. Clearly there are potential economies of scale that mean that larger farms *may* be, on average, more efficient than smaller ones. There may also be economies of scope, where larger firms are able to spread their costs over a greater number of enterprises. However, some have argued that there are also diseconomies of scale that may counteract these. Whilst this might seem a rather academic argument, it has real implications for the degree of structural change that faces English agriculture in the future, and the pace at which that change must happen. This in turn will have a major impact on the viability of those rural communities where agriculture is still an important part of the economy.

The second Defra priority is to 'Help to enhance the environment and biodiversity to improve quality of life'. In the past, there has certainly been some tension between the environment and agricultural production, with some measures adopted to achieve economic efficiency causing damage to the environmental sustainability of the countryside. The second objective of the report is therefore to consider the correlation between economic performance and environmental performance, in order to see whether conflict remains between Defra's first two priorities.

This report deals with grazing livestock farms and builds on similar work already published for cereals farms[2]. It considers both lowland and upland grazing livestock farms within the same models, as previous work has suggested strong similarities between them. However, differences between lowland and upland farms have been checked for all important variables and are reported where statistically significant.

[1] http://www.defra.gov.uk/corporate/about/what/business-planning/

[2] http://www.defra.gov.uk/statistics/files/defra-stats-foodfarm-environ-obs-research-arable-cereals-110505.pdf

2. Methods: Data and statistical models

2.1. Data

Data was taken from the Farm Business Survey of England for 2003-2009; this period was chosen to include two years of data prior to implementation of the most recent Common Agricultural Policy (CAP) reforms, including the Single Payment Scheme (SPS). Farms were included in the analysis if they were classified to 'robust' type[3] lowland grazing livestock or LFA[4] grazing livestock in at least three of these years. 545 farms met this condition, with 167 of these surveyed in all seven years. 90% of the farms were always classified as grazing livestock, with the remainder being classified to another farm type (usually mixed or dairy) in a minority of years. Grazing livestock farms are predominantly involved in beef and/or sheep production. Dairy farms are not part of the grazing livestock type, although a few farms which are classified as grazing livestock due to their beef and sheep enterprises also have dairy cattle.

2.2. Variables used in the analysis

The principal variables used are shown in Table 2.1. Models are either fitted for the entire farm business (i.e. using 'fbout' and 'fbcosts' from Table 2.1), or just for the agricultural cost centre (i.e. using 'agoutput' and 'agcosts').

Table 2.1: principal variables used in the analysis

Variable name	FBS database name	Description
fbout	Farm.business.output	Output in £k including that from diversified enterprises as well as traditional farming sources.
fbcosts	Farm.business.costs	All fixed and variable costs relating to traditional farming, agri-environment schemes and diversified enterprises. It does not include a notional cost of unpaid family labour.
agoutput	crop.output.excl.subsidies + livestock.output.excl.subsidies	Output in £k from agricultural enterprises, excluding direct and indirect government support.
agcosts	agriculture.variable.costs + agriculture.fixed.costs	All fixed and variable costs relating to traditional farming. It does not include a notional cost of unpaid family labour. On owner occupied farms it does not include any notional rent.
Unpaid	Unpaid.labour	Notional cost of unpaid labour provided by the farmer, spouse and other family members. The costs are estimated by the researcher based on the hourly rate for skilled labour in the area.

[3] http://www.defra.gov.uk/statistics/files/defra-stats-foodfarm-farmmanage-fbs-UK_Farm_Classification.pdf

[4] Less Favoured Areas. See for example page 12 of http://www.defra.gov.uk/statistics/files/defra-stats-foodfarm-environ-research-uplands-fullreport-may2010.pdf

2.3. 'Unpaid' family labour

Family labour is an important issue when considering farm efficiencies, and the way it is treated can have important implications for the results (Britton and Hill, 1975). The most common approach is to impute a cost equivalent to the amount that the unpaid staff could earn in similar work elsewhere. This is generally justified as an estimate of the 'opportunity cost'; i.e. the income foregone by the farmer and spouse because they are working on the farm rather than earning money in employment. In this respect it is an imperfect estimate of the true opportunity cost, since some farmers, particularly on the larger farms, will have skills that could command higher rates than the figures for agricultural workers which are generally used.

There are other problems with this approach. When speaking with small farmers ('small' in economic size) it is often clear that they do not expect their business to provide the same monetary returns that they would receive in other alternative employment. Whilst there is no hard data to indicate how common this attitude is, there are good reasons why it should apply to many farmers. This is because the farming family receives other non-monetary benefits from working on the farm, and it is logical for them to discount their monetary payment to allow for this, producing a 'shadow price' below the standard wage rate, particularly on smaller farms (Chavas, 2008). Examples of these benefits will include:

- Housing. Particularly for small tenant farmers, the farmhouse accommodation will frequently be far superior to anything that they could hope to buy or rent if working off the farm.
- Proximity to work. In rural areas long journeys would frequently be required to find alternative work, and these journeys would generally need to be made by private car. It is therefore logical for farmers to accept a lower rate of return for work on the farm in order to avoid this time and expense.
- Independence and status. Many farmers value the freedom to be their own boss. Despite the low financial returns for small farmers, they retain a high status in the minds of many in rural communities.
- Enjoyment of work. Farmers may enjoy the work and consider it more satisfying than alternative employment.

In practice it is not possible to estimate a suitable shadow rate, allowing for these other benefits, not least because they vary according to individual circumstances. They are likely to be significant in comparison to the imputed value for many small farmers, and hence any estimation using the imputed values will tend to underestimate the efficiency and sustainability of the smaller businesses. For the larger farms, the proportionate use of unpaid labour is less, so the issue is of less importance.

In the previous document on cereals farms[5] the approach adopted was to analyse the data with and without imputed costs for unpaid labour, presenting just the results without imputed costs, except where marked differences were present. This approach worked well for cereals farms, but is less satisfactory for grazing livestock farms because labour makes up a higher proportion of total costs (24% of farm business costs on average, increasing to over 30% for smaller farms). A third approach is therefore adopted, with family labour being charged at a rate equivalent to the national minimum wage[6]; whilst this is a

[5] http://www.defra.gov.uk/statistics/files/defra-stats-foodfarm-environ-obs-research-arable-cereals-110505.pdf

[6] Rates are taken from the 'historical rates' table at http://www.lowpay.gov.uk/

somewhat arbitrary figure, it does represent the minimum return for employment within the wider economy and, in practice, gives a discount of around £2 per hour compared to the imputed values.

2.4. Statistical models used

To allow a proper exploration of economic performance statistical models were fitted to the data rather than relying on simple statistics such as the ratio of outputs to inputs. The response variable was the log-transformed total outputs (logfbout for all farm business costs or logagout for agricultural outputs, see Table 2.1):

$logout_{ij} = y_j + b_1 * logcosts_{ij} + ef_i + e_{ij}$ (Equation 1)

Where:
$logout_{ij}$ is the log-transformed output of farm i in year j (calculated using fbout or agout)
y is an effect of the jth year (e.g. allowing for high prices, or poor weather)
$logcosts_{ij}$ is the log-transformed input costs of farm i in year j (calculated using fbcosts or agcosts)
b_1 is the regression slope for logcosts
ef_i is an effect of the ith farm (e.g. allowing for differences in fertility of the land or competence of the farm staff)
e_{ij} is a random error term for farm i in year j (e.g. allowing for random events such as disease losses)

Two variants on this model were used, relating to the form of the farm effects:

1. Frontier model: in this model the farm effects were constrained to be negative and thus measure the distance of the farm from the efficient frontier. The model was fitted using maximum likelihood in the specialist program FRONTIER[7].
2. Mixed effects model: farm effects were normally distributed about a line representing the average efficiency of farms. The model was fitted using restricted maximum likelihood (REML) in GenStat[8].

In practice, the correlation between the farm effects from the two models was found to be very high (around 0.99), meaning that there was little to be gained by using the two different measures of efficiency. Therefore most of the analyses presented here use the REML models, since these can be fitted in standard software and are easily extended to more complex models. Figure 2.1 shows the models in graphical terms.

Equation 1 assumes that the farm effect remains constant over time, which is perhaps unrealistic over the seven year period considered in this report. A random slopes REML model was therefore used, in which each farm's

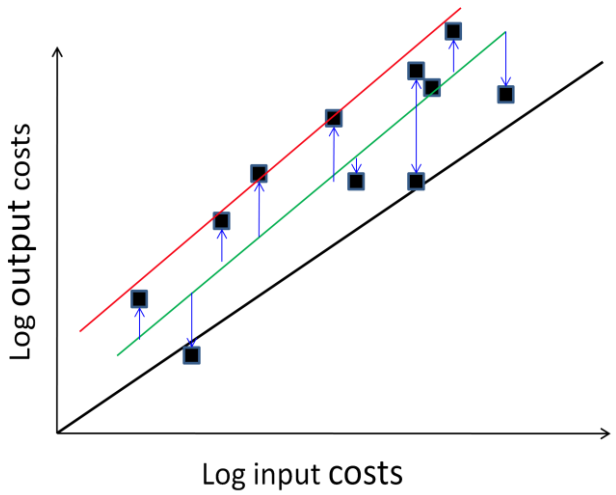


Figure 2.1: graphical representation of the model of equation 1. The black line represents equal inputs and outputs, the green line is the average efficiency (REML) and the red line is the efficient frontier. The blue arrows represent the efficiencies of each farm relative to the average.

[7] http://www.uq.edu.au/economics/cepa/software.htm

[8] http://www.vsni.co.uk/software/genstat/

efficiency can increase or decrease over time:

$logout_{ij} = y_j + b_1*logcosts_{ij} + ef_i + s_i*y_j + e_{ij}$ (Equation 2)

Where s_i represents the trend in efficiency for the ith farm.

The model of equations 1 and 2 assumes a linear relationship on the log scale between the output value and input cost. Polynomial terms for costs were fitted to check that this approximation was appropriate, with quadratic and higher terms being retained if they were significant at the conventional 5% level. Interactions between the year effects and input costs were also checked.

2.5. Impact of price changes

In a frontier analysis the goal is generally to relate outputs to input quantities in order to estimate technical efficiency (i.e. efficiency in terms of the quantity of outputs produced from a given quantity of inputs[9]). Where the inputs are measured in monetary terms it is therefore sensible to deflate them to ensure that they are proportional to the quantities even if prices change over the period of the study.

In this work, by contrast, the objective was to relate output value to input costs in order to estimate economic efficiency[10]. Over the course of the study, prices will change and farmers will respond to these changes; this is a real feature of the system and it would not be sensible to deflate the input or output values to 'correct' for this. For example, if the price of fertiliser dropped sharply farmers might decide to apply more of it, to increase the outputs obtained, where this was possible subject to regulatory and agronomic constraints. This might well increase economic efficiency in terms of the ratio of outputs to inputs, since the optimal rate of application increases when the fertiliser price falls, but any attempt to correct for the price change by adjusting the cost back to the previous higher price would be inappropriate, since the farmer would not have made the purchase had that higher price applied. In this instance the increased fertiliser application would probably lead to a reduction in technical efficiency, despite being a sensible economic decision.

2.6. Factors correlated with efficiency

When investigating factors associated with efficiency, it is best to include these factors within the main efficiency model, using either the frontier or REML approach. The REML model then becomes:

$logout_{ij} = y_j + b_1*logcosts_{ij} + d_1*z_1 + ...+d_p*z_p + ef_i + s_i*y_j + e_{ij}$ (Equation 2)

Where d_1 to d_p are regression slopes for p explanatory variables z_1 to z_p which help to explain the differences in efficiency between farms.

However, for initial exploratory analyis a two stage approach was adopted, in which the efficiencies for each farm are estimated as described above and then used as the dependent variable in a regression. This allows for easy graphical display of relationships in order to assist with identification of non-linearities and interactions.

The spatial pattern of efficiencies was also investigated. This is important since any clustering of efficiencies might indicate that geographic factors (e.g. soils, rainfall) were important, limiting the scope of individual farmers to improve their efficiency. For confidentiality reasons, geographic co-ordinates of farms are only recorded to the nearest

[9] See the book by Coelli et al. cited in the references (Section 9) for more information.

[10] 'Economic efficiency' is used in this report to refer to the optimal ratio of output value to input costs. This is similar to the terminology used by Coelli et al. (see p51) and is the result of both allocative efficiency and technical efficiency. Use of the term is not intended to imply pareto efficiency.

10km; when results are displayed in map form, farms were plotted at a random location within the 10km square to avoid co-incident points.

2.7. Modelling approach

As has been pointed out by Armsworth et al. (2009), the way in which regression models are applied differs between econometrics and scientific disciplines such as ecology and medicine. Economists tend to be more interested in theoretical basis of the models, and are concerned about endogeneity. Scientists often regard regression models more as an exploratory technique for describing empirical relationships between variables, and value parsimony in model selection.

The modelling approach used here is much closer to the empirical scientific approach than it is to the traditional econometric approach, and the results need to be interpreted in that light. Thus significant relationships do not necessarily imply a causal relationship. Estimates derived from the model are not necessarily unbiased estimates of the true causal model, but are approximately unbiased estimates of the relevant parameters for the FBS population of farms.

3. Results: economic efficiency

3.1. Efficiency models and returns to scale

Results of the efficiency models are shown in Figure 3.1 for farm business outputs and costs. The vertical axis is displayed as a ratio of outputs/inputs, rather than as log output costs as in Figure 2.3, as this makes it easier to appreciate the comparatively subtle changes in returns to scale (i.e. the slope of the lines). There is a significant quadratic relationship between inputs and outputs. The red and green lines represent the best fit to the data for LFA and lowland grazing livestock farms respectively (using the model of equation 2) and therefore pass through the black crosses representing individual farms.

The black horizontal line on each graph in Figure 3.1 represents equality between outputs and inputs and so the vertical distance of a point above this line represents the margin of outputs over inputs. In most years both the red (LFA) and green (lowland) lines are higher above the black line for low input costs. This suggests that smaller farm businesses tend

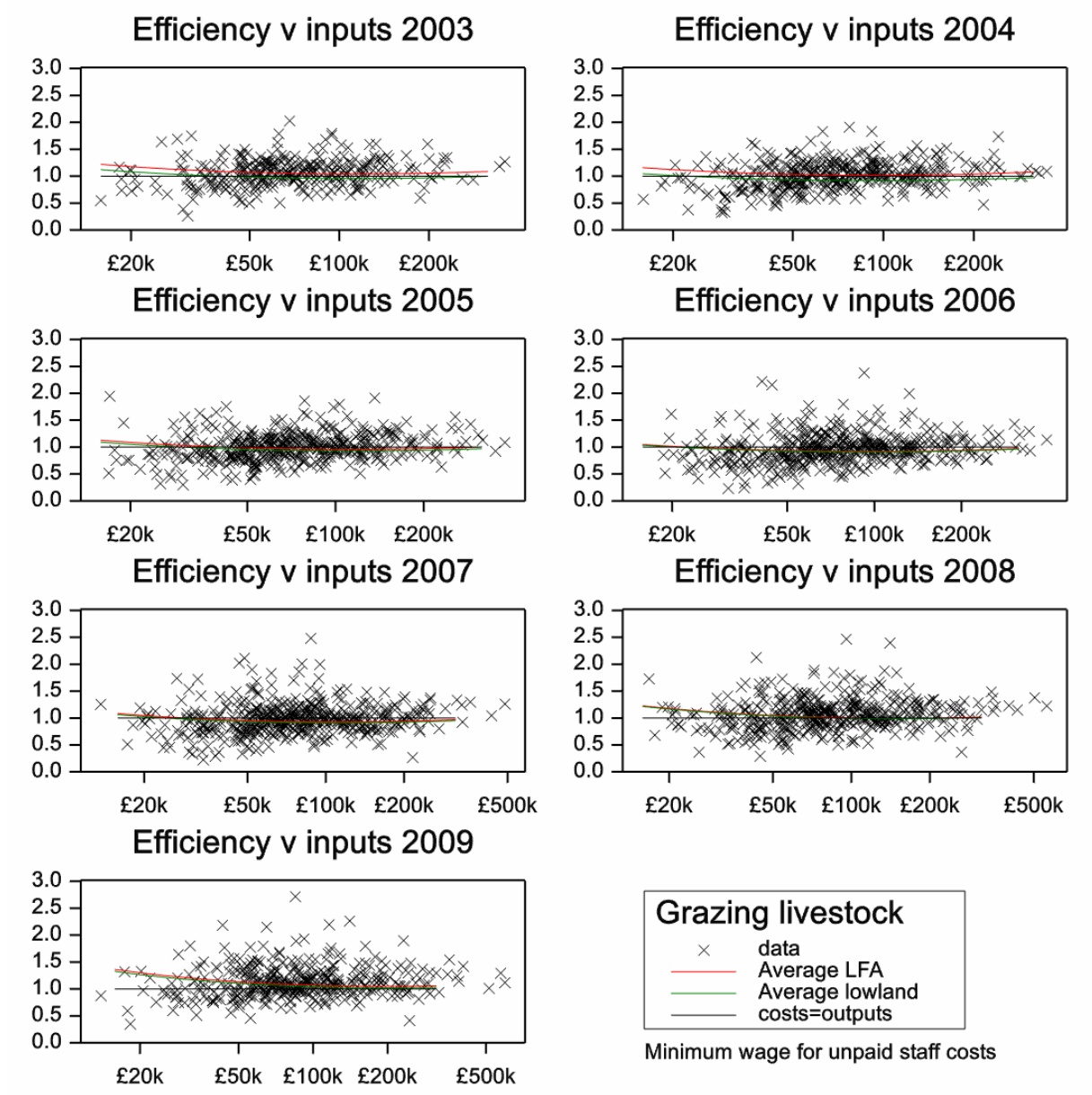
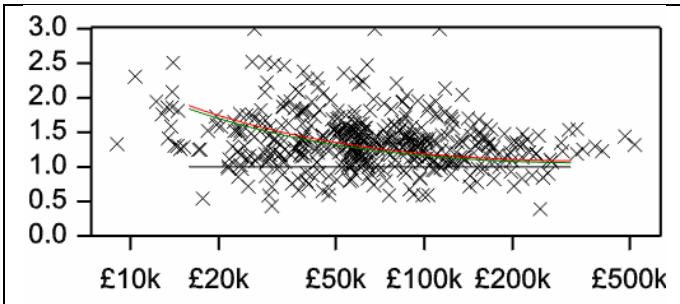
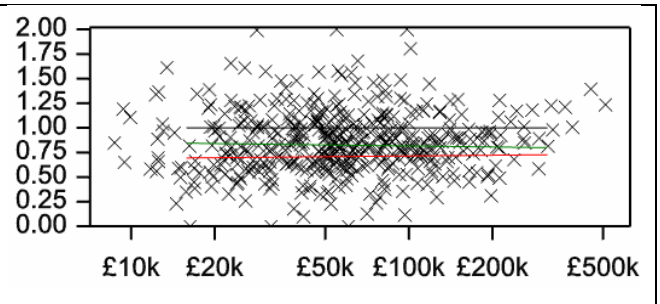


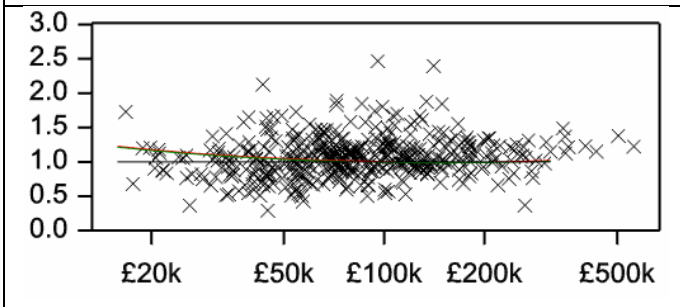
Figure 3.1: REML efficiency models for farm business output. The vertical axis shows the ratio of outputs to inputs, and the horizontal axis input costs, with family labour costed at the national minimum wage. The red line is the modelled average value for LFA farms and the green line is for lowland farms.



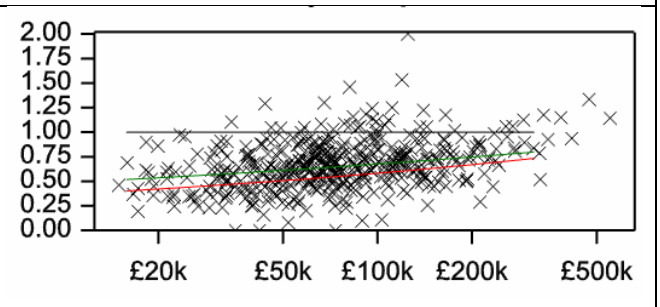
a) Farm business output/costs excluding unpaid labour



b) agricultural output/input excluding unpaid labour



c) Farm business output/costs including unpaid labour at minimum wage rate



d) agricultural output/input including unpaid labour at minimum wage rate

Figure 3.2: efficiency models fitted to the different datasets for 2008. The vertical axis shows the ratio of outputs to inputs, and the horizontal axis input costs. The red line is the modelled average value for LFA farms and the green line is for lowland farms.

to be proportionately more efficient in turning inputs into outputs in terms of the monetary value (i.e. decreasing returns to scale). However, in some years (particularly 2003) the slopes of the lines change as input costs increase above around £100,000 per farm, indicating that the very largest businesses may be more efficient than medium sized ones.

The pattern of returns to scale varies somewhat depending on whether the model is based on the whole farm business, or just the agricultural enterprises. It also depends on whether a notional cost is added for unpaid family labour, including that of the farmer and spouse. These differences are illustrated in Figure 3.2 and Table 3.1 using data for 2008.

Figure 3.2 shows the different models for 2008. When farm business outputs are considered and no allowance is made for the costs of unpaid family labour (Figure 3.2a), there are clearly decreasing returns to scale, with some small businesses having output:input ratios of 2 or higher as a result of excluding most of their labour costs. When family labour is charged at the minimum wage (Figure 3.2c, which is identical to the 2008 graph in Figure 3.1), the downward slope is much less steep, as discussed above. In both cases the red and green lines are close together, indicating little difference in performance between LFA and lowland farms.

If just agricultural outputs are modelled (excluding receipts from subsidies, the SPS and agri-environment schemes) the green line for lowland farms is markedly higher than the red one for LFA farms, indicating the lower returns to agriculture in the uplands. Even with unpaid labour cost excluded (Figure 3.2b) both lines are below the black line for equal inputs and outputs, with substantial numbers of farms having negative margins. When family labour is charged at the minimum wage (Figure 3.2d), even more farms lie below the black line of equality of input and output costs, and the lines have positive slope, indicating that larger businesses are more efficient.

3.2. Spatial pattern in efficiency

Figure 3.3 shows the spatial distribution of farm efficiencies based on agricultural inputs and outputs. Whilst there is some evidence for local clustering within about 15km, there is little sign of any wider regional effects, with most areas having a mix of efficient (circles) and less efficient (crosses) farms. This is shown in Table 3.1 where the spatial component, modelled at the National Character Area[11] (NCA) level, accounts for under 5% of the total variability in agricultural outputs, and under 1% of that in farm business outputs. This figure will underestimate the true figure due to the limited geographic information available for FBS farms, but it is nevertheless much lower than the variability between farms, which accounts for well over half the total variation. Variability between farms will be due to factors such as the skill of the farmer and the livestock kept, as well as more local geographic factors such as grass quality. Just under 40% of the total variation in agricultural outputs is unexplained year to year variation within farms, caused by factors such as poor weather at lambing time or disease outbreaks. Gradual changes in efficiency over the seven years of data, such as the improvements that may happen when management passes from one generation to the next, will also contribute to the year to year variation.

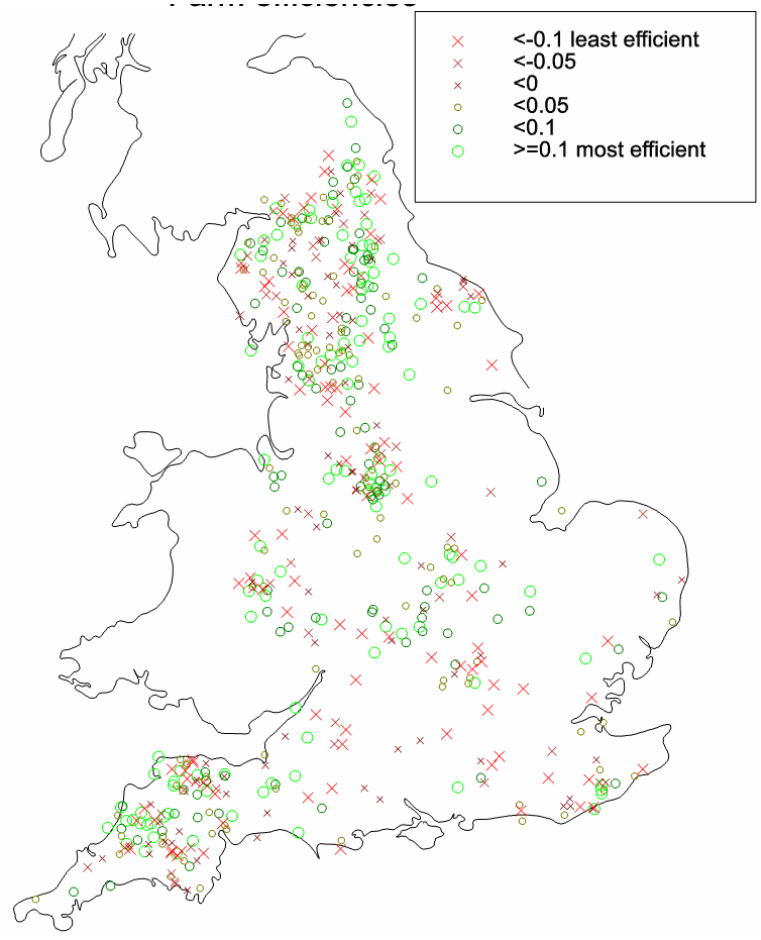


Figure 3.3: Spatial distribution of farm efficiencies. Efficiencies are based on the model for agriculture only, with family labour charged at the national minimum wage.

Table 3.1: proportion of variance at different levels in the data

	Farm business outputs			Agricultural outputs		
	Variance	Variance	Variance	Variance	s.e.	% total
Spatial variation (NCA)	0.0001	0.00025	0.9%	0.0014	0.00077	4.2%
Farm to farm variation	0.0102	0.00070	72.6%	0.0198	0.00145	58.0%
Random year to year variation	0.0037	0.00011	26.5%	0.0129	0.00037	37.8%

Based on a REML model of log transformed agricultural output value with terms fitted for log-transformed input costs and their interaction with year. Family labour is charged at the national minimum wage. This model does not include a term for random slopes.
The spatial variation is based on National Character Areas and does not include more local geographic factors.

[11] National Character Areas, formerly known as Joint Character Areas (JCAs) are a subdivision of England into 159 areas based on landscape features. See http://www.naturalengland.org.uk/ourwork/landscape/englands/character/areas/default.aspx

3.3. Estimating the Frontier

Variance estimates like those displayed above are not easy to interpret, and so this section will attempt to quantify the efficiency of grazing livestock farms by comparing the performance of average farms with those on the economic frontier.

One way to do this is to use stochastic frontier analysis to estimate the frontier of best performing farms, in terms of output produced for a given level of input. This is shown in Figure 3.4 for lowland grazing farms. Comparing the green line of average performance with the red frontier line reveals that the average lowland grazing livestock farm operated at 84% of the efficiency of frontier farms. LFA grazing livestock farms were somewhat less efficient on this measure, with the average farm 81% of the frontier. For comparison, the corresponding statistic for cereals farms is 76%.

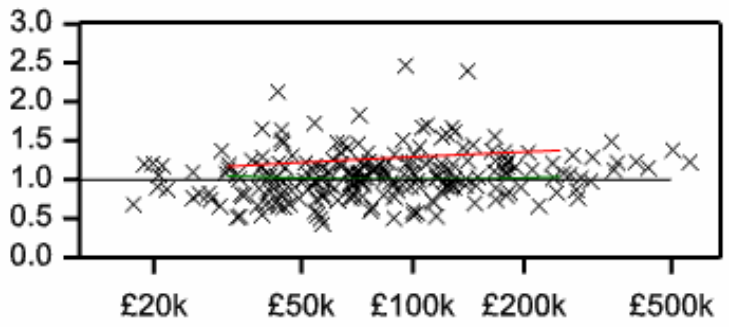


Figure 3.4: Stochastic Frontier model fitted to farm business outputs for lowland grazing farms in 2008. The vertical axis is ratio of outputs/costs, while the horizontal axis is costs, including family labour charged at the national minimum wage. The red line is the frontier and the green line the average, fitted by REML.

Table 3.2 shows what the distribution of performance might mean in terms of the value of outputs from a farm of average economic size. Estimates are shown between the 10th and 90th percentile; estimates at the extreme tails of the distribution will be unreliable and are therefore not shown. Note how a farm at the tenth percentile produces roughly £20,000 more output than one at median efficiency (50th percentile), and this in turn produces £20,000 more than one at the 90th percentile. These figures exclude the impact of random year to year fluctuations in performance; if this were included there would be even more variation in the output produced.

Table 3.2: predicted outputs for a farm with input costs of £75,000 at various points on the distribution of performance.

	Lowland	LFA
Performance percentile	**£000s**	**£000s**
10%	100.1	98.3
25%	86.3	91.0
50%	76.9	79.2
75%	67.4	66.9
90%	57.2	55.9

Note: based on the REML model with family labour charged at the national minimum wage. Estimates are based on 2008 prices and trading conditions, but represent average returns expected over a number of years

4. Results: factors correlated with efficiency

Tables 4.1a and 4.1b shows the significant variables in a stepwise REML analysis of log output against the various predictor variables. As with any stepwise regression, some caution is needed in interpreting the results since there may be alternative models which are equally good in explaining the data. This is particularly the case where predictor variables are highly correlated. For example, models including either %interest (interest payments as a percentage of total costs) or %gearing (gearing ratio) were equally effective; fortunately in this case the interpretation of results remains the same whichever variable is chosen.

This caveat is also important for interaction terms, when the impact of one variable depends on the value of another (e.g. the interaction Porganic.Year means that the performance of organic farms relative to conventional ones varies between different years). The aim of the modelling process was to identify those interaction terms that were stable and not dependent on one or two extreme observations. Hence the absence of an interaction term does not necessarily imply that no interaction was present, but rather that it was not sufficiently strong to be clearly apparent in the data.

It can be seen that there are many differences in the models fitted to the farm business and to agriculture only. However, these are mainly differences in detail, often relating to whether the term has an interaction with year or type (i.e. whether its effect varies between years or between LFA and lowland farms).

Table 4.1a: significant terms from a stepwise REML analysis of log farm business output (costing family labour at the national minimum wage) against the explanatory variables.

Term	F statistic	df1	df2	P	Notes
Costs	41.98	1	1836.3	<0.001	quadratic on log scale
Average costs	9.80	1	1392.2	0.002	quadratic on log scale
%GEARING	12.03	4	525.0	<0.001	Debt as % assets
Farmer age	5.07	1	1098.1	0.024	quadratic
Diversification	9.22	1	2469.0	0.002	
Agri-env scheme	9.30	3	2324.0	<0.001	
Farm assurance	10.85	1	537.3	0.001	Membership of scheme
Costs.Year	5.75	6	2093.3	<0.001	
Type.Year	42.69	12	2188.6	<0.001	
Adjusted area.Year	4.35	6	2064.0	<0.001	Adjusted area on log scale
lfbcosts[1].LADJAREA	25.81	1	998.6	<0.001	
Farmerage.TENURE	4.62	1	1020.1	0.032	Tenure is rented or owned
PFATCAT.Year	4.37	6	1962.5	<0.001	Fat cattle revenue as prop
Type.PFATSHEEP	8.92	1	567.6	0.003	Fat lamb revenue as prop
Type.Specialisation	13.90	1	2120.7	<0.001	
Porganic.Year	3.98	6	2127.2	0.001	Prop organic/in conversion
PSHEEP.Year	8.13	6	1955.7	<0.001	Prop revenue from sheep

Notes: where variables are fitted as linear and quadratic terms the F-statistic shown is for the quadratic term. Interactions with such terms only involve the linear component. Variables in capitals are fitted as average values over the seven years, either because this gives a better fit than using annual values or because values change little from one year to the next (e.g. areas).

Table 4.1b: significant terms from a stepwise REML analysis of log agricultural output (costing family labour at the national minimum wage) against the explanatory variables.

Term	F statistic	df1	df2	P	Notes
Costs	451.00	1	1551.4	<0.001	quadratic on log scale
%GEARING	17.65	4	525.6	<0.001	Debt as % assets
Farmer age	5.32	1	989.0	0.021	quadratic
Agri-env scheme	4.95	3	2257.9	0.002	
FARMASS	18.57	1	537.6	<0.001	Membership of scheme
%UNPAID	17.04	1	531.5	<0.001	Prop family labour
%SDA	19.14	1	532.7	<0.001	% of UAA in SDA
Contracting	4.96	1	523.5	0.026	Costs as prop all machinery/contracting costs
Pbeefsheep	5.32	1	1458.2	0.021	Prop SLR from beef & sheep
Porganic.Year	2.20	6	2185.6	0.040	Prop organic/in conversion
LADJAREA.Specialisation	9.71	1	1755.5	0.002	Adjusted area on log scale
Type.Specialisation	13.68	1	1697.7	<0.001	
Farmerage.TENURE	4.60	1	879.9	0.032	Tenure is rented or owned
PSHEEP.Year	5.59	6	2013.2	<0.001	Prop revenue from sheep
Average costs.TENURE	5.90	1	527.0	0.016	
Type.PFATSHEEP	6.86	1	569.2	0.009	Fat lamb revenue as prop
PFATCAT.Year	4.94	6	2019.9	<0.001	Fat cattle revenue as prop

Notes: where variables are fitted as linear and quadratic terms the F-statistic shown is for the quadratic term. Interactions with such terms only involve the linear component.

There is, as would be expected a highly significant relationship between outputs and costs and, in the case of farm business output, this is quadratic in form and varies according to the farm area. As well as the term for the actual input costs in each year, the models also include a term for the average input costs over the five year period. Despite the high correlation (0.97) between these variables, both are highly significant, indicating that the output of a farm in any one year depends on the inputs in the preceding years, as well as the inputs used in the current year. This may be partially because of carry-over effects; for example due to the effects of fertilisers applied in one financial year leading to increased output in the following year. However, it probably also indicates that rapid increases in inputs may not yield the expected increase in outputs due to constraints of the farm infrastructure.

The following sections deal with each variable in turn. For ease of reference, each section starts with a short summary of the impact of the variable.

4.1. Debt

The effect of indebtedness is large and highly significant, with average efficiencies much lower for farms with high interest payments. This is apparent both at the farm business level and for the agricultural cost centre (i.e. excluding diversification, agri-environment schemes and support payments).

The relationship is illustrated by Table 4.2 which shows the predicted level of outputs from a farm with £75,000 of inputs per annum and 100ha of land (approximately the median levels when family labour costs are included) for various levels of debt. The absolute values in this and subsequent tables should be treated with caution since they are estimated at a combination of average values of the other variables which may not be realistic in practice. Nevertheless, the differences between the rows give a useful

summary of the impact of the variable of interest. In this case, the estimated output from £75,000 of inputs falls markedly as the level of debt increases. As would be expected, returns are much less when only agricultural output is considered (i.e. excluding input and output costs associated with SPS, environmental stewardship and diversification), but the trend is similar in both cases.

Table 4.2: Level of debt (gearing ratio). The table shows predicted outputs from the REML model for a farm with £75,000 of inputs per annum, 100ha of land and average values of the other variables in the model. Figures are for 2008. Standard errors are approximate.

	Farm business output		Agricultural output	
Gearing ratio (debt as % of assets)	Estimated output (£000s)	Standard error	Estimated output (£000s)	Standard error
<1%	85	2.0	51	1.8
1-4.99%	84	1.7	49	1.4
5-9.99%	83	2.0	47	1.6
10-49.99%	78	1.6	42	1.3
50% or more	67	2.1	33	1.5

Note: family labour charged at the national minimum wage. Farm business output includes agricultural output, plus support payments (SPS etc.), agri-environment payments and diversified income.

There is a strong relationship between the level of debt and farm size (Figure 4.1), with smaller farms tending to have much lower levels of debt. This could either be because the farms have not needed to borrow because they have not increased in size, or it may

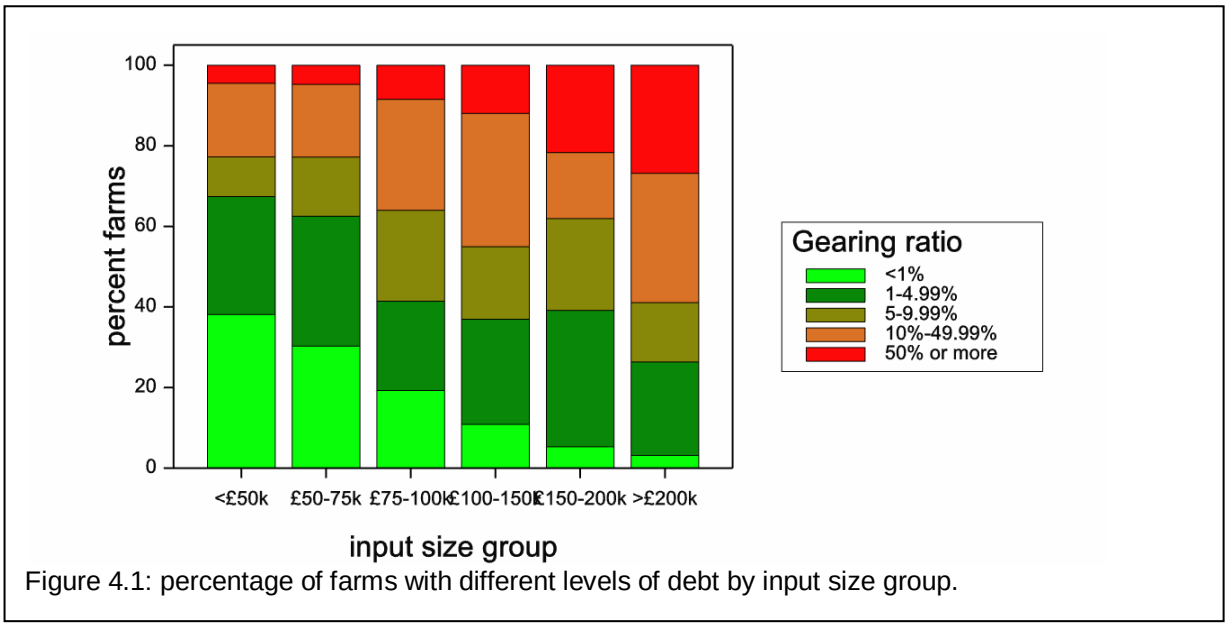


Figure 4.1: percentage of farms with different levels of debt by input size group.

indicate that smaller farms with extensive debt have failed to survive. Whatever the reason, this relative lack of debt will contribute significantly to the relatively good economic performance of small farms in Figure 3.2.

4.2. Farmer age

Farmers above 65 years of age are, on average, less economically efficient than younger ones, both for the farm business as a whole and for the agricultural cost centre.

Table 4.3 shows the effect of the farmers age on output levels separately for owner-occupied and tenanted farms since the effect of age differs between these two groups (Table 4.1a). For owner-occupied farms there is little sign of any trend amongst young and

middle-aged farmers, but economic efficiency seems to drop markedly at 65 years and older. By contrast the tenanted farms seem to reach peak efficiency when the farmer is 55-65 years old, with only a modest drop at age 75. This may indicate that older owner-occupied farmers have more scope to coast into semi-retirement, relying on their assets to survive as the business becomes less productive, whereas the challenges of paying the rent forces older tenant farmers to remain more efficient. The lower performance of younger tenant farmers may be due to lack of experience, but it might also be because some can only afford to rent small or unproductive farms at the start of their farming careers.

Table 4.3: Age of farmer. The table shows predicted outputs from the REML model for a farm with £75,000 of inputs per annum, 100ha of land and average values of the other variables in the model. Figures are for 2008. Standard errors are approximate.

a) Owner occupied farms

	Farm business output		Agricultural output	
Age	Estimated output (£000s)	Standard error	Estimated output (£000s)	Standard error
35 years	80	2.0	43	1.7
45	79	1.4	44	1.1
55	78	1.3	43	1.0
65	74	1.4	41	1.1
75	70	2.0	37	1.7

b) Tenanted farms

	Farm business output		Agricultural output	
Age	Estimated output (£000s)	Standard error	Estimated output (£000s)	Standard error
35 years	77	2.2	41	1.8
45	79	1.5	43	1.3
55	80	1.5	45	1.2
65	79	1.9	45	1.6
75	76	2.9	43	2.5

Note: family labour charged at the national minimum wage. Farm business output includes agricultural output, plus support payments (SPS etc.), agri-environment payments and diversified income.

4.3. Tenure

The impact of tenure type on economic performance appears complex with interactions with both age (see above) and farm economic size. These effects are apparent at both the level of the farm business and for the agricultural cost centre.

Table 4.4b shows the relationship between tenure and economic size. Economically small owner occupied and tenanted farms perform roughly equivalently, but at larger sizes the tenanted farms produce more outputs. A similar tendency can be seen in the model for farm business costs, but in this case the differences are smaller and not statistically significant. In interpreting these results it is important to remember that the costs used in the model do not include an imputed rent for owner-occupied farms, but do include the actual rent paid by tenanted farms. Thus, all things being equal, it would be expected that owner occupied farms should achieve a higher output for the same level of costs.

Table 4.4: Tenancy and farm economic size. The table shows predicted outputs from the REML model for a farm with different economic sizes (in terms of inputs per annum), and average values of the other variables in the model. Predictions are made at the average area for a farm of the appropriate economic size. Figures are for 2008. Standard errors are approximate.

a) Farm Business Output

	Owner occupied		Tenanted	
Economic size (input cost p.a.)	Estimated output (£000s)	Standard error	Estimated output (£000s)	Standard error
£50,000	51	0.9	52	1.0
£75,000	79	1.3	80	1.5
£100,000	106	1.8	109	2.0

b) Agricultural Output

	Owner occupied		Tenanted	
Economic size (input cost p.a.)	Estimated output (£000s)	Standard error	Estimated output (£000s)	Standard error
£50,000	26	0.7	26	0.8
£75,000	43	1.1	45	1.2
£100,000	62	1.6	66	1.9

Note: family labour charged at the national minimum wage. Farm business output includes agricultural output, plus support payments (SPS etc.), agri-environment payments and diversified income.

4.4. Land area

Land area has a substantial impact on efficiency at the farm business level, although care is needed in interpreting this, since land area is, unsurprisingly, correlated with the level of input costs. For the agricultural cost centre (i.e. excluding diversification, agri-environment schemes and support payments) there is little relationship between area and outputs, once differences in input costs are allowed for.

Since there is a significant interaction between area and costs for the farm business model, Table 4.5 displays results for different combinations of costs and area. There is a marked difference between results for the agricultural cost centre and for the farm business as a whole. For the business as a whole (Table 4.5a) outputs are, on average, much higher for a given level of inputs when the farm area is larger. There is also an interaction between area and year, with the relationship strengthening over time, presumably as a result of the move to area-based Single Farm Payments.

Table 4.5: Land area. The table shows predicted outputs from the REML model for a farm with different economic sizes (in terms of inputs per annum), and average values of the other variables in the model. Figures are for 2008. Standard errors are approximate.

a) Farm Business Output

	Adjusted land area					
	50ha		100ha		150ha	
Economic size (input cost p.a.)	output (£000s)	s.e.	output (£000s)	s.e.	output (£000s)	s.e.
£50,000	45	0.9	56	1.0	72	2.7
£75,000	67	1.5	79	1.1	99	2.6
£100,000	88	2.4	102	1.6	124	2.7

b) Agricultural Output

	Adjusted land area					
	50ha		100ha		150ha	
Economic size (input cost p.a.)	output (£000s)	s.e.	output (£000s)	s.e.	output (£000s)	s.e.
£50,000	26	0.7	26	0.7	26	0.8
£75,000	44	1.4	44	0.9	44	1.0
£100,000	63	2.4	63	1.5	64	1.4

Note: family labour charged at the national minimum wage. Farm business output includes agricultural output, plus support payments (SPS etc.), agri-environment payments and diversified income.

By contrast agricultural outputs show little relationship with farm area at a given level of inputs (Table 4.5b). This suggests that the land area of most grazing livestock farms is adequate for their current level of agricultural output.

4.5. Agricultural specialisation

Agricultural specialisation appears to be beneficial for lowland grazing livestock farms, but not for those in the LFA. The impacts are similar for both the entire farm business and for the agricultural cost centre.

The specialisation of each farm was assessed using a method based on the Standard Labour Requirement (SLR) from the different agricultural enterprises. This is similar to the approach used in Observatory report number 11[12]. Interestingly, there is a highly significant interaction with farm type (LFA or lowland), with specialisation appearing economically beneficial for lowland farms, but not for upland ones (Table 4.6). The reasons for this are not entirely clear, but it is likely to relate largely to specialisation within the categories of beef and sheep farming; it is noticeable that a significant minority of lowland farms keep only sheep or only beef, whereas the vast majority of uplands farms have a mixture of the two species.

[12] http://www.defra.gov.uk/statistics/files/defra-stats-foodfarm-environ-obs-research-specialisation-report-jul08.pdf

Table 4.6: Specialisation. The table shows predicted outputs from the REML model for a farm with £75,000 of inputs per annum, 100ha of land and average values of the other variables in the model. Figures are for 2008. Standard errors are approximate.

a) Farm Business Output

	LFA		Lowland	
Specialisation	Estimated output (£000s)	Standard error	Estimated output (£000s)	Standard error
0.2 (not specialised)	79	1.7	78	1.7
0.3 (moderate)	78	1.4	80	1.5
0.5 (highly specialised)	75	1.8	84	1.8

b) Agricultural Output

	LFA		Lowland	
Specialisation	Estimated output (£000s)	Standard error	Estimated output (£000s)	Standard error
0.2 (not specialised)	42	1.5	45	1.4
0.3 (moderate)	40	1.2	46	1.2
0.5 (highly specialised)	37	1.5	49	1.6

Note: family labour charged at the national minimum wage. Farm business output includes agricultural output, plus support payments (SPS etc.), agri-environment payments and diversified income.

Most of the farms considered in this report derive the vast majority of their agricultural income from beef and sheep farming, and so the results in Table 4.6 relate to specialisation within these categories. However, there are a minority of farms that have specialised on other types of grazing livestock, mainly horses but sometimes goats or deer. These farms tend to have significantly lower agricultural efficiencies (term Pbeefsheep in Table 4.1b). There is however no sign that their farm business output is lower than expected, so it is likely that this reduced agricultural performance is counteracted by income from 'added value' activities, such as equine diversification.

4.6. Diversification

Diversification outside the core agricultural activities has a positive impact on farm business efficiency. There are signs that it might have a negative impact for the agricultural cost centre, although the relationship is not statistically significant.

The previous section looked at specialisation within agriculture. A related issue is whether farms perform better if they concentrate on agriculture, or whether they are helped by diversification into other enterprises, such as tourism or renting out buildings. This is examined in Table 4.7 which measures the extent of diversification by looking at the proportion of business costs associated with diversified enterprises. There is a moderate increase in business output as the proportion of diversification increases. When only agricultural output is considered the diversification variable is no longer significant but, if it is forced into the model, the coefficient is slightly negative, suggesting that diversified enterprises do not improve agricultural performance and may even have a deleterious impact, as was the case with cereals farms.

Table 4.7: Proportion of input costs associated with diversified enterprises. The table shows predicted outputs from the REML model for a farm with £75,000 of inputs per annum, 100ha of land and average values of the other variables in the model. Figures are for 2008. Standard errors are approximate.

	Farm business output	
Diversified costs as % total costs	Estimated output (£000s)	Standard error
0% (no diversification)	79	1.2
2%	79	1.1
10%	80	1.2
20%	82	1.5

Note: family labour charged at the national minimum wage. Farm business output includes agricultural output, plus support payments (SPS etc.), agri-environment payments and diversified income.

4.7. Farm Assurance

Farm assurance schemes have a positive impact on performance for both the farm business and for the agricultural cost centre.

Data on membership of farm assurance schemes has been collected in the FBS since 2005 and has a highly significant impact on outputs (Table 4.8). On average, scheme members produce £6,000 more output for a farm with inputs of £75,000, for both the agricultural cost centre and the business as a whole. Around 80% of farms belong to such schemes and there is little change in membership from one year to the next, increasing the risk of confounding between scheme membership and other features of the farms. Non-members are more common amongst older farmers and economically smaller farms (the latter may be due to the membership costs and other overheads of membership). Despite this reservation, the strength of the result suggests that there are genuine benefits from membership, for example in terms of access to high value markets for finished livestock.

Table 4.8: Farm assurance status. The table shows predicted outputs from the REML model for a farm with £75,000 of inputs per annum, 100ha of land and average values of the other variables in the model. Figures are for 2008. Standard errors are approximate.

	Farm business output		Agricultural output	
Farm Assurance status	Estimated output (£000s)	Standard error	Estimated output (£000s)	Standard error
Non-member	74	1.7	39	1.4
Member	80	1.2	45	1.0

Note: family labour charged at the national minimum wage. Farm business output includes agricultural output, plus support payments (SPS etc.), agri-environment payments and diversified income.

4.8. Unpaid family labour

Unpaid family labour has a strong positive impact on efficiency for the agricultural cost centre (i.e. excluding diversification, agri-environment schemes and support payments), but has no significant relationship with farm business performance.

Table 4.9 shows the effect of unpaid labour on agricultural outputs. Those farms with high amounts of unpaid labour (usually from the farmer and family members) perform much better than those relying solely on paid labour. One possible explanation for this result is that the costs of obtaining skilled paid labour exceed the minimum wage figure included in the model. However, the relationship remains significant when the 'unpaid' labour is costed at market rates, suggesting that the family labour is more productive than the

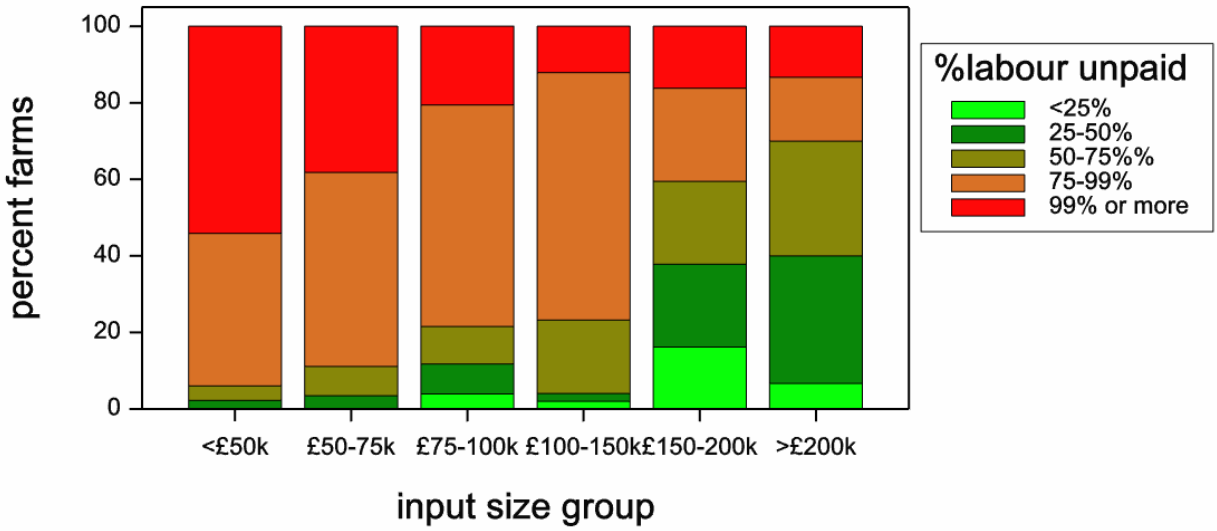


Figure 4.2: percentage of farms with different proportions of unpaid family labour.

equivalent quantity of paid labour. This may reflect the high skill level within many farming families, or may be the result of a greater dedication to the business in those farms using mainly family labour.

There is no significant relationship between farm business output and family labour, which is perhaps surprising given the large contribution of agricultural output to total farm business output. This may indicate that those farms relying on paid labour are better at maximising income from sources such as diversification and agri-environment schemes.

Table 4.9: Paid and unpaid labour. The table shows predicted outputs from the REML model for a farm with £75,000 of inputs per annum, 100ha of land and average values of the other variables in the model. Figures are for 2008. Standard errors are approximate.

	Agricultural output	
Labour type	Estimated output (£000s)	Standard error
Paid only	34	2.2
50% paid, 50% family	40	1.3
Family labour only	46	1.0

Note: family labour charged at the national minimum wage.

Like indebtedness, the proportion of unpaid labour is strongly correlated with farm size and this is illustrated in Figure 4.2. This suggests that the availability of cheap, experienced family labour is important in maintaining the relatively good average economic efficiency figures observed for smaller farms.

4.9. Contract work

The use of contractors has a positive impact on efficiency for the agricultural cost centre , but has no significant relationship with farm business performance.

Table 4.10 shows the relationship between efficiency and the use of contractors for field operations (e.g. hay and silage making). Note that contracting of livestock husbandry (shearing, scanning, etc) is recorded elsewhere on the FBS form and does not contribute to these figures). Increased levels of contracting are associated with greater efficiency in the agricultural cost centre, although there is no significant impact when the farm business as a whole is considered (F=1.88 with 1 and 525 d.f., P=0.170).

Table 4.10: Contract work (percentage of all contracting and machinery costs relating to contract work). The table shows predicted outputs from the REML model for a farm with £75,000 of inputs per annum, 100ha of land and average values of the other variables in the model. Figures are for 2008. Standard errors are approximate.

	Agricultural output	
% contract	Estimated output (£000s)	Standard error
None	41	1.1
20%	43	0.8
40%	45	1.4

Note: family labour charged at the national minimum wage.

4.10. Livestock type

Livestock type has a significant impact on performance at both the farm business and agricultural cost centre level, but the effect varies between years. Those farms which finish lambs and cattle tend to perform better.

Livestock revenue data was used to examine the ratio of sheep sales to cattle sales, and also to see the proportion of sales relating to fat stock. The relative performance of sheep and cattle varies from year to year for both agriculture and for the farm business as a whole

Table 4.11: Proportion of revenue from sheep. The table shows predicted outputs from the REML model for a farm with £75,000 of inputs per annum, 100ha of land and average values of the other variables in the model. Standard errors are approximate. For simplicity, predictions are only shown at the extreme values (i.e. all cattle or all sheep)

a) Farm business output

	All revenue from cattle		All revenue from sheep	
Year	Estimated output (£000s)	Standard error	Estimated output (£000s)	Standard error
2003	78	2.0	74	2.1
2004	72	1.7	77	2.1
2005	69	1.6	76	2.0
2006	71	1.6	70	1.8
2007	72	1.6	69	1.7
2008	79	1.8	79	2.0
2009	81	2.0	89	2.4

b) Agricultural output

	All revenue from cattle		All revenue from sheep	
Year	Estimated output (£000s)	Standard error	Estimated output (£000s)	Standard error
2003	40	1.7	44	2.0
2004	35	1.4	43	1.8
2005	33	1.2	42	1.7
2006	35	1.3	36	1.4
2007	35	1.2	36	1.4
2008	44	1.6	44	1.8
2009	43	1.7	53	2.2

Note: family labour charged at the national minimum wage. Farm business output includes agricultural output, plus support payments (SPS etc.), agri-environment payments and diversified income.

(Table 4.11). Particularly for agricultural outputs, these results reflect changes in prices in different years, with sheep prices generally poor relative to cattle prices in the period 2006-2008[13].

The benefits of finishing cattle on the farm also vary from year to year, with those farms obtaining a high proportion of their revenue from fat cattle doing particularly well in 2007 and 2008. The equivalent variable for sheep did not show significant interaction with years, but did vary appreciably between LFA and lowland farms, with LFA farms showing markedly better performance where they finished animals themselves. This result should be interpreted with care since the analysis may merely be identifying the farms with better land that are capable of finishing lambs; it does not necessarily follow that the performance of the other farms would improve if they produced fat lambs. In terms of agricultural output, lowland farms also perform better when they finish lambs, but for the farm business as a whole there is no significant trend.

Table 4.12: Proportion of sheep revenue from fat lambs. The table shows predicted outputs from the REML model for a farm with £75,000 of inputs per annum, 100ha of land and average values of the other variables in the model. Standard errors are approximate. LFA farms are assumed to be totally within the LFA area, lowland farms totally outside it.

a) Farm business output

	LFA		Lowland	
revenue from fat lambs/hoggets	Estimated output (£000s)	Standard error	Estimated output (£000s)	Standard error
none	73	2.0	83	2.4
50%	77	1.4	81	1.5
90%	81	1.9	79	1.8

b) Agricultural output

	LFA		Lowland	
revenue from fat lambs/hoggets	Estimated output (£000s)	Standard error	Estimated output (£000s)	Standard error
none	33	1.4	44	1.8
50%	39	1.1	47	1.2
90%	44	1.7	49	1.6

Note: family labour charged at the national minimum wage. Farm business output includes agricultural output, plus support payments (SPS etc.), agri-environment payments and diversified income.

4.11. Organic farming

Organic farms tend to perform better than conventional ones at the farm business level, but are less economically efficient for the agricultural cost centre, although the magnitude of these effects varies from year to year.

Organic production appears to have an impact, but the effect varies significantly from year to year (Table 4.13). Until 2006, when extra organic farms were deliberately selected for inclusion, the number of organic farms in the FBS was extremely low, so estimates for 2003-2005 should be treated with extreme caution. Looking at the later years for the agricultural cost centre, organic farms performed slightly better than conventional ones in 2006 and 2007 as a result of a significant price premium. However, in 2008 and 2009 the

[13] See http://www.defra.gov.uk/statistics/foodfarm/farmgate/commodity/ following the link to livestock prices near the bottom of the page.

price premium was considerably reduced, with the result that conventional farms showed higher performance than organic ones. By contrast, when the business as a whole is considered, organic farms always perform better in years with adequate data, although the differential is highest in 2006 and 2007. This improved performance will be largely due to grants (including those for in-conversion land) and agri-environment payments. Other added value activities, such as direct sales of organic meat, will also improve the financial position of some organic farms, although only 8% of organic farms in the sample sell produce direct to the public (compared to 4% of the conventional farms).

Table 4.13: Organic status. The table shows predicted outputs from the REML model for a farm with £75,000 of inputs per annum, 100ha of land and average values of the other variables in the model. Standard errors are approximate. Organic status is modelled as the proportion of the UAA farmed organically (including in conversion), but the vast majority of farms are either fully conventional or fully organic and so predictions are shown for these values. Figures in small italic font are based on a very small sample size.

a) Farm business output

	Conventional		Organic	
Year	Estimated output (£000s)	Standard error	Estimated output (£000s)	Standard error
2003	76	1.3	*76*	*4.1*
2004	74	1.2	*77*	*3.8*
2005	73	1.1	*67*	*3.2*
2006	70	1.0	75	2.6
2007	70	1.0	79	2.6
2008	79	1.2	81	2.6
2009	85	1.3	87	2.8

b) Agricultural output

	Conventional		Organic	
Year	Estimated output (£000s)	Standard error	Estimated output (£000s)	Standard error
2003	42	1.1	*41*	*4.0*
2004	38	0.9	*38*	*3.4*
2005	37	0.8	*30*	*2.6*
2006	35	0.8	36	2.2
2007	35	0.7	37	2.1
2008	44	1.0	41	2.2
2009	48	1.1	45	2.5

Note: family labour charged at the national minimum wage. Farm business output includes agricultural output, plus support payments (SPS etc.), agri-environment payments and diversified income.

4.12. Returns to scale

At the farm business level there is no strong relationship between size and efficiency. For the agricultural cost centre larger farms are, on average, significantly more efficient.

Figure 4.3 shows the relationship between output value and input costs before and after allowing for the explanatory variables described in the previous paragraphs. Family labour is costed at the minimum wage rate. The green lines are the best fitting lines from a model

with terms for costs and year; they are averages of the green and red lines in Figure 3.2c and d. The blue lines are after fitting the model described in Tables 3.1 and 3.2. They represent the expected relationship between economic efficiency and inputs, assuming that

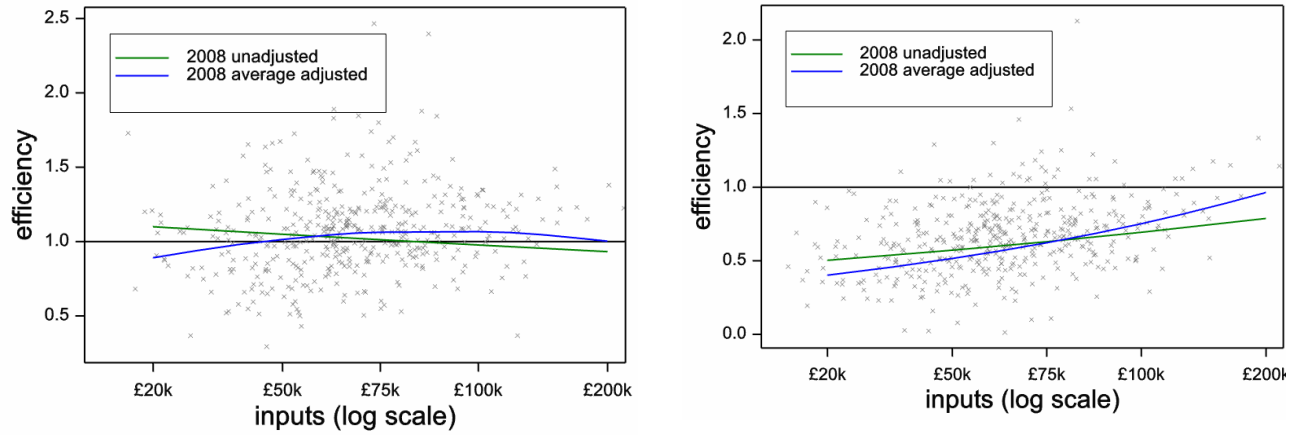


Figure 4.3: the relationship between efficiency and input costs for the whole farm business (left) and agriculture only for 2008. The green line is the best fitting line before adjustment, whilst the blue line is after adjusting for the factors listed in Table 4.1 and 4.2. Imputed costs for family labour are included at the minimum wage rate. Lines are averages across lowland and LFA farms.

all farms had the same levels of debt, unpaid labour, etc.

Looking first at the left hand graph for the entire business, smaller businesses are slightly more efficient before any adjustment, but after adjustment there do appear to be slightly increasing returns to scale, with maximum efficiency being reached for farms of around £100,000 of input costs per year. The right hand graph for agriculture only is more clear-cut; there are increasing returns to scale which are more pronounced after allowing for confounding factors such as debt.

5. Results: relationship between economic efficiency and environmental factors

5.1. Agri-environment scheme membership

Agri-environment schemes have a statistically significant positive effect on economic efficiency at the farm business level. For the agricultural cost centre, the more demanding schemes have a negative impact on agricultural performance.

In the report on cereals farms scheme payments on each farm were converted to a simple £ per ha figure over the five year period. Fortunately, the longer time series and bigger sample size in the current study permit the different agri-environment schemes to be explicitly fitted in the main model. A categorical variable was created representing the type of scheme which each farm belonged to in each year; where a farm received payments from more than one scheme in a year, the highest value scheme was used. This variable was highly significant for both agricultural output and farm business output (Table 4.1), and predictions of output for the different schemes are given in Table 5.1. Payments under the Hill Farming Allowance scheme are not included in this section both because it is not primarily an environmental scheme, and because its impact will be largely confounded with the terms for farm type (LFA or lowland) and LFA status.

Table 5.1: Agri-environment status. The table shows predicted outputs from the REML model for a farm with £75,000 of inputs per annum, 100ha of land and average values of the other variables in the model. Figures are for 2008. Standard errors are approximate.

	Farm business output		Agricultural output	
Agri-environment scheme	Estimated output (£000s)	Standard error	Estimated output (£000s)	Standard error
None	76	1.2	46	1.1
ELS	77	1.2	46	1.1
Classic (CSS/ESA)	80	1.3	44	1.1
HLS	83	1.8	40	1.5

Note: family labour charged at the national minimum wage.

Looking first at the agricultural cost centre, it can be seen that ELS membership has no sizeable impact on output[14]; this is not unexpected, given that most of the scheme's options are relatively undemanding, with many relating to boundary habitats, rather than the productive agricultural area. The classic schemes reduce agricultural output by just over £2,000 for an average-sized farm relative to one not in any scheme, whereas the more demanding HLS prescriptions lead to a reduction of almost £6,000.

The pattern for farm business output is very much a mirror image of that for agricultural output. Membership of ELS appears to give a small increase in output, although this is within the limits of statistical uncertainty. Classic schemes give a statistically significant increase of just over £4,000 for the average farm, whilst HLS gives a output increase of just over £7,000 relative to a farm outside any of the schemes.

5.2. Agri-environment expenditure – 2008 Countryside Management Module

More information on farm expenditure relating to agri-environment activities can be obtained from the FBS 2008-09 Countryside Maintenance and Management module[15]. This asked for information on costs of agri-environment measures in 27 categories,

[14] There is a small reduction which is hidden by the rounding and is small relative to the statistical uncertainty.

[15] http://www.defra.gov.uk/statistics/foodfarm/farmmanage/fbs/envcountryman/

including both activities funded by schemes and those undertaken without payment. A subset of the full FBS panel were asked to complete the module, with data collected from 359 of the 545 farms considered here.

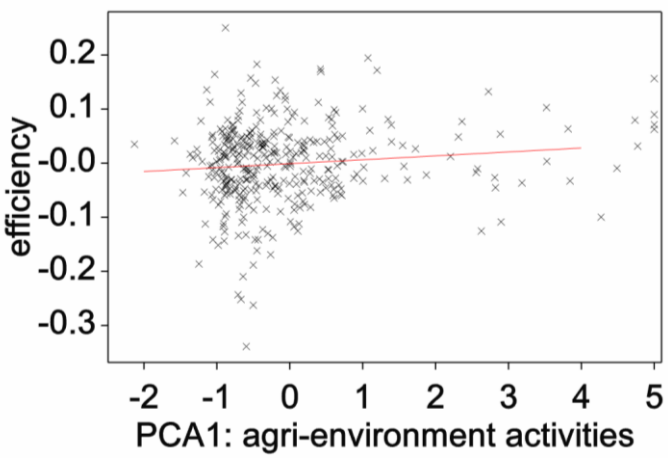


Figure 5.1: efficiencies (after allowing for debt and other factors, but not agri-environment scheme) plotted against the first PCA axis, which represents total agri-environment activities (excluding hedgerows).

Principal Components Analysis was applied to the total level of activity in the different categories (measured either as total areas or total lengths) in order to provide new summary variables that could be linked to efficiency. Figure 5.1 shows farm business efficiencies plotted against the first PCA variable, which represents the total agri-environment activities on each farm (excluding hedgerow activities). There is a significant upward trend, which is partially driven by a number of poorly performing farms with efficiencies below -0.15 with few agri-environment activities.

Average efficiency is also dependent on whether the activity is funded under an agri-environment scheme. Those farms carrying out activities without receiving payments have lower average efficiencies than those where the activities are largely funded under an agri-environment scheme (Table 5.2). This indicates the importance of such schemes in ensuring that farmers can support the environment whilst remaining competitive.

Table 5.2: mean farm business efficiencies (REML farm effects, after allowing for debt and other factors, but not agri-environment scheme) tabulated by funding of agri-environment activity.

Funding of activities	No. of farms	Mean efficiency	s.e.
Not funded by scheme	252	-0.002	0.0048
Partially funded	36	0.005	0.0118
Funded by agri-environment scheme	141	0.011	0.0059

Notes: 'not funded' includes farms where less than 10% of the costs of activities were funded by schemes, whilst 'funded' includes those where at least 90% of the costs were funded.

5.3. Energy Usage Module

There is no significant relationship between economic efficiency and data from the Energy Usage Module, either for the whole farm business or for the agricultural cost centre. However, the lack of a relationship may be due to the limitations of the data.

Energy usage data was collected in 2007 for around 75 of the cereals farms in the study. Much of this data relates to CO_2 emissions from machinery usage and has been analysed in a separate study by Cranfield University[16].

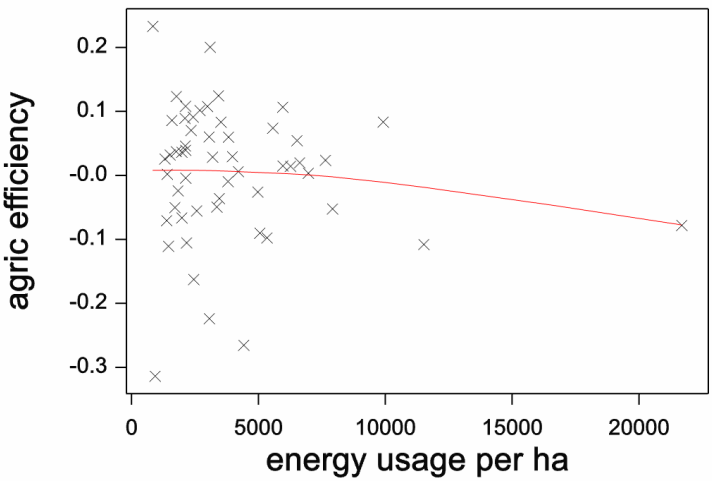


Figure 5.2: efficiency of farms based on agricultural costs and output (after allowing for debt and other factors) plotted against total direct energy usage for agriculture in Mj per hectare. The fitted curve is not statistically significant.

[16] http://www.defra.gov.uk/statistics/foodfarm/farmm

Unfortunately, interpretation of this data is hindered by considerations such as the use of contractors and whether winter feed is grown on the holding or bought in. Perhaps because of these uncertainties, there is little sign of a relationship between agricultural efficiency and overall energy usage (Figure 5.2).

In addition to fuel usage, the energy module collected information on other issues related to energy usage, including fertiliser usage and woodland management.

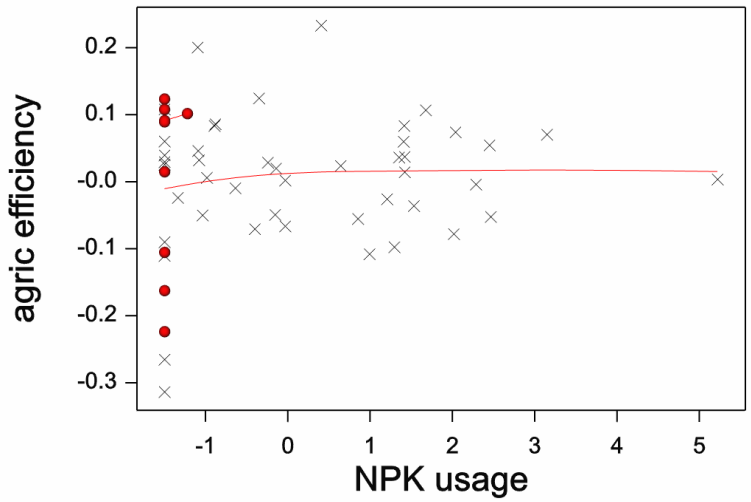


Figure 5.3: efficiency of farms based on agricultural costs and output (after allowing for debt and other factors) plotted against fertiliser usage per hectare (based on the first principal component which has positive scores for all fertiliser types). Red circles are organic farms (at least 50% of area organic), crosses are non-organic.

Figure 5.3 shows the relationship between economic efficiency and fertiliser usage per hectare. The measure of fertiliser usage is based on the first axis of a principal components analysis of rates of N, P and K per hectare. There is no significant relationship between the two variables, although there is an interesting tail of less efficient farms which have no fertiliser usage. Not all of these farms are registered organic and, indeed, the two least efficient ones are conventional, although one of them received substantial payments under the Environmental Sensitive Area Scheme.

In the case of woodland management, data is only available for 16 farms that reported woodland. The mean efficiency is somewhat higher for those who actively manage their woodlands (mean agricultural efficiency 0.058, s.e. 0.029 for those that manage, 0.006 s.e. 0.024 for those that do not), but the sample size is too small to draw any firm conclusions from this.

6. Results: Business management module[17]

As with the agri-environment module, data on business management is only available for a subset of farms and so analysis involves relating the data to the farm-level estimates of efficiency, rather than directly including the business management data in the model. This process was carried out using the farm-level efficiencies both before and after fitting the explanatory variables described in Tables 4.1 and 4.2. Interestingly, the strongest relationships were with efficiencies before allowing for the explanatory variables, whereas after allowing for them the relationships were little stronger than would be expected by chance. This suggests that the business management characteristics examined are associated with the explanatory variables, for example because older farmers are less likely to display these skills.

The module consisted of a series of blocks of questions, with each block relating to a different area of business management expertise. The questions all had a simple yes/no response, with a 'yes' response indicating that the particular skill or practice (see Section 10 for a full list) was used in the farm business (except for the first question in each block which is phrased as a negative). In the sections below, each skill area is discussed in turn. The main emphasis is on tabulation by the responses to the questions, but a Principal Components Analysis has also been used on each group of questions and results from this are presented where they aid interpretation.

6.1. Management accounting

Relationships between these questions and economic efficiency seem to be much stronger for the business as a whole than for the agricultural cost centre (Table 6.1).

Table 6.1: mean efficiencies (REML farm effects, before allowing for explanatory variables) tabulated by questions on use of management accounting. Note that the first question is expressed the other way around, so that a positive response indicates that practices are not adopted.

	Whole Farm Business			Agriculture cost centre		
	no	yes	sig	no	yes	sig
Management accounting not applicable	0.008	-0.042	***	0.005	0.001	NS
Uses gross margins prepared for enterprises on the business	-0.008	0.016	10%	-0.006	0.031	*
Uses cash flows prepared for the business	-0.002	0.004	NS	0.009	-0.020	NS
Reviews the profit and loss account in depth	-0.014	0.006	10%	0.005	0.004	NS
Prepares partial budgets to inform business decisions	-0.008	0.019	*	0.003	0.009	NS
Prepares a budget for the year	-0.001	0.000	NS	0.010	-0.025	10%
Frequently benchmarks and compares business performance with others	-0.010	0.022	**	-0.002	0.019	NS
Regularly attends discussion groups or meetings on business management issues	-0.004	0.010	NS	0.002	0.013	NS
Regularly attends discussion groups or meetings on other issues , eg farm walks/meeetings on cross compliance, new regulations, environmental matters.	-0.009	0.011	10%	0.002	0.009	NS

Note: 'sig' refers to the statistical significance: *** very highly significant (P<0.001), ** highly significant (P<0.01), * significant (P<0.05), 10% almost significant (P<0.1), NS not significant (P>0.1).

[17] See http://www.defra.gov.uk/statistics/foodfarm/farmmanage/fbs/publications/farmmanagepractice/ for more information on this module.

For the agricultural cost centre, higher performing farms tend to use gross margin figures prepared for the different enterprises but otherwise there are no significant differences. By contrast, for the business as a whole, 3 of the 9 questions are statistically significant and another 3 are close to significance. Looking at the significant results in turn, those farms which report that management accounting was not applicable, had much lower average farm business efficiencies. Those preparing partial budgets and those using benchmarking had significantly higher farm business performance.

6.2. Management practices skills gaps

There are no significant associations between these questions and economic performance, either at the farm business level or for the agricultural cost centre.

6.3. IT skills

Information technology (IT) skills are associated with high performing farm businesses, but there are no significant associations with efficiency of the agricultural cost centre (Table 6.2).

Looking at the farm business as a whole, those who do not use a PC on the farm have significantly lower economic efficiency than those that do. Those with broadband access have higher efficiencies, whilst the highest mean efficiency figure is for those using the internet for submitting forms; this may be because of the time saving from electronic submission, but it is more likely that this question is indicative of a good level of computer competence, which then helps many aspects of the farm's performance.

Table 6.2: mean efficiencies (REML farm effects, before allowing for explanatory variables) tabulated by questions on use of IT. Note that the first question is expressed the other way around, so that a positive response indicates that computers are <u>not</u> used.

	Whole Farm Business			Agriculture cost centre		
	no	yes	sig	no	yes	sig
There is no PC used on the farm	0.005	-0.026	*	0.002	0.014	NS
There is a PC used on the farm but not used by the business	0.003	-0.022	10%	0.007	-0.007	NS
There is a PC used on the farm which is used occasionally for some management purposes.	-0.006	0.012	NS	-0.002	0.021	NS
The business has a computer that has broadband internet access	-0.013	0.013	*	0.009	-0.001	NS
The [farm team] is proficient in Excel/Word/E-mail and web-searching	-0.007	0.007	NS	0.012	-0.006	NS
Uses the internet to purchase and/or sell material for the farm	-0.005	0.018	NS	0.006	-0.001	NS
Uses the internet to improve the performance of the farm e.g. benchmarking	*0.000*	*-0.012*	*NS*	*0.005*	*-0.010*	*NS*
The main farm business documents (Business Plan/Finance Accounts etc) are all managed on the computer	-0.001	-0.003	NS	0.013	-0.017	10%
Internet used for submitting forms e.g. CTS/BCMS documents, VAT returns, PAYE forms	-0.016	0.023	***	0.004	0.006	NS
Only uses the computer to submit the SP5	*-0.001*	*0.027*	*NS*	*0.004*	*0.032*	*NS*
Regularly communicates with other farms using the computer	-0.002	0.010	NS	0.006	-0.013	NS

Note: 'sig' refers to the statistical significance: *** very highly significant (P<0.001), ** highly significant (P<0.01), * significant (P<0.05), 10% almost significant (P<0.1), NS not significant (P>0.1).
Italics indicate that less than 30 farms gave a positive response.

6.4. Technical advice

There are signs that technical advice has an impact on both farm business performance and performance for the agricultural cost centre, although the relationships are not particularly strong.

Those farmers obtaining technical advice through events and demonstrations show higher mean efficiencies, for both the farm business and for the agricultural cost centre, than those not using this form of advice. For the farm business there is also a significant difference between those obtaining 'free' technical advice from suppliers and those not doing so. Perhaps surprisingly, since this type of advice might be expected to be most relevant to the agricultural side of the business, the difference is not significant for the agricultural cost centre.

Table 6.3: mean efficiencies (REML farm effects, before allowing for explanatory variables) tabulated by questions on use of technical advice. Note that the first question is expressed the other way around, so that a positive response indicates that practices are not adopted.

	Whole Farm Business			Agriculture cost centre		
	no	yes	sig	no	yes	sig
No technical advice identified	*0.000*	*-0.014*	*NS*	*0.007*	*-0.046*	*NS*
Through talking to other farmers	0.002	-0.002	NS	-0.007	0.010	NS
Through the farming media	0.010	-0.003	NS	-0.013	0.010	NS
Through events and demonstrations	-0.014	0.011	*	-0.014	0.022	*
Through discussion groups, farm walks or workshops	-0.007	0.008	NS	0.002	0.010	NS
Through technical advice supplied with no direct charge (e.g. from input supplier)	-0.016	0.008	*	-0.001	0.009	NS
Through technical advice supplied for a charge	-0.003	0.024	NS	0.004	0.018	NS

Note: 'sig' refers to the statistical significance: *** very highly significant (P<0.001), ** highly significant (P<0.01), * significant (P<0.05), 10% almost significant (P<0.1), NS not significant (P>0.1).
Italics indicate that less than 30 farms gave a positive response.

6.5. Uptake of business managament advice

There are no significant associations between these questions and economic performance, either at the farm business level or for the agricultural cost centre.

6.6. Business planning

There is some association between business planning and successful farms, with the strongest relationship being, as might be expected, at the farm business level.

Those farms without any formal or informal business plan have significantly lower efficiencies than those without them. This difference is more marked at the farm business level, but is also significant for the agricultural cost centre. There is also a very highly significant relationship between those with confidence for the future and efficiency, but this is of less interest since these farmers are presumably more confident because their businesses are performing well.

Unfortunately numbers responding positively for the final three questions are too small to provide precise estimates, making it difficult to assess the impact of these options.

Table 6.4: mean efficiencies (REML farm effects, before allowing for explanatory variables) tabulated by questions on business planning. Note that the first question is expressed the other way around, so that a positive response indicates that practices are not adopted.

	Whole Farm Business			Agriculture cost centre		
	no	yes	sig	no	yes	sig
No formal or informal business plan	0.020	-0.035	***	0.017	-0.015	*
Has sufficient confidence for the future but no formal business plan is produced.	-0.017	0.028	***	-0.013	0.038	***
The [farm team] meet at least once a year to discuss the direction of the farm but does not record plans formally.	-0.004	0.007	NS	0.001	0.016	NS
Measures farm's performance by the profit/loss made at the end of the year	-0.009	0.011	10%	0.003	0.007	NS
Business plan produced in response to a request from a third party e.g.bank. No other use is made of it.	*-0.001*	*-0.008*	*NS*	*0.004*	*0.005*	*NS*
Business plan is shared with the [farm team], reviewed and updated annually.	*-0.001*	*0.005*	*NS*	*0.007*	*-0.054*	*10%*
Business plan is shared with the [farm team], updated annually and reviewed regularly during the year	*-0.002*	*0.022*	*NS*	*0.004*	*0.021*	*NS*

Note: 'sig' refers to the statistical significance: *** very highly significant (P<0.001), ** highly significant (P<0.01), * significant (P<0.05), 10% almost significant (P<0.1), NS not significant (P>0.1).
Italics indicate that less than 30 farms gave a positive response.

6.7. How the business plans ahead

There are a few significant, or nearly significant, associations between these questions and economic performance at the farm business level, and a single significant relationship for the agricultural cost centre.

Table 6.5: mean efficiencies (REML farm effects, before allowing for explanatory variables) tabulated by questions on how the business plans ahead. Note that the first question is expressed the other way around, so that a positive response indicates that practices are not adopted.

	Whole Farm Business			Agriculture cost centre		
	no	yes	sig	no	yes	sig
Not applicable	0.002	-0.036	10%	0.007	-0.021	NS
On basis of information picked up in farming media	-0.009	0.008	NS	-0.004	0.014	NS
On basis of information picked up by talking to other farmers	-0.007	0.005	NS	-0.006	0.016	NS
On basis of discussion within farm household	-0.018	0.006	10%	-0.006	0.009	NS
On basis of feedback/discussions with FBS research officer	-0.007	0.017	10%	-0.004	0.029	*
On basis of business management exercises carried out within the farm	-0.007	0.026	*	0.004	0.006	NS
On basis of discussions with customers	-0.005	0.016	NS	0.007	-0.007	NS
On basis of purchased business consultancy, (not including routine discussions with the accountant)	*-0.002*	*0.010*	*NS*	*0.007*	*-0.024*	*NS*
On basis of routine discussions with the accountant	-0.008	0.014	10%	0.007	-0.002	NS

Note: 'sig' refers to the statistical significance: *** very highly significant (P<0.001), ** highly significant (P<0.01), * significant (P<0.05), 10% almost significant (P<0.1), NS not significant (P>0.1).
Italics indicate that less than 30 farms gave a positive response.

For the agricultural cost centre, those farmers highlighting discussions with the FBS research officers have higher economic performance. This relationship is also close to significance for the farm business as a whole. Farms using business management

exercises have significantly higher farm business performance, but there is no sign of a similar relationship for the agricultural side of the business.

6.8. Setting targets for business and environmental improvement

For this section there are some significant relationships with economic efficiency at the farm business level, but none for the agricultural cost centre on its own.

Those farm businesses with targets identified perform significantly better than those without them. There is also a highly significant association between business-level performance and those farms saying that they put into practice actions to bring about environmental improvement. Unfortunately numbers responding positively are low for some questions, making it difficult to draw conclusions about the effectiveness of these options.

Table 6.6: mean efficiencies (REML farm effects, before allowing for explanatory variables) tabulated by questions on targets for business and environmental improvements. Note that the first question is expressed the other way around, so that a positive response indicates that practices are not adopted.

	Whole Farm Business			Agriculture cost centre		
	no	yes	sig	no	yes	sig
None identified	0.011	-0.015	*	0.003	0.007	NS
The business has forecast budgets prepared and reviews these at least every six months	*-0.001*	*0.005*	*NS*	*0.003*	*0.045*	*NS*
The business has forecast budgets prepared and reviews these at least annually	*-0.002*	*0.012*	*NS*	*0.006*	*-0.021*	*NS*
The business keeps environmental records to monitor the environmental impact of what it is doing and reviews these at least every six months	*-0.001*	*-0.015*	*NS*	*0.004*	*0.009*	*NS*
The business keeps environmental records to monitor the environmental impact of what it is doing and reviews these at least annually	-0.004	0.010	NS	0.008	-0.011	NS
The business puts into practice the action it needs to take to bring about environmental improvements	-0.014	0.015	**	0.008	0.000	NS

Note: 'sig' refers to the statistical significance: *** very highly significant (P<0.001), ** highly significant (P<0.01), * significant (P<0.05), 10% almost significant (P<0.1), NS not significant (P>0.1).
Italics indicate that less than 30 farms gave a positive response.

6.9. Customer relations

There are some statistically significant relationships between farm business performance and customer relations questions. For the agricultural cost centre there is only one result that is nominally significant, but this is based on a fairly small number of positive responses and the direction of the relationship suggests that it may be a chance result.

At the farm business level, those farms that receive regular feedback from customers tend to have improved performance. Those that are looking beyond their immediate customers and studying the wider market, show an even higher average level of performance at the business level. Even stronger associations come out of the Principal Components Analysis for these questions, with a very highly significant difference in performance between those businesses showing a high level of interaction with customers and those either having no discussions or purely transactional discussions.

Table 6.7: mean efficiencies (REML farm effects, before allowing for explanatory variables) tabulated by questions on customer relations. Note that the first question is expressed the other way around, so that a positive response indicates that practices are not adopted.

	Whole Farm Business			Agriculture cost centre		
	no	yes	sig	no	yes	sig
No discussions with customers	0.003	-0.013	NS	0.005	0.004	NS
Dealings with customers are mostly concerned with transactions	0.010	-0.010	10%	0.007	0.002	NS
Has a planning meeting with customers once a year	*-0.002*	*0.068*	*NS*	*0.004*	*0.013*	*NS*
Customers provide regular feedback on the quality of products/services	-0.009	0.016	*	0.000	0.015	NS
Has a collaborative approach with customers, aimed at improving mutual business	-0.002	0.007	NS	0.008	-0.025	NS
Proactive in dealing with customers, and fully understands why they buy the farm business's products	-0.003	0.012	NS	0.007	-0.016	NS
Uses customer testimony to actively promote farm business	*0.000*	*-0.017*	*NS*	*0.009*	*-0.055*	*
Looks beyond immediate customers and studies the consumers/market for business's product/services	-0.007	0.033	*	0.005	0.002	NS

Note: 'sig' refers to the statistical significance: *** very highly significant (P<0.001), ** highly significant (P<0.01), * significant (P<0.05), 10% almost significant (P<0.1), NS not significant (P>0.1).
Italics indicate that less than 30 farms gave a positive response.

6.10. Application of skills in marketing

There are no significant associations between these questions and economic performance, at the farm business level. For the agricultural cost centre there are some significant associations, but these are counter-intuitive and need interpreting with care.

Looking at Table 6.8 it can be seen that four of the five questions show statistically significant differences for the agricultural centre but, in each of these cases, the results suggest that farms applying marketing skills have reduced economic performance for the agricultural cost centre. In practice the scope for applying marketing skills in a traditional livestock farm is often limited, particularly where most income comes from selling stock at markets. As a result, many of those businesses responding positively are those carrying out diversification and added-value activities (e.g. farm shops). It is possible that some of these businesses may be concentrating on these activities to the exclusion of efficient management on the core agricultural activities, as seemed to happen on some cereals farms. Alternatively, it may just be that those with struggling agricultural enterprises are forced to market the diversified enterprises in order to survive, and this would also explain why similar (but non-significant) trends are observed for some questions at the farm business level.

Table 6.8: mean efficiencies (REML farm effects, before allowing for explanatory variables) tabulated by questions on marketing. Note that the first question is expressed the other way around, so that a positive response indicates that practices are not adopted.

	Whole Farm Business			Agriculture cost centre		
	no	yes	sig	no	yes	sig
Not applicable	-0.006	0.001	NS	-0.020	0.016	*
Regularly undertakes market research for the agricultural commodities the business produces	0.002	-0.016	NS	0.008	-0.006	NS
Regularly undertakes market research for the non-agricultural activities the business is engaged in (eg tourism enterprise)	*-0.001*	*-0.001*	*NS*	*0.009*	*-0.057*	*
Regularly engaged in promoting and/or selling the agricultural commodities the business produces	-0.001	-0.001	NS	0.013	-0.039	*
Regularly engaged in promoting and/or selling the non-agricultural activities the business is engaged in	*0.000*	*-0.016*	*NS*	*0.013*	*-0.092*	***

Note: 'sig' refers to the statistical significance: *** very highly significant (P<0.001), ** highly significant (P<0.01), * significant (P<0.05), 10% almost significant (P<0.1), NS not significant (P>0.1).
Italics indicate that less than 30 farms gave a positive response.

6.11. Application of risk management

Risk management strategies are associated with improved performance, particularly at the farm business level.

Those farms having risk management strategies in place have higher mean efficiencies at the business level than those without. The same trend is apparent at the agricultural cost centre, but is not statistically significant, possibly reflecting the fact that such strategies are generally of less use to grazing livestock farmers than they are to other sectors. Farms purchasing inputs on a contract basis perform significantly better for both the farm business and for the agricultural cost centre. Having a range of enterprises is associated with stronger performance for the farm business, but there is no sign of a difference for the agricultural cost centre.

Table 6.9: mean efficiencies (REML farm effects, before allowing for explanatory variables) tabulated by questions on risk management. Note that the first question is expressed the other way around, so that a positive response indicates that practices are not adopted.

	Whole Farm Business			Agriculture cost centre		
	no	yes	sig	no	yes	sig
No risk management strategy	0.015	-0.018	**	0.015	-0.006	NS
Range of crops/enterprises to spread risk	-0.010	0.014	*	0.005	0.003	NS
Markets some commodities on contract basis with agreed price	-0.003	0.032	NS	0.002	0.050	NS
Uses selling groups and pools to market some or all of commodities	-0.001	0.001	NS	0.004	0.025	NS
Purchases some inputs on contract basis with agreed price	-0.006	0.030	*	-0.001	0.039	*
Makes use of 'options'	-0.001	-0.017	NS	0.005	0.002	NS
Animal health insurance	-0.001	0.000	NS	0.010	-0.030	10%
Animal health insurance considered but not pursued	-0.005	0.017	NS	0.000	0.028	NS
Crop damage insurance	-0.001	-0.006	NS	0.003	0.048	NS

Note: 'sig' refers to the statistical significance: *** very highly significant (P<0.001), ** highly significant (P<0.01), * significant (P<0.05), 10% almost significant (P<0.1), NS not significant (P>0.1).
Italics indicate that less than 30 farms gave a positive response.

6.12. Skills acquired through diversification

There are no significant associations between the questions asking about skill acquired through diversification and economic performance at the farm business level. For the agricultural cost centre there are some significant associations, but, as with the marketing questions, these are counter-intuitive and need interpreting with care.

Looking at the detail of the results for the agricultural cost centre, the first row ('non-applicable') picks out business that have not attempted diversification, since responding 'yes' implies that the question is not relevant. Thus it can be seen that those that have attempted diversification tend to have lower mean efficiency. As was discussed in section 6.10, this may be the result of management effort being diverted away from the agricultural enterprises, but may just be the result of those farms that are struggling to make money from agriculture being forced to try diversification.

The second row ('none identified') at first sight appears to contradict the above. However, those answering 'yes' to this are those farms that have diversified, but cannot identify any of the skills mentioned. Thus the 'yes' group for this row is a subset of the 'no' group from row one, and so the interpretation is the same.

Most of the remaining questions have small numbers of positive responses (indicated by italics in Table 6.10), so the results should be treated with caution. The other row that has sufficient numbers and a statistically significant result for the agricultural cost centre is 'marketing and promotion'; those that have acquired these skills through diversification have lower mean efficiencies than the rest (i.e. those that have either not diversified, or have diversified but have not acquired these skills).

Table 6.10: mean efficiencies (REML farm effects, before allowing for explanatory variables) tabulated by questions on skills acquired through diversification. Note that the first question is expressed the other way around, so that a positive response indicates that practices are not adopted.

	Whole Farm Business			Agriculture cost centre		
	no	yes	sig	no	yes	sig
Not applicable	0.004	0.000	NS	-0.037	0.032	***
None identified (see text above)	0.003	-0.011	NS	0.018	-0.035	**
Management accounting	*0.000*	*0.022*	*NS*	*0.013*	*-0.052*	*
Market research	*0.000*	*0.014*	*NS*	*0.010*	*-0.002*	*NS*
Marketing and promotion	0.001	-0.001	NS	0.019	-0.043	**
People management	*0.001*	*0.014*	*NS*	*0.010*	*-0.006*	*NS*
Risk management	*0.001*	*0.042*	*NS*	*0.011*	*-0.189*	*
Regulations etc, eg planning permission, licensing, food hygiene, health and safety	*-0.001*	*0.029*	*NS*	*0.016*	*-0.063*	**

Note: 'sig' refers to the statistical significance: *** very highly significant (P<0.001), ** highly significant (P<0.01), * significant (P<0.05), 10% almost significant (P<0.1), NS not significant (P>0.1).
Italics indicate that less than 30 farms gave a positive response.

6.13. Diversification skills needed

There are no significant associations between the questions asking about skill acquired through diversification and economic performance at the farm business level, but this may be because the number of positive responses is too low for an effective assessment. For the agricultural cost centre there are is a significant difference between those responding 'not applicable' and the rest. This is the same relationship shown in the previous section, since many farms are responding with 'not applicable' to both sets of questions. There are no other statistically significant results with adequate sample sizes and so no tables of means are shown.

6.14. Integrated farm management (IFM) whole farm audit

Very few farms gave a positive response to the questions in this section and, perhaps as a result of this, there are no significant associations between these questions and economic performance, either at the farm business level or for the agricultural cost centre.

7. Discussion and conclusions

7.1. Economic performance and its relationship with farm size

The relationship between size and efficiency of farms has frequently been the subject of academic discussion. It is also an important question for policymakers, particularly in the context of the desire to reduce the support provided by the CAP, and the consequent need for English farms to be capable of competing in world markets.

In the previous study in this series, looking at cereals farms, there was evidence of slightly increasing returns to scale (i.e. efficiency increasing with economic size), after costing out unpaid labour at the market rate and after allowing for confounding explanatory variables, such as debt. This is also the case for grazing livestock farms when costs and outputs are examined for the entire farm business. However, when only agricultural outputs and costs were considered, there was quite a marked trend of increasing efficiency with increasing economic size. This is in contrast to the results of Hadley *et al.* (2006) who found decreasing returns to scale (in terms of technical efficiency) for sheep farms, and only slightly increasing returns for beef farms, using similar data from the FBS up to 2002. This may indicate a real change in the relationship over the last ten years, but it is difficult to be certain of this, given the differences in methodology between that study and the present work.

It is important to note that there is an enormous amount of variation about this pattern. Thus, even for the agricultural cost centre, the best small farms were more efficient than an average economically larger one. Only a small proportion of this variation can be related to large scale geographic differences, but well over 50% relates to other differences between farms. It is likely that a lot of this between-farm variation is associated with differences in land quality, although the confidentiality constraints of the survey prevent the type of detailed spatial analysis that would be required to confirm this.

It is interesting to speculate why the pattern of increasing returns to scale in the agricultural cost centre is not mirrored in the overall farm business results (see Figure 3c and d), given that agriculture accounts for the majority of farm business output. This is likely to be largely due to the impact of the SPS and agri-environment schemes, which are excluded from the agricultural cost centre figures. In particular, farms entering the HLS will tend to become more extensive, with a consequent fall in both agricultural inputs and outputs, whereas their farm business output will be maintained or even increased as a result of the scheme payments. Some small farms also achieve good results at the farm business level due to sensible diversification, but the average rate of diversification is no greater for smaller farms.

All that has been said so far relates to the economic size of farms, measured in terms of groupings based on their costs, but the models also include a term for the physical size of the farm. At the farm business level, for a given economic size, farms with a larger physical area achieve higher outputs; this may well be as a result of agri-environment payments and the Single Payment Scheme, both of which are paid, at least partially, on a per area basis. Some diversified activities (for example, shooting) also require a large physical farm area.

By contrast, for the agricultural cost centre, there is little sign of increasing output with increasing physical size, once the economic size has been allowed for. This is in contrast to the findings for cereals farms, and suggests that, as far as the core agricultural business is concerned, land is less of a limiting resource for grazing livestock farms.

7.2. Debt

There is a very strong relationship between debt, represented by the gearing ratio, and economic efficiency, with heavily indebted businesses performing worse. This applies to the agricultural cost centre and the farm business as a whole. It is in accordance with both results from the cereals report and those from a variety of other studies in the literature, across a range of farm types (e.g. Barnes *et al.,* 2011[18], Hadley et al, 2006). It does however contradict the finding of Barnes (2008) who found improved technical efficiency amongst indebted farms in Scotland.

It thus seems likely that, in many cases, debt leads to economic inefficiency, not least because a heavily indebted farm which is running at its overdraft limit will not be in a position to make sound financial decisions. For example, stock may be sold when money is needed to pay farm or household bills, rather than selling at the best time to maximise profit. However, whilst debt may cause inefficiency, the converse is also true; inefficiency may lead to debt. Thus, the relationship observed here may, at least partially, result from farms that have performed consistently badly over many years accumulating high levels of debt.

The level of variability in the results is also relevant here; some farms with moderate levels of debt perform well, whilst some farms with little or no debt are nevertheless amongst the least efficient farms. These results should therefore not be interpreted to mean that a farm should never take on debt to finance investment in the business. However, they suggest that the business case for such investment should be extremely sound; otherwise the inefficiencies associated with excessive debt may exceed the efficiencies generated by the investment.

7.3. Family labour

Debt is not the only reason for caution in farm expansion. The proportion of 'unpaid' family labour is strongly correlated with performance for the agricultural centre, even when this labour is costed at the full market rate. This in accordance with the expectations of experts (Barnes *et al*., 2011) and probably indicates the experience and dedication of family staff. Thus businesses considering expansion should consider the implications in terms of the need to take on other workers who may be less skilled and less dedicated than family workers.

Interestingly, when the entire farm business is considered, the proportion of family labour is not related to performance. This result is not dissimilar to that for cereals farms, where the relationship was much less strong at the farm business level. It may suggest that, whilst family labour is generally excellent in terms of agricultural expertise, it may be less suited to the entrepreneurial needs of diversified businesses.

7.4. Tenancy

The results in section 4 reveal some complex interactions between tenancy status and other factors. On the whole, tenanted farms tend to perform well for both agriculture and the business as a whole, particularly considering that their costs include rent paid, whereas no imputed rental value is included in the costs of owner-occupiers[19]. This is similar to the

[18] The cereals report noted that Barnes et al found the reverse relationship between technical efficiency and debt. However, errors were later found in the analysis by Barnes et al, and the modified version of their paper now agrees with the findings reported here.

[19] However, note that the impact of this may not be as large as expected. Total agricultural property costs (excluding imputed rents for owner-occupied land) average around £115 per hectare for lowland owner-

findings for cereals farms, but differs from the findings of Hadley *et al.* (2006) who found that rented farmers tended to perform less well for most farm types. The improved performance of tenants is particularly apparent on larger grazing farms, and tenant farmers also show less sign of a reduction in economic efficiency beyond the usual retirement age.

To investigate further the impact of tenancy status on economic performance of the agricultural cost centre, a modified model was fitted, excluding all agricultural property costs to permit a fair comparison. Efficiency values for each farm from this model were then tabulated by tenancy status, subdividing tenanted farms into those renting under Full Agricultural Tenancies (FATs), those renting under Farm Business Tenancies (FBTs), and those with a mix. Results are shown in Table 7.1. The most striking difference is the high performance of the mixed FAT/FBT group, which consists of farmers with secure tenancies under the Agricultural Holdings Act who have nevertheless taken on additional land under the shorter term FBT arrangements introduced in 1995. In view of the results above, it is unlikely that the extra land has, of itself, improved efficiency, so it is more likely that the expansion is indicative of an entrepreneurial spirit which results in efficiency in all agricultural enterprises.

Table 7.1: mean efficiencies for the agricultural cost centre tabulated by tenancy status.

Tenancy type	No. of farms	Mean efficiency	s.e.
FAT (Aat least 50% rented, 90% or more of the rented land under FAT)	92	-0.006	0.0112
Mixed FAT/FBT (at least 50% rented, 10-90% of rented land under FAT)	64	0.037	0.0134
FBT (at least 50% rented, 10% or less of the rented land under FAT)	59	0.017	0.0139
Mixed owned/rented (mainly owned, but 10% or more rented)	112	-0.005	0.0101
Owner occupiers (at least 90% owned)	218	-0.011	0.0072

Notes: table shows REML farm effects, after allowing for economic size, area, specialisation, lowland or LFA, farmer age, debt, organic status, proportion family labour, finishing stock and agri-environment scheme membership. Family labour is costed at the minimum wage rate.

Some caution is necessary in interpreting the differences between the other four groups in Table 7.1 since differences are not that great compared to the standard errors of estimates. However, the FBT group appears to be the next most efficient, with the owner occupiers performing worst on average. However, as discussed above, there is much variation about these averages and some complex interactions with other factors.

7.5. Specialisation

A variety of relationships between specialisation and efficiency are reported in the literature, with Hadley et al (2006) finding a negative relationship for all farm types, whilst Barnes et al (2011) finding positive relationships in most cases. These differences may relate to the complexity of the relationship, but also reflect the many possible definitions of specialisation. In the current study, specialisation refers solely to the agricultural activities, and therefore indicates the degree to which they specialise in either beef or sheep. The results differ between the two types of grazing farms, with lowland farms showing benefits from specialisation, whereas uplands farms are more efficient when they are less specialised.

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occupiers compared to around £80 per ha for lowland tenanted farms. On LFA farms the equivalent figures are £60 for owner-occupiers and £70 per ha for tenants.

Some caution is necessary in interpreting these results, not least because of the difficulties of definition. However, there are conflicting pressures and so the difference between lowland and LFA results may be plausible. On the one hand, greater specialisation may lead to economies of scale in purchasing and in labour use. On the other, greater diversification within the different agricultural activities will give more flexibility to respond quickly to the market and provides a sensible risk management strategy.

7.6. Potential for improvement

This study has shown that there is enormous variation in the performance of farms, but it does not automatically follow that the worst performers can be brought up to the level of the best. A big unknown is how much of the variation in performance is due to factors such as management ability and husbandry practice which are, at least in theory, amenable to change, and how much is due to those factors that are essentially fixed, such as land quality and topography. In the cereals study at least 10% of the variation could be shown to be down to large scale geographic differences (e.g. climate and soil), whereas for grazing farms the results of Section 3.2 indicate that very little of the variation in farm business performance could be explained in this way. However, this may merely indicate that the geographic factors influencing grazing farms operate at a smaller scale than the NCA-level information currently available for FBS farms (see section 3.2); this seems likely since grazing quality can change enormously in a short distance, particularly when moving up the hillside in upland areas.

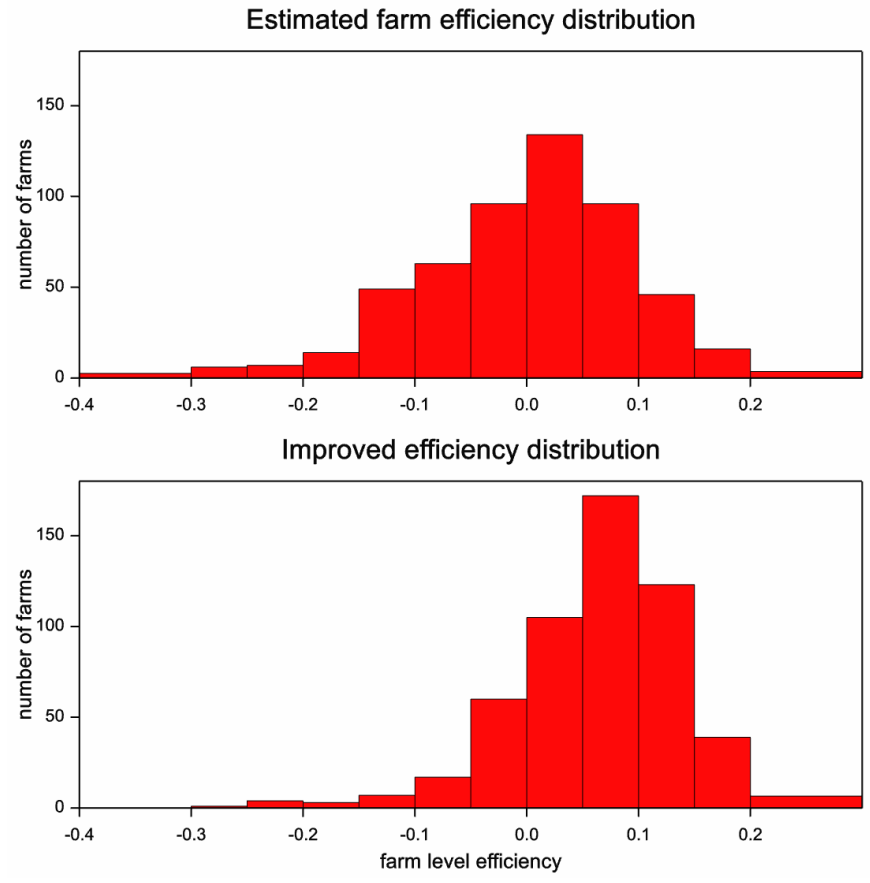

Figure 7.1: farm level efficiency distributions for the real REML model (top graph) and for the simulated improved distribution (bottom graph).

We are currently exploring how better geographic information can be collected for FBS farms without either breeching the strict confidentiality conditions for the survey or imposing an excessive administrative burden on farmers. In the meantime, speculation is required to obtain some feel for the capacity for change.

Figure 7.1 shows the actual distribution of farm-level efficiency terms in the top graph and, below this, a hypothetical distribution based on improved performance across grazing livestock farms . The distribution of improved performance makes the assumption that improvements in efficiency might halve the overall farm-level variation, with the mean of the new distribution equal to the upper quartile of the current distribution. Applying this distribution to the REML model causes an increase in output value of 13.6% for the current level of input costs. Whilst the 50% reduction in variance and the improvement to the old upper quartile are

very much guesses, this 13.6% figure does provide some indication of the scale of efficiency gains that might be achievable in practice.

7.7. Links between economic and environmental performance

As was the case for cereals farms, the strongest information on links between economic performance and the environment relates to agri-environment schemes. This reflects the fact it is difficult for a general farm survey to obtain robust information on environmental performance, even through the use of specialist modules; specialist surveys by experts (for example, ecological field surveys) are ideally needed and these are beyond the scope of the FBS. Fortunately, agri-environment schemes provide a convenient categorical measure of the effort devoted to the creation and maintenance of ecological features on the farm, although these will not, of course, necessarily lead to the desired environmental outcomes.

The impact of different schemes on the agricultural performance of farms is very much as would be anticipated; the relatively undemanding Entry-level Scheme (ELS) has little impact, whereas the classic schemes and, to an even larger extent, the Higher-Level Scheme (HLS) lead to a significant loss of agricultural output. Thus, when considering just the agricultural cost centre (which excludes the scheme payments), there is a negative relationship between the environmental activities delivered through the schemes and economic efficiency. This is precisely what is expected and is the reason why the taxpayer compensates the farmers through the scheme payments.

At the farm business level the reverse applies, with those farmers delivering the greatest environmental benefits through HLS showing the greatest economic efficiency. One interpretation of these results is that the scheme payments are set too high so that they over-compensate farmers, but this analysis is simplistic for two reasons. Firstly, this type of observational survey data cannot prove causation. The greater economic efficiency of HLS farms may not result directly from their membership of the scheme. Instead it is possible that those farms seeing the opportunities provided by HLS are already more efficient than average[20]. Secondly, the agricultural costs of scheme membership will vary from farm to farm depending on factors such as the quality of their land and the type of farming system operated. Scheme payments are set to reflect costs on a typical or an average farm, and schemes will inevitably tend to attract those farmers who can achieve the requirements at lowest cost. Hence the net benefit of a scheme to those farmers signing up to it will always tend to exceed the net benefit for the 'average' farm on which payment rates are based.

7.8. Links with business management skills

The analyses of section 6 revealed a variety of links between business management skills and economic performance, particularly at the farm business level. Good performance is linked to the use of management accounting, benchmarking, IT, technical advice and business planning.

However, whilst these links exist, they are not particularly strong and explain only a small proportion of the total variation in economic performance. So why is this linkage not

[20] However, since ELS and HLS started during the period covered by this study, much of the information about these schemes is estimated from within-farm comparisons (i.e. the change after a farm joins, rather than the difference between farms in the scheme and those outside it). This is in contrast to variables such as debt, land area and farm assurance schemes, which change comparatively little from year to year so that estimation is largely based on between-farm differences.

stronger? Two quotations may help here. The first is from the FBS researcher who collected data from an exceptionally high performing farm in the current study:

'There is no one reason for this [the farm's high performance] but rather unrelenting attention to detail is applied throughout the business'

The second quotation comes from a book by Ian Campbell Thomson (2007) describing his experiences working on a small mixed farm in the 1940s[21]:

'I had long admired the boss's business acumen, his instinctive feel for the optimum between input cost and expected return. He had been doing the job for a long time now. The whole farm business, the husbandry that ran a parallel course, all that was continually being thought about, balanced one against the other with simple logic, while keeping abreast of future trends.'

The message of these quotations is that high performing farms are not the result of a tick-box list of skills that can be captured in a survey form. Instead their success will be down to a natural flair for business, applied consistently across all areas of the farm. Formal business training and business skills may aid this process, but they are not a magic potion that will transform a poor farmer into a high performer.

[21] Page 96

8. References

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9. List of abbreviations used

CAP Common Agricultural Policy

ELS Entry Level Stewardship

FBS Farm Business Survey

HLS Higher Level Stewardship

IT Information Technology

LFA Less favoured area

NCA National Character Area (formerly Joint Character Area, JCA)

PCA Principal Components Analysis

REML Restricted (or residual) maximum likelihood

SLR Standard Labour Requirement (a measure of economic size of farms)

SPS Single Payment Scheme

UAA Utilised agricultural area

Annex: questions from the business management module

This module was asked as a series of yes/no questions relating to use of each type of skill/practice on the farm. Note that the first question in each block is generally expressed as a negative (not applicable, none, etc.) so a response of 'yes' means that the relevant skills are not present or not applied.

Application of skills in management accounting

Not applicable

Uses gross margins prepared for enterprises on the business

Uses cash flows prepared for the business

Reviews the profit and loss account in depth

Prepares partial budgets to inform business decisions

Prepares a budget for the year

Frequently benchmarks and compares business performance with others

Regularly attends discussion groups or meetings on business management issues

Regularly attends discussion groups or meetings on other issues , eg farm walks/meeetings on cross compliance, new regulations, environmental matters.

Management practices knowledge and skills gaps

No identified business competence knowledge or skills gap

Needs to know more about management accounting

Needs to know more about people management

Needs to know more about risk management

Needs to know more about marketing

Needs to know more about environmental maintenance eg hedge maintenance, woodland management

Needs to know more about impact of farming practices on biodiversity, habitats, nature conservation e.g. timing of operations, winter vesus spring cereals, residual effects of agrochemicals

I.T. skills

There is no PC used on the farm

There is a PC used on the farm but not used by the business

There is a PC used on the farm which is used occasionally for some management purposes.

The business has a computer that has broadband internet access

The [farm team] is proficient in Excel/Word/E-mail and web-searching

Uses the internet to purchase and/or sell material for the farm

Uses the internet to improve the performance of the farm e.g. benchmarking

The main farm business documents (Business Plan/Finance Accounts etc) are all managed on the computer

Internet used for submittingforms e.g. CTS/BCMS documents, VAT returns, PAYE forms

Only uses the computer to submit the SP5

Regularly communicates with other farms using the computer

Uptake of technical advice

None identified

Through talking to other farmers

Through the farming media

Through events and demonstrations

Through discussion groups, farm walks or workshops

Through technical advice supplied with no direct charge (e.g. from input supplier)

Through technical advice supplied for a charge

Uptake of business management advice

None identified

Through talking to other farmers

Through the farming media

Through events and demonstrations, eg meetings organised by banks or accountancy firms

Through discussion groups, farm walks or workshops

Through advice supplied with no direct charge (e.g. from casual discussion with accountant or bank manager) or subsidised specific advice, eg FBAS

Through specific business managemnt advice supplied for a charge (eg via consultant)

Business Planning

No formal or informal business plan

Has sufficient confidence for the future but no formal business plan is produced.

The [farm team] meet at least once a year to discuss the direction of the farm but does not record plans formally.

Measures farm's performance by the profit/loss made at the end of the year

Business plan produced in response to a request from a third party e.g.bank. No other use is made of it.

Business plan is shared with the [farm team], reviewed and updated annually.

Business plan is shared with the [farm team], updated annually and reviewed regularly during the year

How the business plans ahead

Not applicable

On basis of information picked up in farming media

On basis of information picked up by talking to other farmers

On basis of discussion within farm household

On basis of feedback/discussions with FBS research officer

On basis of business management exercises carrried out within the farm

On basis of discussions with customers

On basis of purchased business consultancy, (not including routine discussions with the accountant)

On basis of routine discussions with the accountant

Setting targets for business & environmental improvement

None identified

The business has forecast budgets prepared and reviews these at least every six months

The business has forecast budgets prepared and reviews these at least annually

The business keeps environmental records to monitor the environmental impact of what it is doing and reviews these at least every six months

The business keeps environmental records to monitor the environmental impact of what it is doing and reviews these at least annually

The business puts into practice the action it needs to take to bring about environmental improvements

Customer relations

No discussions with customers

Dealings with customers are mostly concerned with transactions

Has a planning meeting with customers once a year

Customers provide regular feedback on the quality of products/services

Has a collaborative approach with customers, aimed at improving mutual business

Proactive in dealing with customers, and fully understands why they buy the farm business's products

Uses customer testimony to actively promote farm business

Looks beyond immediate customers and studies the consumers/market for business's product/services

Application of skills in marketing

Not applicable

Regularly undertakes market research for the agricultural commodities the business produces

Regularly undertakes market research for the non-agricultural activities the business is engaged in (eg tourism enterprise)

Regularly engaged in promoting and/or selling the agricultural commodities the business produces

Regularly engaged in promoting and/or selling the non-agricultural activities the business is engaged in

Application of risk management

No risk management strategy

Range of crops/enterprises to spread risk

Markets some commodities on contract basis with agreed price

Uses selling groups and pools to market some or all of commodities

Purchases some inputs on contract basis with agreed price

Makes use of 'options'

Animal health insurance

Animal health insurance considered but not pursued

Crop damage insurance

Areas where the business has acquired more skills through diversification

Not applicable

None identified

Management accounting

Market research

Marketing and promotion

People management

Risk managment

Regulations etc, eg planning permission, licencing, food hygiene, health and safety

Diversification: areas where the business needs to acquire more skills

Not applicable

None identified

Management accounting

Market research

Marketing and promotion

People management

Risk managment

Regulations etc, eg planning permission, licencing, food hygiene, health and safety

IFM whole farm audit

None identified

No - the business has looked into this but does not consider it worthwhile

No - the business does not have enough information about the benefits of a whole farm audit

No - although this is something the business intends to introduce within the next six months

Yes, the business does this.