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Published in:
Journal of Agricultural Science

DOI:
10.1017/S0021859614001221

Print publication: 01/01/2015

Document Version
Peer reviewed version

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Short title: *Impact of CAP greening and flat rate payments on Scottish beef and sheep farms*

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SUMMARY

The latest Common Agricultural Policy (CAP) reforms could bring substantial changes to Scottish farming communities. Two major components of this reform package; an introduction of environmental measures into the pillar 1 payments and a move away from historical farm payments towards regionalized area payments, would have a significant effect on altering existing support structures for Scottish farmers, as it would for similar farm types elsewhere in Europe where historic payments are used. An optimising farm level model was developed to explore how Scottish beef and sheep farms might be affected by the greening and flat rate payments under the current CAP reforms. Nine different types of beef and sheep farms were identified and detailed biophysical and financial farm level data for these farm types were used to parameterize the model. Results showed that the greening measures of the CAP did not have much impact on net margins of most of the beef and sheep farm businesses, except for 'Beef Finisher' farm types where the net margins decreased by 3%. However, all farm types were better off adopting the greening measures than not qualifying

for the greening payments through non-compliance with the measures. The move to regionalized farm payments increased the negative financial impact of greening on most of the farms but it was still substantially lower than the financial sacrifice of not adopting greening measures. Results of maximizing farm net margin, under a hypothetical assumption of excluding farm payments, showed that in most of the mixed (sheep and cattle) and beef suckler cattle farms the optimum stock numbers predicted by the model were lower than actual figures on farm. When the regionalized support payments were allocated to each farm, the proportion of the mixed farms that will increase their stock numbers increased whereas this proportion decreased for beef suckler farms and no impact in sheep farms was predicted. Also under the regionalized support payments, improvements in profitability were found in mixed farms and sheep farms. Some of the specialized beef suckler farms also returned a profit when CAP support was added.

INTRODUCTION

Beef and sheep production systems are important sectors in Scottish agriculture and elsewhere in Europe, contributing around 34% of total Scottish agricultural output. There are around 15,000 beef and sheep farms representing a majority (91%) of farms in Scotland (ERSA, 2013). Unlike many European countries Scotland's beef and sheep sectors are primarily focused on the production of meat as opposed to livestock products based on milk and wool. This means there is a wide variety of types of beef and sheep farming systems that are often determined by available resources, climactic conditions, topography and management system. Over 85% of Scotland's agricultural area is classified as less favoured (ERSA, 2013) and due to the lack of alternative agricultural uses for much of the land it means that beef and sheep farming play an important role sustaining local economies and the environment. Some are efficient producers but many rely heavily on Common Agricultural

Policy (CAP) support payments to sustain their farming activities.

Earlier reforms in the CAP have seen changes in beef and sheep production systems in Scotland. During 2004 to 2007, sheep population reduced by 6% as a response to the decoupling of farm payments (Thomson 2011). Based on previous experiences, some changes on Scottish farms, particularly from regionalisation of the payments, are expected once latest CAP reform package is fully implemented post 2015, meaning any transition period would give farmers a time-frame with which to plan for future changes to their systems. It is envisaged that farm profit, flock size, stocking density, grazing management and animal health and welfare will be affected by the forthcoming changes. For example it was reported that reduced animal welfare may be an unintended consequence of such policy change in extensive sheep farms as subsidy decoupled from production may, under some circumstances, reduce incentives to maintain outputs associated with aspects of animal welfare (Stott *et al*. 2012).

The CAP support is split into two Pillars: Pillar 1 relates to direct support payments whilst Pillar 2 supports the Rural Development Programme. The latest CAP reform (European parliament and council of the European union 2013), sees two major changes in Pillar 1 payments which are considered to have potentially significant impacts on Scottish farms. The first of these two changes is the greening of farm payments. This has arguably been one of the most debated components of CAP reform since it was announced in October 2011 (EU Commission 2011). Greening means that in the future 30% of a farmer’s support (the 'Basic Payment') through the CAP must be compliant with the three greening measures proposed by the EU Commission: i) preserving an ecological area; ii) crop diversity and iii) maintenance of permanent grassland (EU Commission 2011). The aim of these measures is to bring increased environmental protection issues into the ambit of Pillar 1 payments. Pillar 1 has in the past been associated with production, not environmental goals.

The second major change in CAP reform is a mandatory move from historical payments to a regionalized payment system. This is a progressive step taken in the reform as it became increasingly difficult to defend farm payments based on production decisions taken more than a decade ago. Scottish farms, which are currently in receipt of historically-based ‘Farm Payment’ support, are expected to experience a substantial redistribution in direct support payments when the regionalisation process is fully implemented. It has been suggested that the payments would shift from the intensive and efficient farms towards the small and less efficient farms under flattening of the payment (Buchan *et al*. 2010). Previous studies predicted a similar redistribution of payments, for instance in Ireland where the benefits were predicted to move from the South (a region with more efficient farms) to the North (a region with small extensive farms) under regionalisation of the single farm payments (Shrestha *et al*. 2007). One would expect similar redistribution of benefits among Scottish farms with small extensive farms benefiting from it but a number of large farms losing out. It is also envisaged that stock numbers on beef and sheep farms as well as mixed farms will be affected by the regionalisation of farm payments. Any increase or decrease in stocking rate will have further impacts on livestock management such as animal health including occurrence of diseases and impacts on biosecurity levels, animal welfare, available labour, grazing and nutritional management of livestock and these will have knock on effects for the farms, up-stream and down stream industries and wider rural communities.

In this paper, we developed a farm level model to explore how Scottish beef and sheep farms would respond under the CAP reform proposals. The objective was to explore the financial and structural impacts of CAP reform on these farms. Farm net margin was considered as a financial indicator and stock number (flock size) as a structural indicator reflecting the impacts. This paper used the original CAP greening proposal as tabled by the EU Commission in October, 2011 (EU Commission 2011). Among the three greening measures, Scottish beef and sheep farms would be required to fulfil two measures; first to ensure at least 7% of their eligible farm area under ecological focus area and second to maintain at least 95% of their permanent grassland. We assumed that these farms would be exempt from crop diversity, as typically, the majority of the farm land would be used for pasture. For regionalisation of the farm payments, Scotland still has to decide upon a specific model to adopt, but options being examined include three main choice sets: (a) “region” scale (e.g. parish or farm level); (b) “regional” basis (e.g. based on land type, land capability, etc.), and; (c) “regional” budgets (e.g. based on historic payments, new economic criteria or production based criteria) (Matthews *et al*. 2013). In this paper, however, we assumed a national average flat rate of £108.04 per hectare of farming land based on Buchan *et al*. (2010) that is justified by the calls from some quarters in the CAP reform debate for convergence of Pillar I support rates. This rate is one of the 10 different flattening scenarios used in the Buchan *et al*. (2010) report. Although it presents a much more generalized average payment scheme and could be the least likely regionalisation option to be adopted in Scotland, it still provides general indications of how reforms will impact farmers.

MATERIALS AND METHODS

Input data

The farm level data used for this paper were taken from a database established and maintained by the levy body Quality Meat Scotland (QMS 2012). The dataset consists of a physical description as well as performance and economic data at enterprise level for 69 breeding ewe, 116 beef suckler cattle, 12 lamb finishing and 50 beef finishing enterprises in Scotland. This dataset covers a good geographical and biophysical representation of beef and sheep farm types in Scotland (Thomson 2011). A farm level dataset was established by identifying the associated enterprises to each farm. The farms were grouped into nine different farm types based on the prominent enterprise on the farm. The data were averaged in each of the farm types and were used in a farm level model which is described in the following section. These nine farm types and their characteristics are provided in Table 1, showing the six categories of beef farms and three categories of sheep farms.

Insert Table 1

Table 1 provides an indication of the variability among different beef and sheep farm types. The 'Beef Rearer/Finishers' are the intensive farms with the largest total production costs (i.e. variable plus overhead costs) per animal and farm payment they receive. The 'Beef Hill Suckler' and 'Sheep Hill' were the largest farm types based on land area but have the smallest farm payment rate per hectare.

In addition to calculated average figures for the nine identified farm types, farm-specific data including land area, number of cattle and/or sheep, net margins, enterprise and farm level farm payments related to a sample of 40 farms were used as input to the model to examine the extent of dependency of these farms on farm payments. The selected 40 farms consisted of 14 breeding sheep farms, 11 beef suckler farms and 15 mix farms (both sheep and beef suckler cattle). These farms belonged to six beef suckler and sheep farm types identified in the dataset (Table 3) excluding three farm types namely: 'Beef Cereal Finisher', 'Beef Grass Finisher' and 'Beef Rearer/Finisher'. Table 2 provides input figures related to these farms that were used in the model.

Insert Table 2

Farm level model

Optimising farm level models have been used extensively in policy change impact studies in the EU (Donaldson *et al*. 1995; Ramsden et *al*. 2000; Shalloo *et al*. 2004; Breen *et al*. 2005; Gohin 2006; Bartolini *et al*. 2007; Hennessy *et al*. 2009). An optimising linear programming farm level model, referred to as “ScotFarm”, was developed for this study. The model has a generic linear programming set up, that is:

$$\text{Max} \quad z = (p - c)*x + \text{Farm Payments};$$

$$\text{Subject to} \quad A*x \leq R \text{ and } x \geq 0.$$

Where, z is farm net margin (NM); x are farm activities; p is a measure of the returns; c are the costs procured for x; Farm Payments is the farm payment per ha; A is an input-output coefficient for activity x; and R is a limiting farm resource.

The ScotFarm model draws on and combines features from two earlier models (Shrestha *et al*. 2007; Stott *et al*. 2012). A schematic diagram of the model ScotFarm is provided in Fig. 1 where everything inside the shaded rectangle represents a farm and outside is considered as a market. Beef and sheep production activities are the core of the model. These activities were constrained by land and labour as well as feed and animal replacement available on a farm. However, farms were allowed to buy in feeds, animal replacements and hire casual labour if required. Farm net margins comprised the accumulated revenues collected from the final product of the farm activities less costs incurred for inputs under those activities including the fixed costs plus single farm payment. Fixed costs that include wages, machinery, property, depreciation, land and finance were added as one activity in the model and therefore were not linked to the production activities.

The beef system consists of four categories of animals; calf, suckler, beef under 1-year old and beef under 2-year old. The animals in calf and beef under 1-year category can be sold and replaced at the end of year. All beef under 2-year are sold at the end of the year whereas a maximum 25% of the suckler cows are culled and replaced every year. The sheep system consists of two categories of animals; lamb and ewe. A proportion of female lambs are sold and the rest are retained for use as ewe replacers. Cast ewes can be sold and replaced at the end of the year. The animals were replaced by on-farm and off-farm replacement stocks.

A feed requirement model was used to determine monthly feed requirements for each of the animals on a farm based on type, age and production level of the animal. This feed model used animals' protein and metabolisable energy requirements and dry matter intake by each animal on farm based on Alderman & Cottril (1993). Feeds available to the livestock on farm were fresh grass, silage, hay, and concentrate. Feed costs are included in the variable costs for each animal. Grass yield for pasture area of the land in each of the farm types was generated by a dynamic mechanistic crop/grass model "COUP" (Eckersten *et al*. 1998; Eckersten, *et al*. 2001; Jansson & Karlberg 2004). This grass growth model simulates plant development and grass yield by accounting for the variation due to changes in location (soil type, local weather conditions etc.) and key farm specific decisions such as fertilizer applications. This model provides a monthly yield for fresh grass assuming it has been grazed daily or put aside for hay or silage (one-cut silage in May) where grass is conserved. The ScotFarm model makes a decision as to how much land would be used for grazing on pasture and hill land, or silage and hay based, on optimized number of animals on farm. Grass yield for the hill area of land for each farm was based on the model of Armstrong *et al*. (1997). In earlier papers we provided a more detailed description of the nutritional demand and supply aspect of the model and its application to predict the impact of CAP reform on animal welfare (Stott, *et al*. 2012; Stott, *et al*. 2010; Vosough Ahmadi *et al*. 2010). The solution of the model provides a maximized farm net margin, the optimum number of beef suckler cow and/or ewes, a feeding and grazing pattern across different land areas including hill, pasture and forage producing areas along with annual dry matter intake and the monthly casual labour utilized. As we envisaged the greening and regionalisation of farm payments will affect both farm economics and optimum stock numbers, in this paper we particularly report the optimum financial results and stock numbers before and after CAP reform.

Insert Fig. 1

The model differs from other farm level models mentioned earlier in this section as it is a pseudo-dynamic model which runs within a 10-year time frame. This enables the model to represent herd dynamics on a farm much better than previous models. In this model a farm activity in a particular year was based on the farm activity in the previous year. For example, the number of beef suckler cattle in year *'t'* for each of the farm types *'f'* was based on the number of beef suckler cattle and heifers in year 't-1' as well as number of replacements and culled animals in year 't' as shown in equation 1;

$$dairy_t = dairy_{t-1} + heifer_{t-1} + replacement - cull_t \qquad \forall f \qquad \text{Equation (1)}$$

From the results of the 10-year run, from the first three years and last three years were discarded to minimize the starting and terminal effects of linear programming (Ahmad 1997; Shrestha 2004). Accordingly, the model outputs from the middle four years were averaged to provide the final results for both the baseline scenario and the climate change scenario runs. The model used farm level data for the nine representative farms as stated in Table 1. The data which were not available in the farm dataset such as livestock units and labour requirements were taken from the Farm Management Handbook (SAC 2012).

In this paper, the farm payment is considered to be an area based payment, hence the payments are included in the farm margin linked with the pasture land on farm. The proposed greening measures were used in the model such that all farms maintain permanent grassland to at least 95% of the initial permanent grass land area and also the eligible farm land is reduced to 93% to allocate an ecological focus area on each farm. The rate of farm payment per hectare of land is changed in such a way that total farm payment stays the same as the current figure under these greening measures. For the flattening of the farm payment scenario, this paper used a flat rate of £108.04 per ha of farmed land as determined by Buchan *et al*. (2010).

Model runs and scenarios

In the first step, the model was run under three scenarios: S1) Baseline scenario (using full farm payments), S2) Greening scenario (with three greening measures) and S3) No Greening scenarios (no greening measures and 30% reduction in farm payments) under historical farm payments. These three scenarios were repeated under the regionalisation of payment condition by replacing historical farm payments with the flat rate of farm payment. Averaged input values for the nine identified farm types (Table 1) were used for these model runs. The objective of these model runs was to estimate the percentage change on farm margin with greening and no-greening measures under farm payments and regionalized flat rate farm payment.

In the second step, additional model runs were conducted at farm level for those farms which showed no impact of greening on their farm margins to determine the extent of dependency of these farms on farm payments (excluding Scottish Beef Calf Scheme subsidy that was already included in the output of suckler cattle). These model runs were categorized under three further scenarios: S4) 'without Farm Payments' scenario, S5) 'with Historic Farm Payments' scenario and S6) 'with regionalized Flat Rate Payments' scenario. For these scenarios farm-specific data of 40 individual farms (Table 2) were used in the model runs. The hypothetical scenario of 'without Farm Payment' (S4) was considered as it was assumed that results from such scenario would be able to demonstrate both economic and technical viability of the studied farms and provide an understanding on farm responses when there were no financial support to the farms. The assumption behind scenarios S5 and S6 was that the farm payments were still perceived as coupled by beef and sheep farmers and therefore could affect farm net margin and the optimal decision about the farm size and stock numbers. Therefore, scenarios S5 and S6 compare the impact of the current and future CAP reforms under a coupled assumption.

RESULTS

The results for scenarios S1, S2 and S3 under historical farm payment are presented in Table 3. The second and third columns in the table show farm margins in the Baseline scenario (S1) and share of farm payments in that margin. The fourth column provides percentage changes of farm margin under 'Greening' scenario (S2) and 'No Greening' scenario (S3) compared to the Baseline scenario. The last column shows the benefit of complying with greening against non-compliance. This is the percentage difference of farm net margins under 'Greening' scenario compared to the 'No Greening' scenario.

Insert Table 3

There was a small but negative impact of greening of the CAP support payments on the farm net margins of both of the 'Beef Finisher' as well as the 'Beef Rearer/Finisher' farm types. But all of the beef suckler and sheep farm types did not indicate any impact of greening on farm net margins. The three beef finisher farm types which showed a negative impact of greening (i.e. 'Beef Cereal Finisher', 'Beef Grass Finisher' and 'Beef Rearer/Finisher') were the farms which have a lower share of margins coming from farm payments (61%, 75%, and 83% respectively) compared to the farm groups showing no impact of greening on farm margins. Although these farms have a small reduction in farm margins while implementing greening measures, they have a benefit of around 20%-30% in farm margins when they fail to comply with greening measures.

Under the flat rate regionalized payment, farm margins were decreased in the baseline scenario for most of the farm types (Table 4), compared to the baseline farm margins under historical payment as shown in Table 3. This is obvious as the rate of farm payments per hectare of land was decreased in most of the farm types under the flat rate payment at £108.4 per hectare (Fig. 2). Only 'Beef Hill Suckler' and 'Sheep Hill' farm types would have an increased rate of payments under the flat rate payment. Under the flat rate payment, three farm types (i.e. 'Beef Cereal Finisher', 'Beef Grass Finisher' and 'Beef Rearer/Finisher') showed a decrease in farm margins under the greening scenario (Table 4). These are the same farm types which showed a negative impact of greening under the historic farm payment (Table 3).

Insert Table 4 and Fig. 2

Although all farm types would benefit from adopting greening measures compared to not adopting them, the benefits of adopting greening measures became less under the flattening scenario as shown in Fig. 3. Only the farm types with lower farm payments than flat rate payment had better benefits from adopting greening measures under the regionalisation scenario (for example sheep hill farms).

Insert Fig. 3

The results of model runs using farm-specific data and under the hypothetical scenario of 'without Farm Payment' (S4), the optimum stock numbers in mixed farms and in beef suckler farms were substantially changed though this was less significant on sheep farms. Results showed that in most of the mixed and beef suckler cattle farms, the farms response was to lower the optimum stock numbers (Fig. 4) compared to actual figures on farm (Table 2). Under the 'with Historic Farm Payments' scenario (S5), in 67% of the mixed farms and 93% of the sheep farms stock numbers increased to actual figures observed in the dataset (Table 2) and improvements in profit were observed. Some of the beef suckler farms also returned a profit under this scenario (Fig. 5). Stock numbers in 82% of the beef suckler farms were also increased to actual figures. Under the 'with regionalized Flat Rate Payments' scenario (S6), in a greater proportion of mixed farms (87%) an increase in stock numbers to actual figures was observed than under the 'with Historic Farm Payments' scenario (67%) (S5). However, under the 'with regionalized Flat Rate Payments' scenario (S6), in a smaller proportion of beef suckler farms (64%) an increase in stock numbers to actual figures was predicted compared to the proportion observed under 'with Historic Farm Payments' scenario (82%). In the remaining 36% of the beef suckler farms, the stocking numbers was in average 66% lower than actual figures. Almost no change in stock numbers of sheep farms was predicted under the flat rate scenario (Fig. 6).

Insert Fig. 4, Fig. 5 and Fig. 6

DISCUSSION

The impact of greening of CAP payments was very small in most of the beef and sheep farms in Scotland. This was expected as the target of the greening measures are largely lowland arable farms. This agrees with other studies who have argued that there will be very little impact of greening on EU agricultural production with little to no impact on livestock production (Mathews 2012; Allen & Hart 2013; Hart & Menadue 2013). PBL (2012) pointed out the impact of crop diversification and permanent grassland measures will be negligible as most of farmers already meet these criteria. They argue that the most effective measure would be the ecological focus area criteria, where changes will be seen in the levels of production and GHG emissions in the EU.

The model results suggest that the greening measures affect only those farm types which have a lower share of subsidy payment on their farm margins (i.e. 'Beef Rearer' and 'Finisher') compared to the rest of the farm types. The production level in these farm types is affected by a 7% reduction of eligible farm area that is allocated to ecological focus area. However, for the rest of the farm types (i.e. 'Beef Suckler' and 'Sheep' farm types), a change in farm subsidy payments is more critical than greening of payments. The farm subsidy payments in these farms contribute to 90%-100% of their farm margins. This indicates that the more dependency on farm payments, the less impact is seen when the greening measures are implemented. Nevertheless, when greening measures were ignored and the 30% greening payment was foregone, as seen under ‘No Greening’ scenario, all farms had a substantial reduction in farm margins. This shows that for Scottish beef and sheep farms, a change in farm payment is more important than changes that reduce farm production. The benefits of adopting greening measures against not adopting and forgoing the payment was substantially higher in most of the farms.

Within the farm types that are not affected by greening measures, results of the ‘without Farm Payments’ scenario (S4) showed that 67% of the mixed farms would keep no cattle and 53% would keep no sheep on farm. Under this hypothetical scenario, for sheep farms, keeping sheep on farm was not part of the optimal solutions for 28% of these farms. For the beef suckler farms, 55% of those modelled farms would destock the entire herd from the farms, highlighting the uneconomic nature of un-supported beef production in Scotland. In general the mixed farms fared better, under a no farm payments scenario than the sheep and beef suckler farms. This indicates the resilience of the mixed farms in relation to change in support payment. It should be noted that, under the current CAP policy, these farms do not forego the farm payments for not keeping animals on farms as farm payments are paid regardless animal numbers on a farm. However, it is likely that the introduction of the minimum activity criteria, referred to as the “Scottish Clause” (RACCE 2014), may change this from 2015 onwards. Farms not meeting these criteria, based on stocking density, would be disqualified from payment.

Results showed that in general a change in CAP support payments from the ‘with Historic Farm Payments’ scenario (S5) to the ‘with regionalized Flat Rate Payments’ scenario (S6), will increase the proportion of the mixed farms who will increase their stock numbers.

This proportion decreased for the beef suckler farms whereas no impact on stock numbers in sheep farms was predicted. The stock numbers in beef suckler farms, who will decrease the flock size, was in average 66% lower than the actual stock numbers. These predicted fluctuations of stock numbers in different farm types as a result of change in CAP support may have unintended positive or negative consequences for the farm environment as well as for animal health and welfare. A key issue for change in support rate is by how much and in what ways the potential negative consequences of increased stock numbers could be minimized.

The net margins of 63% of the farms, particularly beef suckler farms, were lower under the flattening scenario compared to the historical basic payment scenario. Around 53% of the mixed farms, 18% of the beef suckler farms and 29% of the sheep farms were financially better off under this scenario. These results support the assumption that farmers may still consider decoupled CAP support as a coupled payment. However, farmers may have other incentives in maintaining their current production level such as making an annual contribution to fixed costs that are perceived to be unavoidable. Moreover, it may be that minimum activity criteria will be required to qualify for the farm payments (NFUS 2014). Ultimately, CAP support makes beef and sheep livestock enterprises viable when they might otherwise become uneconomic and, in that sense, CAP support can be seen as coupled. A number of earlier studies analysing the 2003 Mid-Term Review of the CAP reported that many farmers still considered single farm payments coupled to production (Breen *et al*. 2005; Gohin 2006; Gorton *et al*. 2008; Renwick *et al*. 2011). It should be noted that the fixed costs used in the model were not changed and therefore the presented results demonstrate the short-run effects of the examined scenarios. Further work could therefore look at the effect of flat rate payments in a longer run situation by allowing fixed costs to change.

Under a flat rate farm payment, two hill farm types ('Beef Suckler' and 'Sheep') receive a major improvement to their support payment from the regionalisation scenario, doubling the farm gross margin as a result. Farm gross margins were still reduced for most of the farm types under regionalisation of payments. The impact was slightly higher than the impact under the farm payment condition for the 'Finisher' and 'Rearer/Finisher' farm types. As with the previous case, the remainder of the farm types did not observe any impact of greening on their farm margins. Under a 'No greening' scenario all these farms showed a similar reduction of margins, principally due to foregoing 30% of their farm payments.

CONCLUSIONS

The results suggest that for Scottish beef and sheep farms, changing from the historic farm payment system is more critical than opting for the greening measures. For many farm types moving to a flat rate of £108.04/ha reduced farm margins substantially. For lowland sheep farms this decrease was almost 45%. Only a few beef suckler farms and sheep farms on hills in our sample (18% and 29% respectively) improved their net margins under the flat rate regionalisation scenario. Majority of these sheep farms were extensive with an average area of 1,600 hectares and had a large flock size of in average 1,120 ewes. Clearly, as compulsory requirement for payment, all the farm types benefit from implementing greening measures, rather than not adopting and foregoing 30% of their farm payments. Results also show that in general, the mixed farms (keeping both sheep and cattle) perform better under a 'No farm payments' scenario than the specialized farm types. Most of the farms showed an increase in stock numbers and returns on profit when subsidies were added to their margins. Under a flat rate scenario, stock numbers and farm margins increased in 53% of the studied mixed cattle and sheep farms. However, for the rest of the farms almost no change in stock numbers was found under a flat rate scenario, compared to the historical farm payment scenario.

ACKNOWLEDGMENT

Authors thank the Scottish Government for funding this research. We are also grateful to the Quality Meat Scotland (QMS) for providing data. This research was undertaken within the Scottish Government Rural Affairs and the Environment Portfolio Strategic Research Programme 2011-2016, Theme 4: Economic Adaptation.

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Table 1: *Beef and sheep farm types and their characteristics**

Farm types	Land (ha)	No. of beef	No. of sheep	Variable costs (£/head)	Overhead costs (£/head)	Family labour (man hr)	St rate (LU/ha)	Farm payment
Beef Cereal Finisher	392.5	75	0	320.6	66.1	1.26	0.14	72,989
Beef Grass Finisher	415.6	54	0	281.0	196.6	1.02	0.08	90,952
Beef Rearer/Finisher	450.2	278	0	459.3	461.1	1.09	0.39	94,190
Beef Hill Suckler	1761.7	160	0	299.3	399.3	0.65	0.06	86,507
Beef Upland Suckler	429.1	197	0	275.0	336.4	1.13	0.33	61,121
Beef Lowland Suckler	362.5	117	0	265.9	366.8	1.61	0.23	92,956
Sheep Lowland	384.7	0	1037	39.0	45.3	1.38	0.15	93,763
Sheep Hill	1668.2	0	1493	23.0	35.6	0.64	0.05	74,038
Sheep Upland	560.1	0	1562	28.3	44.7	1.4	0.16	79,543

* *Source: calculated based on QMS dataset (2012)*

Table 2: *Input data for a sample of 40 farms that showed no impact under greening measures (mix farms F1-F15, sheep farms F16-F29; beef suckler farms F30-F40.*

Farm	Land (ha)	No. of cattle	No. of sheep	Cattle GM*‡ (£/head)	Sheep GM*‡ (£/head)	Cattle NM†‡ (£/head)	Sheep NM†‡ (£/head)	Enterprise FP‡ (£1000)		Farm FP ‡ (£1000)
								Cattle	Sheep	
F1	765	16	950	366.2	43.8	-251.9	-8.9	5.0	25.5	68.9
F2	1,123	38	950	259.7	22.5	-133.6	-10.9	5.8	12.4	28.0
F3	446	150	1100	325.9	96.4	-66.8	43.8	32.6	32.0	94.7
F4	296	10	220	193.5	23.1	33.3	7.7	2.2	4.7	8.0
F5	1,832	215	2139	335.8	2.3	39.8	-22.4	55.9	46.4	165.8
F6	765	112	950	437.2	43.8	-97.4	-8.9	30.4	25.5	68.9
F7	4,025	22	213	385.7	11.4	-211.0	-49.7	13.2	13.0	35.7
F8	343	66	850	444.8	93.4	102.9	49.1	14.0	23.3	42.4
F9	99	58	164	232.5	71.4	-29.0	42.9	0.0	0.0	0.0
F10	96	27	130	492.8	38.1	190.9	15.8	7.9	2.8	10.7
F11	3,100	56	908	218.9	3.9	-101.3	-23.4	3.5	4.8	9.3
F12	127	120	550	346.0	82.9	4.3	35.4	27.5	17.5	45.0
F13	206	77	359	610.6	86.3	144.3	21.2	26.4	14.0	84.8
F14	171	172	248	639.6	105.9	278.3	44.2	22.8	4.0	53.2
F15	209	116	510	613.3	51.2	311.7	19.6	28.6	13.2	44.7
F16	1,218	0	1250	-	26.2	-	-7.7	-	33.4	38.9
F17	500	0	503	-	54.6	-	14.7	-	9.1	78.1
F18	3,240	0	1728	-	51.8	-	19.2	-	41.9	65.0
F19	677	0	320	-	6.5	-	-43.8	-	9.7	10.3
F20	252	0	258	-	24.6	-	1.9	-	11.8	27.6
F21	163	0	175	-	57.2	-	35.8	-	4.2	21.0
F22	1,123	0	950	-	22.5	-	-10.9	-	12.4	28.0
F23	96	0	437	-	96.8	-	44.8	-	9.4	56.9
F24	105	0	259	-	70.7	-	29.9	-	20.2	24.8
F25	96	0	476	-	65.9	-	41.8	-	8.8	59.4
F26	1,140	0	1204	-	88.5	-	43.5	-	42.7	207.5
F27	81	0	437	-	88.8	-	61.2	-	5.2	15.9
F28	137	0	525	-	86.8	-	29.2	-	20.0	20.0
F29	840	0	567	-	28.6	-	-10.9	-	15.8	31.5
F30	137	11	0	283.4	-	3.4	-	2.7	-	3.2
F31	140	125	0	340.6	-	-86.8	-	26.2	-	149.1
F32	50	63	0	363.0	-	-22.8	-	11.5	-	68.9
F33	72	63	0	-48.7	-	-799.7	-	18.1	-	28.3
F34	840	54	0	285.9	-	-126.0	-	15.7	-	31.5
F35	111	42	0	608.9	-	130.1	-	7.6	-	41.1
F36	118	57	0	430.3	-	161.5	-	2.8	-	30.6
F37	305	133	0	441.1	-	56.4	-	39.5	-	77.6
F38	29	52	0	241.2	-	96.0	-	6.3	-	21.4
F39	157	90	0	502.4	-	283.8	-	13.0	-	36.8
F40	41	57	0	274.6	-	-30.3	-	9.5	-	14.0

*Cattle and sheep gross margins excluding feed and forage costs. Feed and forage costs were included separately in the model. Calf subsidy (calf scheme) was included to suckler cattle output.

†Cattle and sheep net margins excluding Farm Payments.

‡ "-" denotes no value as there were no sheep or cattle on the related farms.

Table 3: *Percentage change on farm margin with greening and no-greening measures under the Historic Farm payments*

Farm types	Farm margins including farm payments (£) under the baseline scenario (S1)	Share of farm payments in the baseline farm margin (%)	% change in farm margin under greening scenarios compared to the baseline scenario		Benefits of greening (% change)
			Greening(S2)	No Greening (S3)	
Beef Cereal Finisher	119,747	61	-2.7	-18.5	19.3
Beef Grass Finisher	121,271	75	-1.8	-22.5	26.8
Beef Rearer/Finisher	113,583	83	-1.2	-24.9	31.5
Beef Hill Suckler	86,507	100	0	-30.0	42.9
Beef Upland Suckler	64,772	94	0	-28.3	39.5
Beef Lowland Suckler	96,031	98	0	-29.0	40.9
Sheep Lowland	93,763	100	0	-30.0	42.9
Sheep Hill	77,966	95	0	-28.5	39.8
Sheep Upland	79,475	100	0	-30.0	42.9

Table 4: *Percentage change on farm margin with greening and no-greening measures under Flat Rate Payments*

Farm types	Farm margins including flat rate FP (£) under the baseline scenario (S1)	FP(£)/ha	% change in farm margin under greening scenarios compared to the baseline scenario		Benefits of greening (% change)
			Greening (S2)	No Greening (S3)	
Beef Cereal Finisher	89,305	↑	-3.7	-14.3	12.4
Beef Grass Finisher	75,370		-2.8	-17.9	18.4
Beef Rearer/Finisher	68,195		-2.0	-21.5	24.8
Beef Hill Suckler	190,968	108.04	0	-30.0	42.9
Beef Upland Suckler	50,165		0	-27.8	38.5
Beef Lowland Suckler	42,370		0	-27.7	38.6
Sheep Lowland	41,701		0	-30.0	42.9
Sheep Hill	184,761	↓	0	-29.4	41.6
Sheep Upland	60,646		0	-30.0	42.9

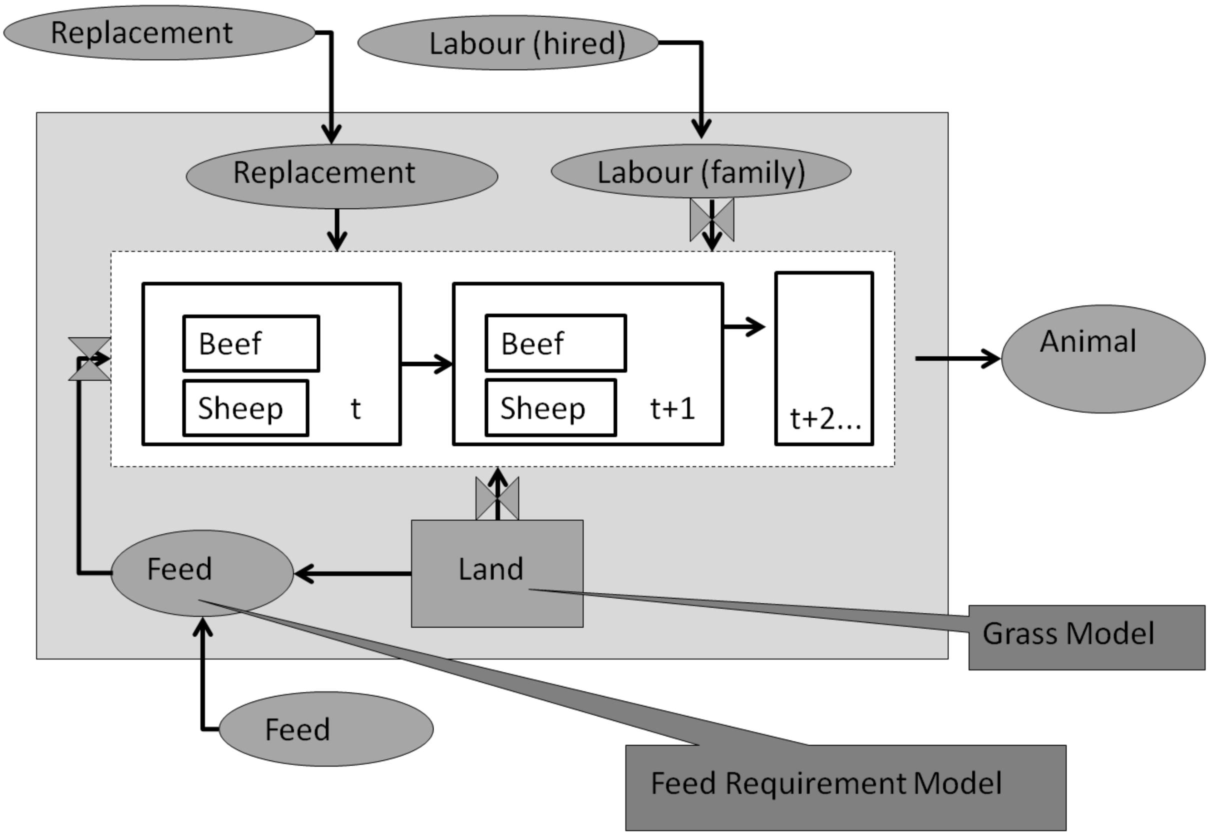

Replacement
Labour (hired)
Replacement
Labour (family)
Beef
Sheep
t
Beef
Sheep
t+1
t+2...
Animal
Feed
Land
Grass Model
Feed
Feed Requirement Model

Fig. 1.

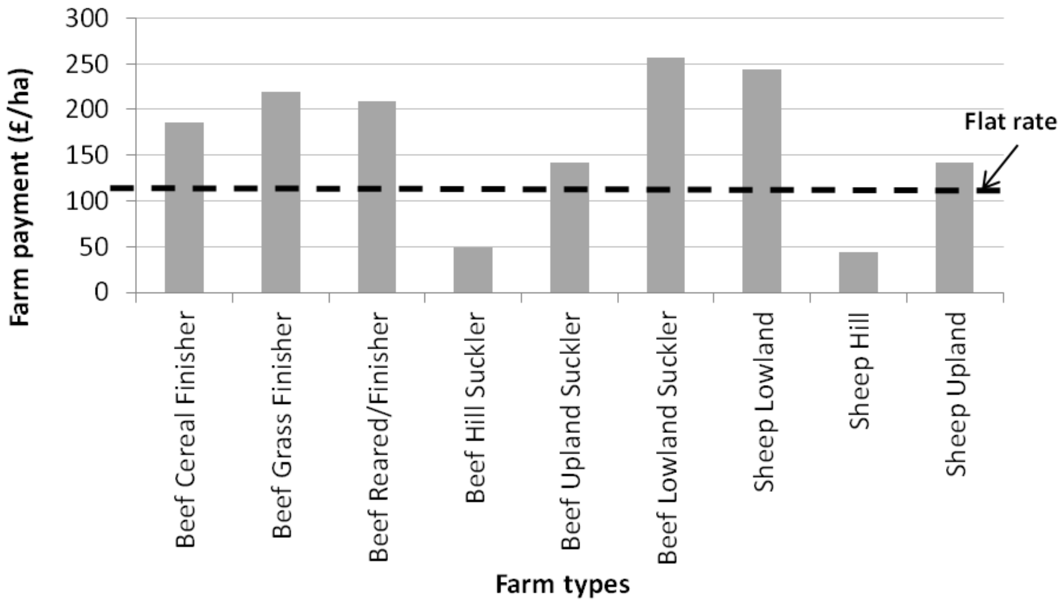
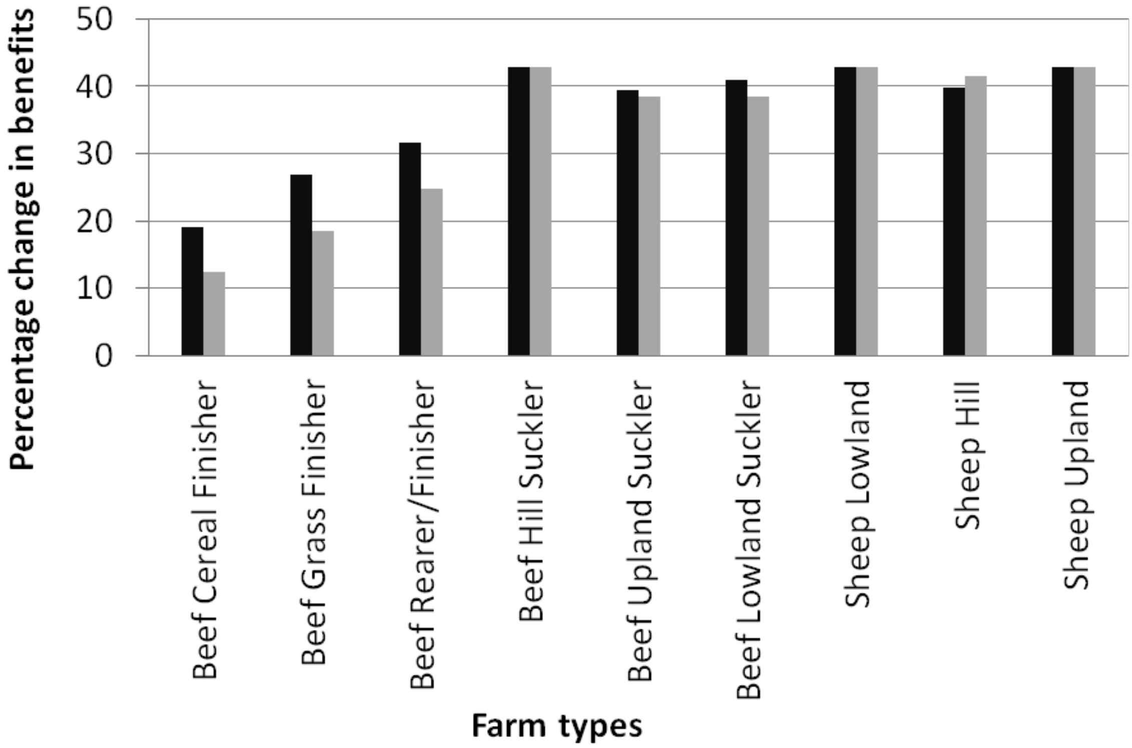

300
250
200
150
100
50
0
Farm payment (£/ha)
Flat rate
Beef Cereal Finisher
Beef Grass Finisher
Beef Reared/Finisher
Beef Hill Suckler
Beef Upland Suckler
Beef Lowland Suckler
Sheep Lowland
Sheep Hill
Sheep Upland
Farm types

Fig. 2.


Percentage change in benefits
50
40
30
20
10
0
Beef Cereal Finisher
Beef Grass Finisher
Beef Rearer/Finisher
Beef Hill Suckler
Beef Upland Suckler
Beef Lowland Suckler
Sheep Lowland
Sheep Hill
Sheep Upland
Farm types
Fig. 3.

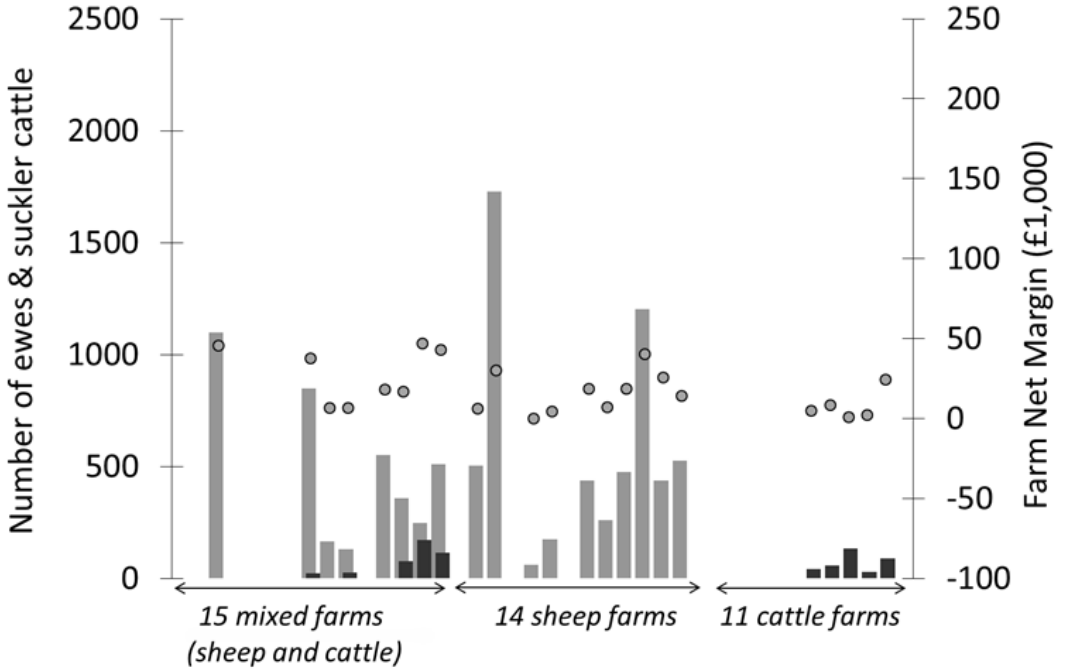

Number of ewes & suckler cattle
2500
2000
1500
1000
500
0
Farm Net Margin (£1,000)
250
200
150
100
50
0
-50
-100
15 mixed farms (sheep and cattle)
14 sheep farms
11 cattle farms

Fig. 4.

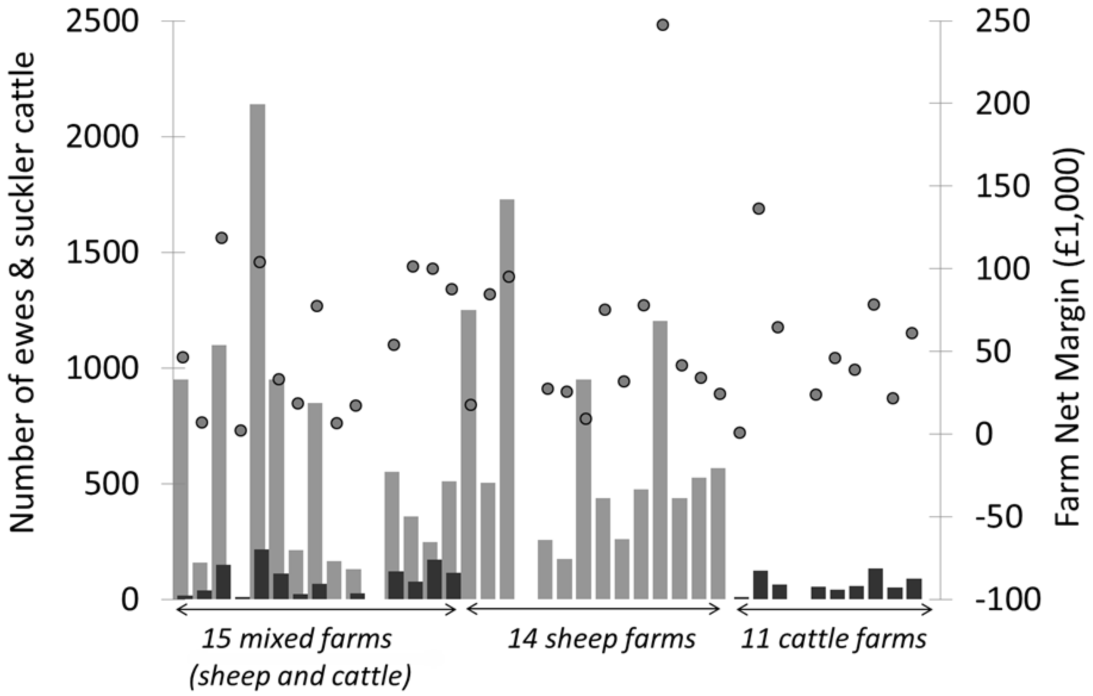

2500
2000
1500
1000
500
0
Number of ewes & suckler cattle
250
200
150
100
50
0
-50
-100
Farm Net Margin (£1,000)
15 mixed farms
(sheep and cattle)
14 sheep farms
11 cattle farms

Fig. 5.

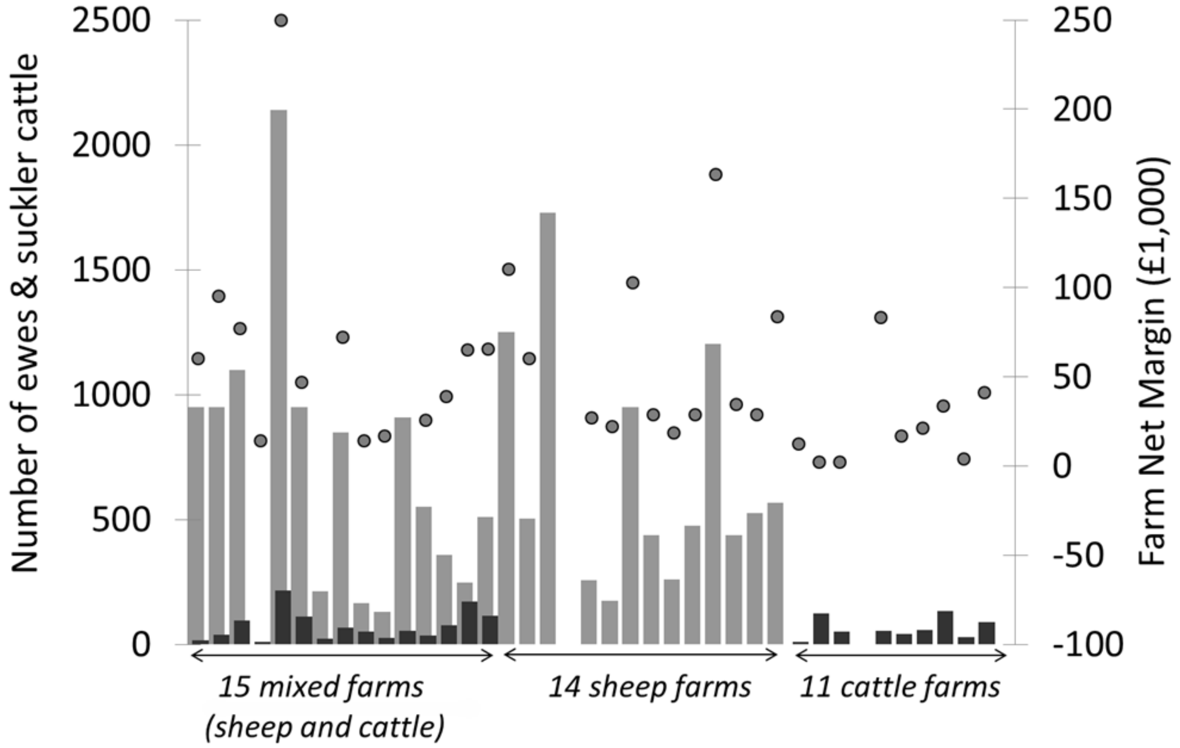

2500
2000
1500
1000
500
0
Number of ewes & suckler cattle
250
200
150
100
50
0
-50
-100
Farm Net Margin (£1,000)
15 mixed farms
(sheep and cattle)
14 sheep farms
11 cattle farms

Fig. 6.

Figure captions

Fig 1. *A schematic diagram of optimising model ScotFarm*

Fig 2. *Historic Farm Payments per hectare of farmed land in each farm types*

Fig 3. *Benefits of adopting greening measures (S2 scenario) compared to not adopting greening measures (S3 scenario) under Historic Farm Payment (dark bars) and Flat Rate Payment (light bars) for the nine studied farm types*

Fig 4. *'Without Farm Payments' scenario S4): optimised stock numbers (sheep light bars and cattle dark bars), and farm net margin (NM) (circles) of 40 farms estimated by the model using net margin per head reported in the dataset as input. Farms included in Figure4, Figure5 and Figure 6 belong to the farm types mentioned in Table 3 and Table 4 excluding three farm types namely: Beef Cereal Finisher, Beef Grass Finisher and Beef Rearer/Finisher*

Fig. 5. *'With Historic Farm Payments' scenario S5): optimised stock numbers (sheep light bars and cattle dark bars), and farm net margin plus Historical Farm Payments (circles) of 40 farms estimated by the model*

Fig. 6. *'With regionalised Flat Rate Payments' scenario S6): optimised stock numbers (sheep light bars and cattle dark bars), and farm net margin plus flat rate Farm Payments (circles) of 40 farms estimated by the model*