Extended Abstract

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Paper/Poster Title	An exploration of the labour and environmental efficiency of Scottish cattle and sheep farms

Abstract prepared for presentation at the 97th Annual Conference of the Agricultural Economics Society, The University of Warwick, United Kingdom

27th – 29th March 2023

Abstract	***200 words max***
The analysis on labour conditions in the Scottish case study focuses on how efficient these farms are in their use of (paid and unpaid) labour to deliver environmental (renewable energy and woodland) and diversification (tourism) outputs. We use FADN data and data envelopment analysis (DEA) i.e., Russell non-radial (NR) efficiency measure in an adjusted CCR model. Results show a strong difference between how efficiently paid and unpaid labour are used for creation of both environmental/ diversification and livestock outputs, with unpaid labour scores consistently higher than paid labour scores. The efficiency of unpaid labour in creation of traditional livestock products as compared to environmental/diversification is, as expected, lower. Both paid and unpaid labour are more efficiently used on sheep farms than cattle farms to produce livestock outputs. It is less surprising that, compared to all other inputs, the use of unpaid labour is the most efficient for creation of environmental outputs, than it is the fact that unpaid labour is still highly efficient for creation of traditional livestock products, e.g., higher than land area and paid labour. This is consistent with the current discussion on distribution of paid and unpaid labour across these types of farms.	

Keywords	Labour, efficiency analysis, diversification, livestock farming, Scotland
JEL Code	Labor and Demographic Economics J0; Q120 Micro Analysis of Farm Firms, Farm Households, and Farm Input Markets; C6 Mathematical Methods; Programming Models; Mathematical and Simulation Modeling see: www.aeaweb.org/jel/guide/jel.php?class=Q)

Introduction	***100 – 250 words***

Cattle & sheep (LFA) farms represent 42 per cent of total Standard Labour Requirements (SLR) compared to their 27 per cent share of standard output (SO) in the Scottish agriculture i.e., this farm type has a much higher labour requirement in proportion to its total SO. The average income of commercial farms in Scotland is estimated to have halved over the period covered in this study (2011-2015), where the largest decline was seen in sheep farms in LFA (Scottish Government, 2016). This has been reflected in a return to unpaid labour on commercial farms. In absence of direct payments post-Brexit, the potential decline ceteris paribus in the profitability of many cattle and sheep farms will reflect in a further decline in paid labour.

Reliance on non-agricultural sources of income e.g., tourism, renewables and woodland, and financial support from grants and subsidies is apparent for many farms in the cattle and sheep industry (Scottish Government, 2016). This is even more relevant post-Brexit, with the economic viability of cattle and sheep farms at risk according to many studies analysing the impacts of Brexit on the UK agriculture. While there are mixed findings based on modelling assumptions, overall, this farm type is under threat in most scenarios forecasting the separate or combined effects of changes in prices, trade, and farm payments. Ojo et al. (2020) found that close to 60 per cent of beef and sheep farms are sustainable due to access to non-farm income, and their sustainability may be dependent on e.g., on-farm diversification or increased labour efficiency contingent to changes in farm payments and international trade.

Methodology	***100 – 250 words***

The elements shaping the research question focus on how efficient the Scottish cattle and sheep farms are in their use of (paid and unpaid) labour to deliver environmental (renewable energy and woodland) and diversification (tourism) outputs. This is compared with the efficiency of the labour input used to produce 'traditional' livestock products output.

We use FADN data and data envelopment analysis (DEA) i.e., Russell non-radial (NR) efficiency measure in an adjusted CCR model. The Russell non-radial efficiency measure allows for the nonproportional adjustment of different inputs/outputs and has a higher discriminating power than the radial efficiency measure in comparing decision making units (farms). The NR CCR model provides information on the efficiency of specific inputs or outputs. We run input-oriented DEA for both constant returns to scale (CRS) and variable returns to scale (VRS). While the reference technology for the CCR model presents constant returns to scale (CRS), the addition of a separate constraint to the reference technology allows for a VRS setting (adjusting the CCR into the BCC model (Färe et al. 1983). As we are not including undesirable outputs, integrating efficiency measures with the CRS and VRS reference technologies is fitting since this provides information on both the technical and scale efficiency. The models were developed in Excel Visual Basic for Applications (VBA) (self-coded programs).

Next, we run OLS regressions with Huber-White robust standard errors to estimate the effect of secondary variables on efficiency scores within and across farm type (cattle and sheep samples) using SHAZAM v11.1 software package.

We used EUROSTAT Farm Accountancy Data Network (FADN) for Scotland for 165 cattle and 104 sheep farms (defined by FADN as farms where at least 66% of their gross margin comes from cattle and sheep products respectively). Observations for each farm for years 2011 to 2015 led to a total sample of 1006 farms (630 cattle and 376 sheep farm observations).

We estimated two models, the 'environmental labour' model estimating the efficiency of labour used to create the environmental (renewable energy and woodland)/ diversification (tourism) output; and the 'traditional labour' model estimating the efficiency of labour used to create livestock/ livestock products output.

The reason for estimating the two models separately is linked to the empirical focus of the exercise i.e., a ranking of farms with a specific environmental/ diversification profile. This has the added benefit of simplification of the models i.e., a lower number of variables which is particularly welcome for the 'environmental labour' model run on a smaller sample. Additionally, not including both the traditional and environmental outputs in the same model prevents the exclusion of a large number of farms that produce only the traditional output (i.e., not the environmental/ diversification one) from a model that would focus on both types of outputs.

The 'environmental labour' model estimates the efficiency of labour used to create the environmental (renewable energy and woodland)/ diversification (tourism) output. This was run for the farms with an environmental/ diversification output, which constitute a small sample (89 observations pooled for years 2014 and 2015 - cattle and sheep farms together). The number of observations is acceptable according to both widely adopted rules of thumb i.e., the number of DMUs should be larger than the product and be at least two times larger than the sum of the number of inputs and outputs (Dyson et al., 2001; Ramanathan, 2003 as cited in Zhou et al., 2008).

The 'environmental labour' model has four input variables - total assets (minus land value), total intermediate consumption, paid labour (hours), unpaid labour (hours) – and one output variable - environmental/ diversification output.

The 'traditional labour' model estimates the efficiency of labour used to create livestock/ livestock products output. This was run for the farms with livestock/ livestock products output (run separately for 630 cattle and respectively 376 sheep farm observations).

The 'traditional labour' model has five input variables - total assets (minus land value), total intermediate consumption, paid labour (hours), unpaid labour (hours), land area owned or rented (ha) – and one output variable - livestock/ livestock products output.

Results | ***100 – 250 words***

Figures 1-6 present the histograms for all NR CCR input-orientated models run for all inputs, and separately for each input. Re the latter, it is important to recall that NR CCR model assumes that all the other inputs are held constant.

Figures 1 and 2 for the VRS and CRS 'environmental labour' models run for the cattle and sheep farms together show a dispersed distribution of the input scores, indicating significant potential for efficiency improvements. Scores for all inputs, and assets and intermediate consumption run separately show similar trends and values (with twice as high averages for the VRS case).

There is a strong difference between how efficiently paid and unpaid labour are used for creation of environmental/ diversification outputs in both CRS and VRS models, with unpaid labour scores three (CRS) to four times (VRS) higher than paid labour scores.

Moreover, efficiency scores for unpaid labour are the highest across all inputs. This is consistent with the current discussion on distribution of paid and unpaid labour across these types of farms – even more evident following the period of analysis due to recent developments e.g., Brexit -, and certainly not surprising for the case of environmental/ diversification activities.

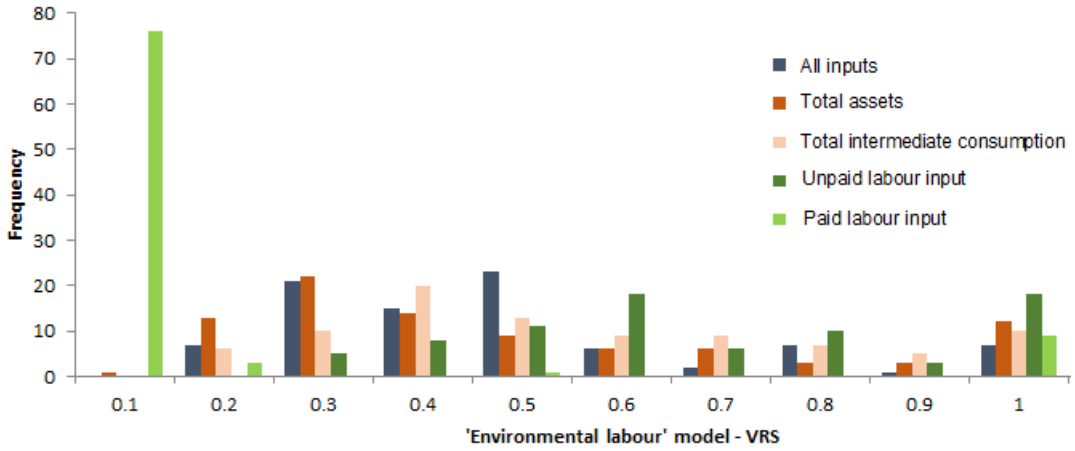

Figure 1. 'Environmental labour' model_VRS_efficiency scores_cattle and sheep farms sample (superimposed histograms)

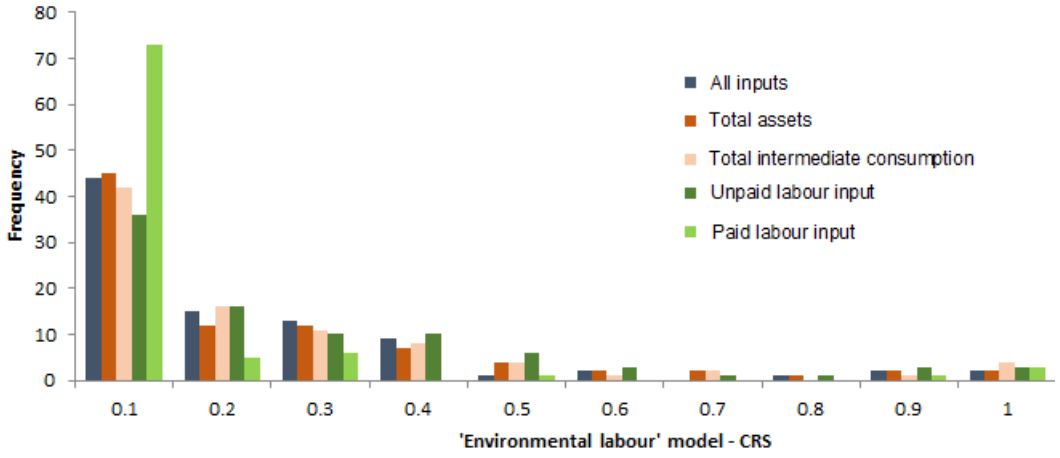

Figure 2. ‘Environmental labour’ model_CRS_efficiency scores_cattle and sheep farms sample (superimposed histograms)

When looking at the efficiency of labour use for traditional outputs – livestock and livestock products (Figures 3-6), results across models are less differentiated between the CRS and VRS cases (still higher for the latter). Scores for all inputs, and assets, intermediate consumption and land area run separately show similar trends and values across cattle and sheep models. Intermediate consumption shows the highest average efficiency scores, followed by total assets, unpaid labour, land and paid labour.
Again, as in the case of environmental/diversification models, there is a strong difference between how efficiently paid and unpaid labour are used for creation of livestock outputs in both CRS and VRS models, with unpaid labour scores four (CRS) to seven times (VRS) higher than paid labour scores in the cattle models, and respectively three (VRS) to four times (CRS) higher in the sheep models.
This is, again, consistent with the current discussion on distribution of paid and unpaid labour across these types of farms – even more evident in the context of events leading up to, and particularly following, Brexit.
The efficiency of unpaid labour in creation of traditional livestock products as compared to environmental/diversification is, as expected, lower. It is less surprising that, compared to all other inputs, the use of unpaid labour is the most efficient for creation of environmental outputs, than it is the fact that unpaid labour is still highly efficient for creation of traditional livestock products, e.g., higher than land area and paid labour.

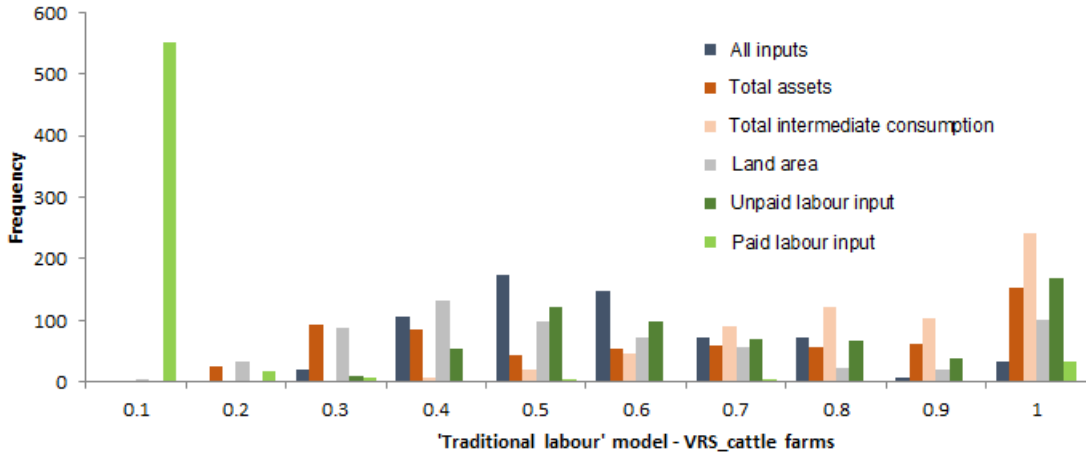

Figure 3. ‘Traditional labour’ model_VRS_efficiency scores_cattle farms sample (superimposed histograms)

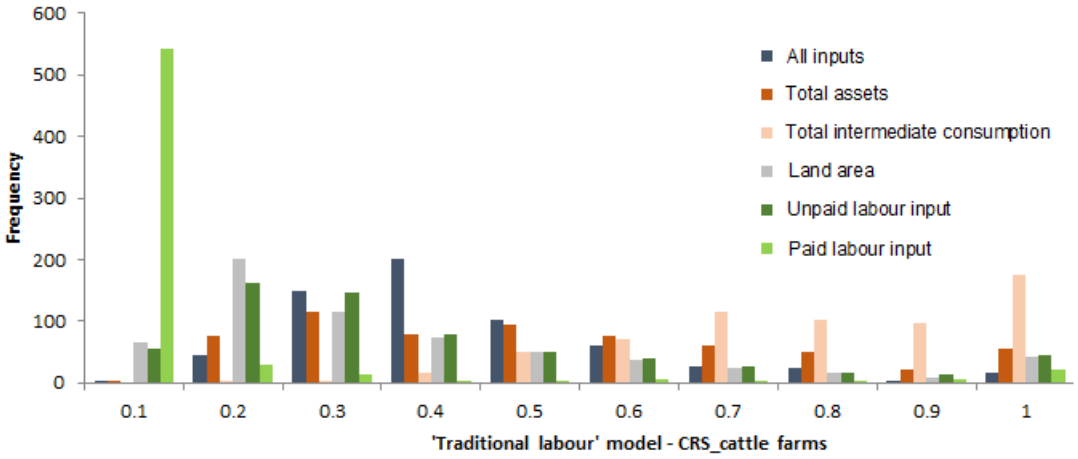

Figure 4. ‘Traditional labour’ model_CRS_efficiency scores_cattle farms sample (superimposed histograms)

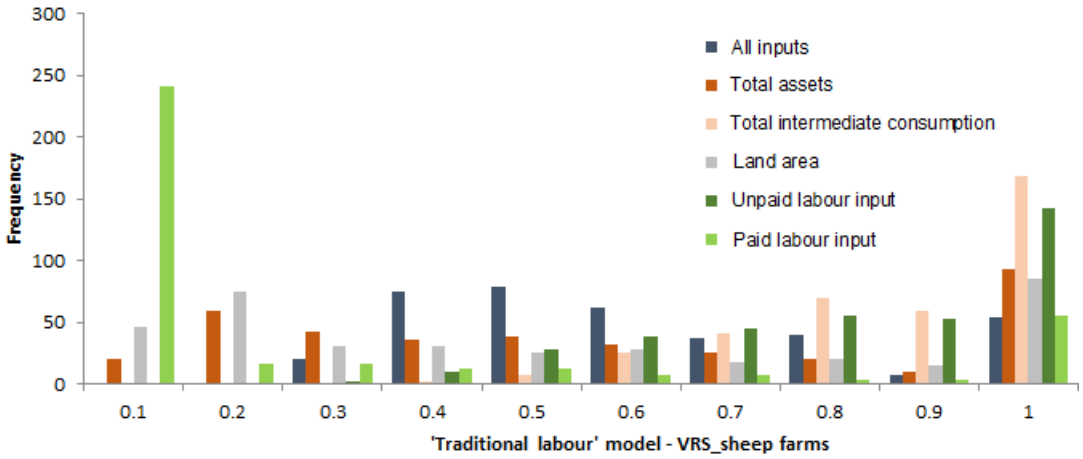

Figure 5. ‘Traditional labour’ model_VRS_efficiency scores_sheep farms sample (superimposed histograms)

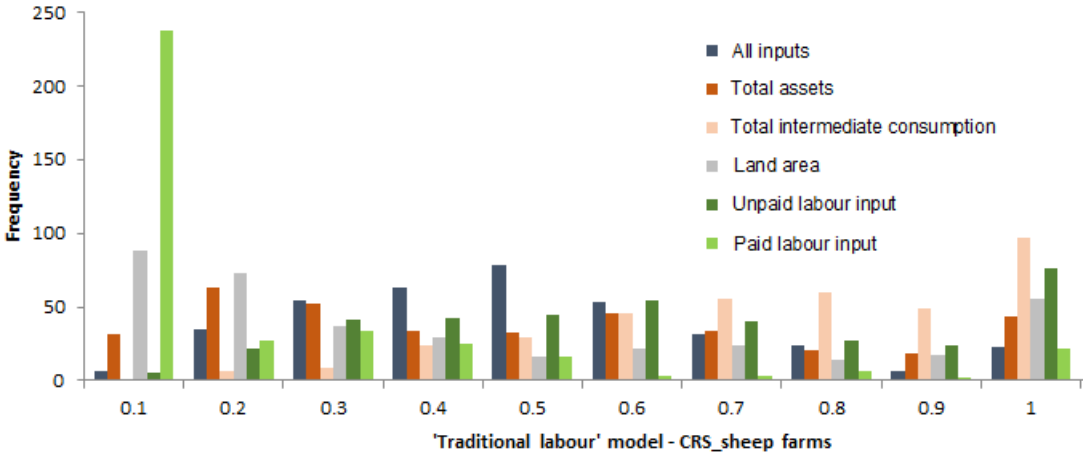

Figure 6. ‘Traditional labour’ model_CRS_efficiency scores_sheep farms sample (superimposed histograms)

We regressed (controlling robustness) the efficiency scores on variables identified in the literature as potentially influencing factors. The findings support the evidence on subsidies dependence and differences between types of labour. The relationship between farm organic status and efficiency scores of labour used for both ‘traditional’ and ‘diversification’ outputs emphasise that organic production is not only environmentally oriented but has a clear economic reasoning.

Discussion and Conclusion	***100 – 250 words***

In accordance with key elements shaping the current and future situation of the Scottish cattle and sheep farms e.g., transitions in labour use and access to subsidies following Brexit and other shocks to markets, the analysis focused on the efficiency of labour used for creation of both environmental and traditional outputs on cattle and sheep farms using efficiency models allowing for better discrimination at the level of specific inputs and outputs. There is a strong difference between how efficiently paid and unpaid labour are used for creation of both environmental/ diversification and livestock outputs, with unpaid labour scores consistently higher than paid labour scores.
The efficiency of unpaid labour in creation of traditional livestock products as compared to environmental/diversification is, as expected, lower. Both paid and unpaid labour are more

efficiently used on sheep farms than cattle farms to produce livestock outputs. It is less surprising that, compared to all other inputs, the use of unpaid labour is the most efficient for creation of environmental outputs, than it is the fact that unpaid labour is still highly efficient for creation of traditional livestock products, e.g., higher than land area and paid labour. This is consistent with the current discussion on distribution of paid and unpaid labour across these types of farms – even more evident following the period of analysis due to recent developments e.g., Brexit.
Regression findings show subsidies and organic status as consistently significant in a majority of environmental and traditional models, which supports the issues presented in the case study description on subsidies dependence and differences between types of labour. The relationship between farm organic status and efficiency scores of labour used for both 'traditional' and 'diversification' outputs emphasise that organic production is not only environmentally oriented but has a clear economic reasoning.

References

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