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Disadvantage and economic viability: characterising vulnerabilities and resilience in upland farming systems

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ABSTRACT

Less Favoured Areas (LFA) were designated to support farming activity on land with limited productive potential. However, progressive land abandonment in these areas questions the rationale and targeting of support payments to maintain viable farming enterprises. Using micro level data on farm businesses over the period 2003-2016 matched to land capability and spatial data we identify the distribution of viable and vulnerable enterprises in Less Favoured Areas. We find five categories of household based on progressive quality of life thresholds, namely i. vulnerable, ii. sustainable, iii. viable, iv. resilient, and v. robust. A proportional odds model measured the effect of biophysical and remote disadvantage on predicting these states of viability, along with farm family lifecycle factors. Whilst we would expect higher proportions of disadvantaged farmland to be negatively related to viability, when combined with rural remoteness this increases the magnitude of the effect. However, clear succession planning and tenancy arrangements suggest that approaches to management of the business and the farm family life-cycle may overcome some of these disadvantages. These results have to be considered against the UK's planned withdrawal from the Common Agricultural Policy. This offers opportunities to provide a more nuanced approach to targeting and supporting disadvantaged regions beyond current criteria. However, there would seem to be dissonance between the proposed payment for public goods agenda, which is results orientated, and support for correcting natural disadvantages where opportunities for delivery of these public goods will be limited.

1. Introduction

One of the rationales for intervention in the rural economy is the desire to correct for biophysical disadvantages (Caskie et al., 2001; Shucksmith and Rønningen, 2011; Renwick et al., 2013). Agricultural land disadvantage can be defined as '*farming on land in mountain areas, farming in areas affected by specific handicaps which produce ecological or social benefits, or farming in areas at risk of specific land abandonment*' (Renwick et al., 2013; Milenov et al., 2014; Terres et al., 2015). Less Favoured Areas (LFAs) were designated as part of the rural development component of the Common Agricultural Policy (CAP) and covered around 57 % of utilised agricultural area within the European Union (European Commission, 2017). The purpose of the area designation was to contribute "*through continued use of agricultural land, to maintaining the countryside, as well as to maintaining and promoting sustainable farming systems*" (Council Regulation (EC) No 1698/2005). Less Favoured Areas were defined nationally against biophysical, environmental and rural criteria (Orshoven et al., 2014). The mechanism for support tended to compensate for disadvantages across a number of discrete gradients, from least to most disadvantaged land.

The low land productivity of these areas reflects a limited production set which constrains the ability to generate a sustainable household income directly from agricultural production. Activity on least favoured land is generally characterised by extensive livestock farming, usually hill sheep and cattle systems (European Commission, 2010). High proportions of LFA land are also in remote regions which has social effects in terms of isolation, limited access to health services, broadband and transportation links, but also economic effects as there are limited opportunities for non-farm employment (Copus and Crabtree, 1992; Dax, 2005).

The narrative for support of these areas tends to coalesce around ensuring land is not abandoned to continue to generate positive ecosystem services from extensive practices (Hodge, 2000; Navarro and Pereira, 2015). In addition, a social argument to support sustainable rural communities exist in areas where alternative employment is limited (MacDonald et al., 2000; Gray, 2000; Barnes et al., 2011; Keenleyside and Tucker, 2010; Renwick et al., 2013). Operating a farm within a disadvantaged area will have multiple implications for

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decision-making (Bowler et al., 1996; Hill, 2012; Barnes et al., 2015). Labour resources are constrained as family farms are dominant within these areas with little or no dependence on non-family labour (Berry, 1987; Hayes-Conroy, 2007). Nevertheless, a variance in performance has been observed across similar biophysical or peripheral areas, which reflect differences in both the outlook and on-farm entrepreneurial activity of farmers managing their approach to these disadvantages (Phillipson et al., 2004; Vittis et al., 2017).

The main risk factor leading to abandonment is a sustained low level of economic viability (Strijker, 2005; Terres et al., 2015). Farm viability can be defined as the "*farm household that receives enough income from all sources to cover minimum family living expenses, cash farm operating costs and capital replacement costs at the same time as it improves its net worth by making scheduled principal payments on its debts*" (Salant et al., 1986). Implicit within this definition is the capacity of business entities to meet their operating expenses and financial obligations and also, if this matches business objectives, to accommodate growth within the business enterprise. Viability consequently underlines the evolution of a system to defined constraints (Aubin et al., 2011). This includes a time dimension, however very few studies have used longitudinal data to analyse the micro-dynamics of farm viability, though there is considerable evidence of volatility in individual farm incomes (Hegrenes et al., 2001, Meuwissen *et. al.*, 2008). This emphasises the importance of using multi-year data to draw meaningful conclusions about the living standards of individual farmers under climatic, structural and economic pressures (Meuwissen et al., 2018).

The aim of this paper is to extend the current studies on farm economic viability to farming systems in areas of low opportunity. In so doing we aim to identify whether a viability gap exists across these farms and highlight more nuanced policy dialogues aimed at supporting economic viability in these marginal areas. We focus on Scotland which has the largest proportion of remote and disadvantaged rural area in Europe. In addition, assessing viability of these systems is more pertinent with the UK's withdrawal from the EU Common Agricultural Policy and current UK discussion documents on future support frameworks (Defra, 2018; H M Government, 2018). These documents argue for a significant rethinking of the rationale behind intervention and the outcomes desired from UK taxpayers for its land . A further methodological addition to the literature is to utilise the opportunity afforded by linking farm accountancy data with multiple spatial data sets on land use and remoteness. This widens the range of factors which may explain a particular observed economic state.

The paper is set out as follows. The next section provides a conceptual overview on both the measurement of viability, but also the factors which have been found to influence viability. This shapes the approach for data gathering and modelling these factors. Then results are presented and discussed in terms of implications for future methodologies and policy issues.

2. Conceptual framework

Farming viability generally refers to the financial return from management of productive land. This infers a relationship between income and appropriate land stewardship (Christensen and Limbach, 2019). Moreover, O'Donoghue et al. (2017) argued that viability should reflect the importance of making a living as a key priority. This suggests that the farm household should obtain an income which reflects a standard of living that supports some level of farming activity. When measuring income most studies use indicators from farm national accountancy databases, such as farm family income or farm business income (Vrolijk et al., 2010; Barnes et al., 2015; O'Donoghue et al., 2017).

Some authors have augmented this income measure with a return to assets as a means to accommodate the actual financial return from land and capital. An example is a 'cost of capital' measure which has been used for a number of years in Ireland. This has remained fixed at 5% to reflect the lack of movement in land markets within Ireland (Frawley and Commins, 1996; O'Donoghue et al., 2016). For countries with more liquid land markets, Vrolijk et al. (2010) argued that this return on assets should equate to an alternative low risk return. They applied the return to Government bonds (as a safe low yielding asset) to their assessment of a number of European countries. The return is then compared against a threshold measure which reflects an equitable standard of living or at least a return which is positive (Frawley and Commins, 1996; Hennessy and O'Brien, 2006; Hennessy et al., 2008; Barnes et al., 2015; O'Donoghue et al., 2016).

Frawley and Commins (1996) compared Irish farming incomes from national farm accounts with the minimum agricultural wage rate to set the threshold for viability. Vrolijk et al. (2010) used the EU farm accountancy data network (FADN) to identify the viability of farms after reform of the Common Agricultural Policy in 2003. Their indicator rested on family farm income being positive. They then tested this further by including opportunity costs, reflective of income foregone, set at local interest rates for 10-year government bonds. Some authors have extended analysis of viability using multiple years from the FADN to incorporate the dynamics of farming incomes (Aubin, 1991; Barnes et al., 2015; Allanson et al., 2017; Hooks et al., 2017).

Studies on farming viability to date have only associated differences to a restricted set of factors. Vjorlick et al. (2010) found variances across EU countries in the proportion of farms classified as viable within their sample. They argued that this disparity may be due to natural circumstances, but also structural and institutional factors, e.g. the penetration of advisory and research services within a particular country. Barnes et al. (2015) found that both on-farm and off-farm diversification were positively related to viability within both Scottish and Swedish farms. Moreover O'Donoghue et al. (2016) applied a standardised metric of income across 8 different European countries finding differences due to the presence of off-farm employment.

A more common farm level structural factor found to influence viability has been ownership status. This infers a long-term return from land assets and offers leverage for borrowing and investment (Hill, 2012), but also includes rights to subsidies on land rented to other farmers. Related to this are both succession and retirement which emphasises the importance of farm family life cycles and reflects an accumulation of capital or withdrawal from investment (Potter and Lobley, 1996; Errington, 1998; Burton, 2006; Lobley and Butler, 2010; Barnes et al., 2016). These studies find that, in general, farms run down the business if there is no planned successor. Conversely, there is investment activity to make the business attractive for the successor or another investor. A further reason for investment is to benefit from taxation effects through passing on property within the family (Leonard et al., 2017; Calus et al., 2008; Inwood and Sharp, 2012).

The common metric for identifying biophysical disadvantage is based in the Land Capability for Agriculture (LCA) characterisation. This is inferred through a composite mixture of soil type, climatic constraints, higher slopes and gradients. This classifier is used in most European countries reflecting the extent to which the physical characteristics of the land impose long term restrictions on productivity and cropping flexibility (Simensen et al., 2018). Within upland grazing systems there are large tracts of land that are poorly productive, and farms have a limited labour resource to regularly monitor cattle and sheep health. The lack of quality forage further increases the probability of loss in yield and higher mortality (Matthews et al., 2006; Acs et al., 2010). This is compounded by variable climatic factors which will reduce productivity through either heat/cold stress or increased disease prevalence in these marginal areas (Olesen and Bindi, 2020; Berry, 1987; Rounsevell et al., 2006).

In addition to biophysical and climatic constraints, viability is affected by rurality. Distance to urban markets can have multiple effects for on and off farm economic development (Shucksmith and Chapman, 1998; Wiggins and Proctor, 2001; Buciega et al., 2009). These include increased costs for transport of goods to livestock markets and, conversely, the cost of importing inputs onto the farm (Pangbourne and Roberts, 2015; Warren, 2007; Lima et al., 2018). More pertinently upland farms tend to rely on off-farm income sources, but this greater remoteness limits the range of opportunities available (Bowler et al., 1996; Barnes et al., 2016; Weltin et al., 2017). Lange et al. (2013) also found that '*rural attractiveness*' was a predictor of off-farm employment generation. Specifically, they argued that in areas of low rural attractiveness where the distance to urban markets is large this can be a predictor of abandonment.

3. Data and methodology

We focus on Scotland as 88 % of agricultural land is classified as LFA and which has the highest proportion of land in remote rural areas in Europe (Scottish Government, 2017). Farm income is heavily supported by subsidy and these areas are characterised by family farms operating mostly extensive beef and sheep systems.

3.1. Data

The farm business survey (FBS) is collected on an annual basis. This provides the main source of microeconomic data on farm businesses in Scotland. The farms in the survey are chosen to be representative of their size and type, where the economic size of the business is measured as standard labour requirements for activities on the farm[1] . Within the FBS the farm type classification is based on the relative importance of the various crop and livestock enterprises in terms of standard gross margin[2] (Allanson et al., 2017)[3] . The FBS is typified by low dropout rates as, once recruited, farms can stay in the survey for an unlimited length of time (Scottish Government, 2013). Whilst focused on agricultural activities some information is also available on non-farm income sources and investments.

We take the observations from the 2003 − 2016 time period and drop all farms purely with land in non-LFA areas. This removes some of the high performing specialist cereal, general cropping, lowland beef and dairy enterprises who traditionally operate intensively. In addition, any farm with less than 3 years of consecutive observations was dropped from the panel in order to asses continuity of performance. This leads to a final sample of 5072 observations over a 14-year period, equalling an average of 362 farms per year. The Scottish farm business survey data is limited in terms of biophysical and indicators of remoteness. In order to overcome these weaknesses, the FBS data were joined with the Scottish Land Capability Assessment data and rural distance markers from the June Agricultural Survey.[4]

Land Capability Assessment provides information on the types of crops that may be grown in different areas dependent on environmental and soil characteristics.[5] For Scotland this breaks down into 13 discrete classes of land plus 1 for urban areas. Land capability ranges from Class 1 defined as 'Land capable of producing a very wide range of crops' to Class 7, defined as 'Land of very limited agricultural value'. The bulk of land in our sample of farms coalesces around land which only offers limited opportunities for grass growth and rough grazing. To indicate the amount of poor land on each farm we take the proportion of land within the categories 5.1–7 as a ratio of total land on the farm.

A common metric of rurality is the rural-urban typology approach (OECD, 1994, 2001; 2006; European Commission, 2010). Remote rural regions are defined based on driving time to an urban centre (Dijkstra and Poelman, 2008). This provides a more nuanced approach to rurality and accommodates those farms near to and away from urban centres. This would affect market access and transportation costs, as well as accessibility to infrastructural and support services. The farms in the sample are in areas with one of the following classifiers:

i)'accessible rural', defined as 'areas with a population of less than 3000 people, and within a 30 min drive time of a settlement of 10,000 or more',

ii)'remote rural', defined as 'areas with a population of less than 3000 people, and with a drive time of over 30 min but less than 60 min to a settlement of 10,000 or more',

iii)very remote rural', also defined as 'areas with a population of less than 3000 people, and with a drive time of over 60 min to a settlement of 10,000 or more'.

Moreover as both poor land and remoteness are not mutually exclusive, we take an interaction term composed of the ratio of poor land to total area by rural classifier for each farm. This shows the magnitude of increasing proportions of poor land being in different remote rural regions. The full set of variables used within the estimation, their data source and the descriptive statistics are shown in Table 1.

3.2. Defining viability

Following O'Donoghue et al. (2016) we define viability in a three-stage approach:

a. Construct an hourly rate for return

We take our income metric to be family farm income[6] . This represents the return to all unpaid labour. A return is expected on annual asset values in order to infer costs of own capital and we take the annual return on UK government bonds per year as the main measure. Eq. (1) shows the per hour value of Family Farm Income ($FFIhr_{nt}$) equal to the Family Farm Income for farm n in time t (FFI_{nt}) less the return on assets (RoA_{nt}), divided by the hours worked for the farmer and family labour (hr_{nt})

$$FFIhr_{nt} = \left(\frac{FFI_{nt} - RoA_{nt}}{hr_{nt}}\right) \tag{1}$$

b. Identify the viability threshold

The hourly rate of return should exceed a threshold value which would represent a positive return. The minimum agricultural wage is mostly used as the key threshold (Hennessy et al., 2008; Barnes et al., 2015), or where studies are multi-national (and therefore do not reference a national level metric) they use more generalised benchmarks, such as a positive return to investment (Vrojlick et al., 2010; O'Donoghue et al., 2016). We would argue that applying the minimum agricultural wage, where possible, is a better metric as it provides a common indicator of a standard of living. It also reflects discussions on social equity and reduction of poverty found within the wider literature on poverty thresholds (Hirsch, 2017; Parker et al., 2016).

c. Identify whether the farm is viable

The viability indicator is an ordered category. A number of authors (Hennessy et al., 2008; Hanrahan et al., 2014; Barnes et al., 2015; Donoghue et al., 2016) identify farms as i) vulnerable, ii) sustainable, and iii) viable. We define and extend these further into 5 ordinal

[1] Standard Labour Requirements (SLR) are a coefficient represent the notional amount of labour required by a holding to carry out all of its agricultural activity. Standard Labour Requirements are derived at an aggregate level for each agricultural activity.

[2] The standard gross margin is a measure of the production or the business size of an agricultural holding. The standard gross margin (SGM) for a farm is the difference between the gross production (to which subsidies are added) and the variable specific costs.

[3] The sampling frame excludes small farms of less than 0.5 Standard Labour Requirements (SLRs) thereafter.

[4] We are grateful for Kev Bevan and the Scottish Government for approval to match these data.

[5] https://soils.environment.gov.scot/maps/capability-maps/national-scale-land-capability-for-agriculture/.

[6] Family farm income is a broader measure than net farm income in that it represents the return to all unpaid labour (farmers and spouses, non-principal partners and directors and their spouses and family workers). It also includes breeding livestock stock appreciation.

Table 1
Variables used within the estimation, with descriptive statistics.

Source	Variable		Mean	Std.Dev	Min	Max
June Agricultural Survey	Management	Categorical variable reflecting ownership structure, where (0) is owner-occupier (44 %), (1) tenanted (25 %), (2) mixed (30 %)	0.85	0.85	0.00	2.00
Farm Business Survey	Specialisation	Ratio of livestock activity relative to total turnover	0.84	0.37	0.00	1.00
Land Capability for Agriculture	Poor Land[a]	The ratio of least productive land to total agricultural area	0.68	0.38	0.00	1.00
June Agricultural Survey	Distance Disadvantage[b]	Dummy variable representing urban-rural classification. Where (1) accessible rural (42 %); (2) remote rural (33 %); (3) very remote rural (25 %).	1.51	0.75	1.00	3.00
June Agricultural Survey & Land Capability for Agriculture	Rural Classification* Poor Land	Interaction terms capturing the effect of poor land and rural distance, namely (1) accessible rural * poor land; (2) remote rural * poor land; and (3) very remote rural * poor land				
Farm Business Survey	Successor	Binary variable where 1 indicates a successor has been identified	0.43	0.50	0.00	1.00
Farm Business Survey	Retiree	Binary variable where 1 is 5 years or less to retirement identified by farmer	0.11	0.31	0.00	1.00
Farm Business Survey	Education	Binary variable where 1 is educated to diploma level in agriculture	0.68	0.47	0.00	1.00
June Agricultural Survey	SLR	Standard Labour Requirement, reflecting intensification of the enterprises	3.73	4.83	0.004	76.82
Farm Business Survey	Dairy	Binary variable where 1 identifies a dairy farm type	0.08	0.28	0.00	1.00
	Time Trend	Representing years (2003 – 2016)	8.00	4.00	1.00	15.00

[a] These are defined as limited opportunity land (LCA class 5.1–7).
[b] These are defined as Accessible Rural: Areas with a population of less than 3000 people, and within a 30 min drive time of a settlement of 10,000 or more. Remote Rural: Areas with a population of less than 3000 people, and with a drive time of over 30 min but less than 60 min to a settlement of 10,000 or more. Very Remote Rural: Areas with a population of less than 3000 people, and with a drive time of over 60 min to a settlement of 10,000 or more.

categories:

1. *Vulnerable farms*: farms who do not meet the minimum wage threshold and generate less than 50 % of total income from measurable non-farming activities,
2. *Sustainable farms*: farms who do not meet the minimum wage threshold, but have at least 50% of total income from measurable non-farm activities[7],
3. *Viable farms:* farms where the return is higher than the minimum agricultural wage,
4. *Resilient farms*: those farms who are consistently viable for at least 3 years, and
5. *Robust farms:* those resilient farms who are still viable with 50 % subsidy removed from farm income for at least 3 years.

A resilient group accommodates the temporal element by simply identifying farms which maintained their viability over at least 3 years. This should be a suitable length of time to accommodate economic and climatic perturbation in the sample time period (2003–2016) and assess relative movement of farms against these thresholds. There is limited literature which defines a time frame for assessing resilience in farming (Shadbolt et al., 2017). Given the nature of how farms are included, or drop out, of the Farm Business Survey 3 years is a pragmatic choice in which to capture enough consistency in performance. This allows us to make a judgement on the farm's ability to resist exogenous and endogenous changes whilst not compromising sample size.

Family Farm Income includes the value of outputs plus subsidies and we simply reduce the value of subsidy payments by 50 % from the income calculation. This is in order to identify robustness of their survival under significant policy change. Total removal of subsidies has been discussed as an extreme scenario in UK conditions under a potential Brexit scenario (see Shrestha et al., 2018), but it is also worth noting that the amount spent on the CAP has been reducing and it is likely that subsidies may reduce further in the next round of CAP talks. Consequently whilst an extreme and unlikely case in the short-term this may reflect a longer-term policy ambition for farms in Europe.

3.3. Estimation approach

In order to explain the effects of various factors on viability a proportional odds model (POM) was used. The states of viability follow progressive hurdles and can be defined as 1 (Vulnerable) 2 (Sustainable) 3 (Viable) 4 (Resilient) 5 (Robust). Accordingly, the proportional odds model approach allows us to understand what determines progressively higher levels of viability within Scottish farming. The model is usually written as

$$logit\,[P(Y \leq \kappa)] = \alpha_\kappa - \beta x \quad (2)$$

Where Y is an ordered response category with κ levels, α is an intercept, β a simple linear slope, and x a vector of explanatory variables. In this form the slope of β does not change, but the intercept reflects the cut-off point between two ordinal categories. In our case these are between vulnerable and sustainable, sustainable and viable, viable and resilient, and resilient and robust.

4. Results

4.1. Distribution of viability states

Fig. 1 shows the average proportion of the FBS households across the whole time period who are classified into the 5 viability states. On

[7] In some studies this is simply identified as having an off-farm job. Our data cannot identify this as an activity to our satisfaction and therefore we take a threshold for non-farm income.

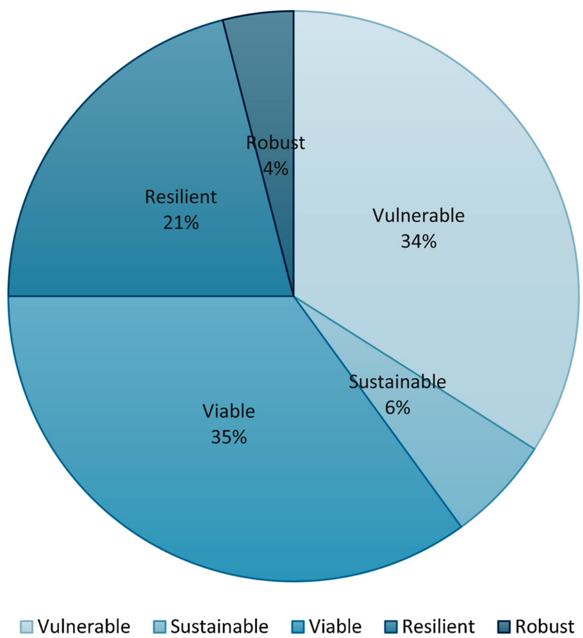

Fig. 1. Average proportion of farms by viability state, 2003-2016, percent.

average the proportion of farms classified as vulnerable account for 34 % of the sample, with 6 % of farms identified as sustainable. The remaining 60 % of farms in the sample are classed as either viable, resilient or robust.

O'Donoghue et al. (2016) provides the most recent assessment of viability states within selected European Union countries. However, they found a great deal of variance across countries. The proportion of farms that were deemed viable ranged from 9% to 57 %, with Greece and Hungary having the highest levels of viability. In addition, they found the proportion of vulnerable farms varied from 30 % to 60 %. Barnes et al. (2015) also found wide variances between farms in Scotland and Sweden, using a different income measure. Overall, they identified around 70–80 % of Scottish farms were viable for the period 2000–2012, compared to 40–50 % within Sweden. Accordingly, the viability assessment is dependant on the meassure used but also the time frame of the assessment.

4.2. Proportional odds model

The proportional odds model was fitted with clustered standard errors to allow for farm data with repeated observations. The model showed a reasonable fit with a pseudo R^2 of around 0.43. Tests for collinearity showed variance inflation factors with a mean of 2.7, encompassing a range from 1.9 to 3.2 which are within the bounds of acceptability (Hair et al., 2006). The Wald chi^2 (308.63***) rejected the null hypothesis, hence including the predictors is a statistically significant improvement in the fit of the model.

Table 2 shows the coefficients, the exponents of the coefficients (odds ratios) and standard errors for the model. As our response variable runs on an ordinal scale the results show the effect of an explanatory variable leading to a more viable, compared to a less viable, outcome. Variables with odds ratios above 1 have a positive effect on viability, compared to those below 1 which have a negative effect.

Tenancy and mixed forms of management, namely businesses composed of both tenancy and owner-occupation, tend to be more viable than solely owned enterprises. This follows multiple studies which find that the flexible status of tenants, as well as the external demands of tenancy relationships, compared to owner-occupiers, leads to the pursuit of higher efficiencies (Garcia et al., 1982; Feng, 2008; Barnes et al., 2010).

Table 2
Maximum likelihood estimates of the Proportional Odds Model, coefficient effects, odds ratios, standard errors and significance.

	Coeff. (β)	Odds (exp(β))	*Std. Err.*	Significance
Management[a]				
Tenant	0.669	1.952	0.083	***
Mixed	0.519	1.680	0.077	***
Specialisation	−0.253	0.776	0.084	**
Poor Land	−0.402	0.669	0.145	**
Rural Classification * Poor Land [b]				
Remote rural	−0.176	0.839	0.210	
Very remote rural	−1.586	0.205	0.320	***
Successor	0.411	1.508	0.069	***
Retiree	0.194	1.214	0.102	–
Education	0.252	1.287	0.073	***
Standard Labour Requirement	0.065	1.067	0.010	***
Dairy	0.525	1.690	0.111	***
Time Trend	0.025	1.025	0.008	**
Thresholds				
k_1	0.404		*0.116*	
k_2	0.767		*0.117*	
k_3	1.868		*0.121*	
k_4	3.870		*0.140*	
Count R^2	0.430			
Liklihood Ratio (df = 14)	333.6	***		
Log-Liklihood	−4586.1			

[a] Referenced against 'owner-occupier'.
[b] Referenced against 'accessible town'.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

A higher level of specialisation within the business, namely farms obtaining the majority of agricultural income from a livestock enterprise, has a negative effect on viability. Diversification of enterprises leads to balancing of a farm risk portfolio and increasing income (Glover and Reay, 2015; Barnes et al., 2015). There are shared resources within extensivefarms which leads to economies of scale within labour tasks. Abson et al. (2013), using a simple measure of farm income, also found a positive correlation between diversity of land use and the resilience of agricultural returns.

An increasing proportion of poor land within the farm negatively affects farm viability. This is land with limited production possibilities, and it would be expected that this negatively affects yields. This emerges through both poor weather but also limited monitoring of animal health. This result supports the argument that land that is disadvantaged leads to low financial returns (Macdonald et al., 2000; Crabtree et al., 2003; Dax and Hovorka, 2007; Vjorlick et al., 2010).

The interaction term measures the effect of increasing proportions of poor farm land in different remote rural regions. The odds ratios are negative, when compared with those farms in accessible rural towns, but only significant in very remote rural areas. Wu et al. (2011) focused on the economic connections between urban and rural divides in California. They found that nearness to urban centres had a positive effect on input and output services within the agricultural economy which led to greater levels of viability. Brown et al. (2012) examined extended travel times on the ability to maintain viable farms within selected US states. They argued that differences in viability may be related to the cost of farm land which would be a composite of the productivity of the land but also the increasing value of land when near to urban areas. Consequently, it would seem that farms in very remote rural regions with high proportions of poor land are most likely to be classed as vulnerable. Moreover, the urban-rural classifier is a composite of economic and social indicators, such as access to health services and transport networks. Farmers in very remote regions with poor land are both economically vulnerable, but also affected by limited access to these wider public services.

We find that identifying a successor has a positive effect on viability and the succession variable could reflect an accumulation of capital within the business. Succession has been recognised as a major determinant in ensuring long term planning for uncertainties (Lobley and Potter, 2004; Barnes et al., 2016; Suess-Reyes and Fuetsch, 2016; Darnhofer et al., 2016). Without a succession plan, farms have been found to experience business stagnation and have a higher probability of abandonment (Antrop, 2005; Wheeler et al., 2012). Nevertheless, the relationship between viability and succession is complicated by the nature of the family transfer. This may lead to succession over a number of years as successors are engaged within various enterprises that allows knowledge and experience to grow and ensure a successful handover (Jervell, 1999; Calus et al., 2008). However, the retirement variable, whilst positive, is not significant and may be interrelated to the succession variable. Nevertheless, this argues that focusing on both succession and retirement emphasises the importance of farm family life cycles within sustainable farming structures (Potter and Lobley, 1996; Errington, 1998; Burton, 2006; Lobley and Butler, 2010; Barnes et al., 2016).

Agricultural education, a binary variable dictating whether they have a formal post-school qualification in agriculture, was also found to be positive. This was taken as a proxy for innovation as well as the confidence to enable change to overcome financial issues (Ondersteijn et al., 2003; Barnes et al., 2011). The positive result for this variable tends to confirm, as with previous studies, that education provides a basis for ensuring greater levels of viability within farming (Hennessy and Moran, 2016).

The standard labour requirement reflects farm size, through a notional amount of labour required by the business to carry out agricultural activity. This is positive which indicates a higher probability that larger farms will be more viable. Greater farm size captures economies of scale by spreading their fixed costs and bulk purchasing of inputs. They also have more power in terms of dictating equipment use in response to fluctuating weather events (Duffy, 2009). The dairy farm type also has a positive effect and identifies those farms which have at least two thirds of their income from dairy farming. This also captures the differences in dairy farm economics which tend to be more intensive, efficient and gather higher returns than sheep or beef enterprises (Cabrera et al., 2010; Sobczyński et al., 2015).

5. Discussion

Developed country economies have tended to pursue mechanisms which limit inequality (Painter and Goodwin, 1995; Collantes, 2010). Although support in Less Favoured Areas aims to compensate for physical disadvantages there has been continued land abandonment in areas of low productivity across the European Union (Lasanta et al., 2017; Benayas et al., 2007). Scotland is the only country in the EU to maintain the LFA support scheme (LFASS). The Scottish Government argued that this allowed them to address the specific disadvantages within Scottish upland farming (Scottish Government, 2019). Despite this support, we find around a third of farms are vulnerable and a likelihood of farms becoming more vulnerable if they are in very remote rural regions and have high proportions of poor land. Moreover, this analysis does not accommodate recent reductions in LFASS payments due to changes to EU regulations.[8] The 2019 LFA support payments were cut to 80 % of their 2018 value. Consequently, with lower levels of support these farms will carry an increased risk of becoming vulnerable and exiting the industry.

Understanding the transition from economic vulnerability to exit from farming is complicated by both management ability and the farm family life cycle (Terres et al., 2013). A small number of studies have concentrated on the confluence of age, tenure and limited educational qualifications which determine land abandonment (Łowicki, 2008; Abolina and Luzadis, 2015). Accordingly, current instruments, such as support under the Pillar 2 rural development policies of the Common Agricultural Policy, may be a more effective approach to support these businesses. Specifically, disadvantages from land and remoteness can be addressed through higher levels of training and support for succession planning which could be targeted under current rural development programmes.

Succession planning has been found to positively influence farm viability. Studies applied to various regional contexts also find a positive association between succession and financial indicators, as the successor gradually takes the farming business over, or the enterprise builds up capital to support dual business structures (Lobley and Potter, 2004; Lobley et al., 2010; Barnes et al., 2010; Barátha et al., 2015; Vittis et al., 2017). In addition to succession the support for new entrants and non-family transfer of farms provides an oppourtunity for innovative thinking and approaches to overcome disadvantage (Joosse and Grubbström, 2017). New entrants can lead to more innovative approaches towards land use planning and towards seeking new markets (Winter and Lobley, 2016; Ingram and Kirwan, 2011).

We have also extended previous approaches to viability assessment to encompass resilience of farming systems. Economic resilience covers a range of parameters and farm accountancy data provides some insight into both assessing the persistence of vulnerable states and the stability of a farm business over time. Moreover, micro-data allows an assessment of the incremental adjustment to change within a farm due to exogenous changes (Shadbolt et al., 2017). A measure based on annual incomes over time naturally raises questions on long-term decision-making, especially how wealth is being accumulated and what investment strategies are revealed within the presently observed 'vulnerable' group. Allanson et al. (2017) found that price volatility shocks were transitory and did not fundamentally affect the structural inequality observed within the farming sector in Scotland. This may indicate some underlying resilience due to accumulation of wealth. A wider discussion therefore emerges from this work on measurement of wealth, of which land ownership forms a major component. However, a full assessment of the underlying wealth, as oppose to income, of these farms will be biased as some indicators, such as returns from non-farm investments, are not collected in official accounts (See Hill, 2012; Barnes et al., 2018). Further work, such as examining farm tax returns, would offer a richer evaluation of viability and wealth within the sector.

We use a standard of living indicator which equates to a minimum agricultural wage as a threshold to determine viability. This is not ideal as, unlike other rural workers, farmers do not tend to expend their income on daily commuting nor, in most cases, pay directly for accommodation. They further benefit from hedonic landscape values, relative to those in urban poverty. Some work has focused on rural cost of living indicators (Smith et al., 2010), however so far, comparators for farming are yet to be produced and may be the focus of future work (Hill, 2012; Barnes et al., 2018).

A wider dialogue focuses on the rationale of compensatory instruments correcting for market failures. Waterhouse et al. (2008) and Thomson (2011) identified a loss in breeding sheep numbers in the Scottish uplands as evidence of increasing abandonment. They called for future CAP reforms to address this retreat from hill farming due to the environmental goods generated from these extensive systems. Cooper et al. (2006) identify negative changes in land use and landscape that Less Favoured Area support schemes were expected to offset. Whilst it could be argued that protection against negative land use change has been averted, principally through extensive agricultural practices, it is less clear how other benefits have been achieved from this targeting of support for correcting disadvantages.

The criteria by which a system is said to be disadvantaged differs per region and tends to be exhibited through an evolving set of arguments for continued public expenditure. These arguments currently cover maintaining economic viability to support ecological and social

[8] This is due to lags in receipt of farm accountancy data.

goals within rural areas. The present support mechanism aims to preserve viable businesses and promote ecosystem benefits. This must now be viewed in light of the UK's withdrawal from the EU. Specifically, the potential continuation of any scheme outside of the CAP which recognizes disadvantage as a criterion for support.

Recent statements around promoting payments for public good outcomes in post-Brexit agriculture (Helm, 2017; H.M. Government, 2017) are also pertinent to this study. This dialogue has only so far focused on delivery of public goods and not specifically included discussion of issues around those farming on disadvantaged land. Whilst opaquely connected, i.e. through extensive livestock grazing, there is a clear delineation between compensation for correcting for physical disadvantages compared to payment for activities which lead to public good generation. The former infers the goal of equity distribution, whereas the latter focuses solely on maximising environmental outcomes. Hence, a question for any future support framework is whether the link between payment for public goods can fully address disadvantages due to poor land and remoteness. More crucially there may be limitations in terms of the range of public goods that farms in disadvantaged areas could produce. This could, if ignored, continue the disparities between productive and non-productive regions.

Author statement

AB: Conceptualization, Methodology, Writing. ST: Data Curation and Analysis, Writing. JF: Conceptualization, Data Analysis.

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Appendix A. Supplementary data

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