A typology of cattle farmers in Ireland: An overview of data, method and indicators

By Geraldine Murphy and David Meredith

Rural Economy Development Programme, Teagasc, Dublin 15

Included in the Food Harvest report, which outlines how agricultural sectors may meet a target increase in the value of primary output by 2020, is a suggestion that beef production systems need to improve farm competiveness, technology and knowledge transfer. To implement policies that effectively improve these measures on cattle farms, policy makers need to first account for the high level of heterogeneity that exists across these production systems. Hence, we have developed a typology for Irish cattle farmers. The typology is created using a latent class cluster model, which groups farmers according to demographic, economic and farm level criteria. Eight types of cattle producers are identified: dairy farmers, finishing with tillage farmers, bachelor finishers, elderly farmers selling stores, extensive suckler farmers, hobbyist farmers (or those retaining ownership of their holdings), opportunist farmers and on-farm diversifiers.

Keywords: drystock systems; typology; latent class model

1 Introduction

In a major initiative to create a long-term plan for the agri-food, forestry and fisheries sectors in Ireland the Department of Agriculture, Fisheries and Food (DAFF) commissioned the "Food Harvest 2020" report in 2010. The report is concerned with outlining how these sectors may meet a target increase in the value of primary output (when compared with the base years 2007 to 2009) of €1.5 billion annually by 2020 (DAFF, 2014). As this paper is concerned with the development of a typology for Irish cattle farmers, we are particularly interested in the section of the "Food Harvest 2020" report that addresses beef and livestock production, which assigns the sector a value of approximately €1.9 billion in gross outputs per year. The report suggests that target increases in the beef and livestock sector may be met by improving farm competitiveness, technology and knowledge transfer and production systems.

To create improvements in farm competitiveness, technology, knowledge transfer and production systems for the beef and livestock industry in general require farmers to change their practices at farm level. However, there is substantial variation in the structure of Irish livestock farms, and across individual farmers, which means a farmer's capacity to implement improvements under the "Food Harvest 2020" varies throughout the population. Typologies provide artificial methods for defining different groups based on specific criteria in an attempt to organise and analyse reality (Valbuena, Verburg, & Bregt, 2008). Hence, the typology developed in this paper is pertinent to achieving optimal outcomes for the beef industry[1] under the "Food Harvest 2020" report because it categorises cattle farmers according to the structure and constraints of their holdings and individual-specific factors. In doing so, it develops seven cattle farmer types, which may be targeted by policymakers to meet "Food Harvest 2020" targets in a manner most appropriate to the status of their holdings.

Farm types occur as a function of the outcomes of many choices made by farm households, subject to constraints. To date, the main classification system used for Irish farms differentiates between holdings according to the amount of standard gross outputs they earn from different farm enterprises[2] (Hennessy, Moran, Kinsella, & Quinlan, 2011). That this typology is based solely on gross outputs does not, however, result in a categorisation system that is expected to aptly represent the outcomes of decision-making processes made by farmers. This is because there is substantial evidence that Irish farmers do not make their farm management decisions based solely on which option optimises outputs from farm-specific activities (Howley, Donnellan, & Hanrahan, 2009). In fact, more than 29% of Irish cattle farm were not viable in 2012[3]. The typology used in this paper emphasises the role that potentially constraining farm-level factors, as well as demographic variables, plays on farm type, in addition to variables on farm-specific activities (including gross margins). In doing so, it attempts to model how farm households actually make on-farm decisions, thereby

[1] Irish cattle farms are dealt with specifically in this report because the high degree of heterogeneity in this sector has not been addressed in the related literature before.

[2] This is the EU farm typology set out in Commission Decision 78/463 and its subsequent amendments.

[3] Based on the work of Hennessy (2011) and Frawley and Commins (2013), viable farms are defined as having (a) the capacity to remunerate family labour at the average agricultural wage and (b) the capacity to provide an additional 5% return on non-land assets

capturing a typology that better reflects variation across Irish cattle farms according to the outcomes of these decisions.

The model used for the development of a typology in this paper is a latent class (LC) cluster model, which is a category of latent variable model. Latent variable models are capable of estimating variation in samples that is caused by observed variation. In addition, they can calculate measurement error, or variation in samples that is caused by unobserved behaviour, and adjust the value of underlying latent variables according to these values. A type of latent variable model that is commonly used in related literature for the formulation of farm typologies is factor cluster analysis (De Lauwere, 2005; Magne, Cerf, & Ingrand, 2012; Shucksmith & Herrmann, 2002). The use of LC cluster models for the development of typologies is relatively new but is likely to become increasingly common because these models have a number of advantages over factor analysis, including that they provide probability-based classifications, as well as permitting the concurrent evaluation of relationships between latent classes and covariates (Collins & Lanza, 2010; Magidson & Vermunt, 2002). In addition, LC models do not adhere to the assumptions that data are normally distributed or homogeneous and variables of mixed scale types may be included in the same analysis (Costa, Santos, Cunha, Palha, & Sousa, 2013). To the best of our knowledge LC cluster models have not been used to develop farm typologies in related literature; hence, this paper takes a novel approach for the achievement of this goal.

The following section of this paper describes some of the most relevant typology literature to this study. Section 3 describes Becker's farm household model and how it can be used to theorise how individuals make decisions that determine their type of farm. The estimation model used in this paper, an LC cluster model, is detailed in Section 4 and the data used to develop the farm typology, the National Farm Survey (NFS), is introduced in Section 5. Section 6 shows how the variables used to describe the cattle farm typology were transformed into items as well as providing results from the LC model. In particular, Table 4, and Table 5, shows the item response probabilities (I-Rs) for each item, and the odds ratio for each covariate, associated with the seven latent classes, respectively. This section concludes with a comparison between the newly defined typology and the system classification used in the NFS. Section 7 discusses the results from Section 6 and outlines how they can be used to define a typology with seven categories for Irish cattle farms. Finally, Section 8 provides some concluding remarks.

2 Related literature

Within agricultural economics, geographies of agriculture, rural geography and rural sociology, typologies are often used as tools to simplify highly diverse behaviour, and resulting management strategies, amongst farmers. Farmers' decisions are influenced by a wide range of factors which Edwards-Jones (2006) has grouped under six headings: socio-demographics of the farmer, psychological make-up of the farmer, the characteristics of the farm household, structure of the farm business, the wide social milieu and the characteristics of the potential change to be made. Ideally, farmers should be categorised according to as many of these influences as possible. Two broadly-defined methods for developing typologies are outlined here: descriptive and normative typologies[4]. Studies using descriptive typologies focus on the processes that underlie farmers' choices. In other words, these studies identity farmers' perceptions of, knowledge of, and/or attitudes towards the management of their holdings, all of which are assumed to determine farmers' choice outcomes. Descriptive typologies are developed using qualitative methods to obtain information and have been used, for example, farm restructuring (Lobley & Potter, 2004), environmental- or business-orientated management (Willock et al., 1999) and animal welfare (De Lauwere, Van Asseldonk, Van't Riet, De Hoop, & Ten Pierick, 2012). They have also been used to group farmers according to their modes of survival (Daskalopoulou & Petrou, 2002) and their intentions for the future of their farms (Van Doorn & Bakker, 2007). Aside from describing farming, farmers and farm households, the most common application of descriptive typologies is the identification of baseline (or non-intervention) scenarios with which alternative future scenarios may be compared (Van Notten, Rotmans, Van Asselt, & Rothman, 2003). Advantages of using descriptive typologies include that they are capable of emphasising the significance of commonalities between farmers, of examining interactions between factors influencing farmer type and of viewing farmers' identities as being non-uniform (Fish, Seymour, & Watkins, 2003). In addition, by virtue of the fact that they are developed using techniques that capture individuals' views and intentions towards farming, they are perfectly validated (Davies & Hodge, 2012). However, their specific nature means that descriptive typologies can be difficult to apply to entire farm populations.

Normative typologies, on the other hand, identify trends in farm types using information on internal and external factors relating to the farm. They are often used to categorise holdings according entire farming processes, meaning they require large datasets on farm-specific activities. Examples of normative farming typologies include those by Reidsma, Tekelenburg, van den Berg, and Alkemade (2006), who used variables relating to farm-specific activities from the 2000 Farm Accountancy Data Network (FADN) to classify crop systems in EU25 countries, and Alvarez-Lopez, Riveiro-Valino, and Marey-Perez (2008), who employed data on production processes, yield and consumption from the Census of Agriculture to create a typology for dairy systems in North West Spain. A normative typology was developed for Irish dairy farmers by Smyth, Butler, and Hennessy (2009) who used information on their cost structures, taken from variables contained in the NFS, to develop a typology for economic performance. Another study by Crowley, Walsh, and Meredith (2008) looked at trends in the number of farmers and average farm size per Electoral District (ED) on Irish holdings from 1991 to 2000. The authors identified four types of behaviour with regard to changing layouts of Irish farms: consolidation, dispersal, contraction and expansion. A drawback to these Irish studies is that they only consider the influence of structural and economic factors in their categorisation of farms, which limits their capacity to fully explain heterogeneity in the sector.

Regardless of whether a descriptive of normative framework is used, the criteria for constructing, and evaluating, a typology primarily depends on the objectives of its implementation (Costa et al., 2013). Similar to this study, Bowler, Gordon, Crockett, Ilbery, and Shaw (1996) were interested in grouping farms in the northern Pennines in terms of farm

[4] There are examples of overlap between these definitions. For example, Valbuena et al. (2008) used farm accountancy data, additional socio-economic data, biophysical data and information from a sample attitudinal study to identify farmer types in the Netherlands.

business, farmer and farm household characteristics and identified six categories: industrialists, conventional alternative farm enterprises, non-conventional alternative farm enterprises, other gainful activities, traditionalists and winding down farmers. Shucksmith and Herrmann (2002) show that Scottish farmers in a Less Favoured Area could be grouped as hobby farmers, pluriactive successors, struggling monoactives, contented monoactives, potential diversifiers and agribusinessmen. As previously mentioned, factors that potentially influence farmers' decision-making processes include the wide social milieu, meaning the applicability of UK studies to the Irish case is somewhat limited.

To understand which socio-demographic, psychological, household and farm structure factors are likely to impact on Irish beef farms requires a review of behavioural studies on Irish holdings specifically, which are somewhat limited. Farm income, size, soil type, farmer age and presence of a successor have been found to influence Irish farmers' decision-making with regard to agri-environmental scheme adoption and implementation (Murphy, Hynes, Murphy, O'Donoghue, & Green, 2011; Murphy, Hynes, O'Donoghue, & Murphy, 2014) in addition to organic farming adoption (Lapple & Van Rensburg, 2011). Hennessy and Rehman (2008) show that Irish farmers' off-farm labour decisions are significantly influenced by farm size, system type, farmers' age, the number of individuals living in the household, the value of the farm and the number of unpaid family labour units. Finally, in a qualitative study of what is likely to impact on whether a farmer will consider changing on-farm management practices, Macken-Walsh, Crosson, and Murray (2012) identified both youth and educational and leisure pursuits off-farm as being highly influential.

3 Theoretical model

Farms develop as a consequence of the outcome of on-going management choices made by the farmer or farm household. Behind each choice is a decision-making process. In this paper, we consider Becker's (1993) model, which operates on the basis that farm household decisions are time-allocation decisions[5]. The farm household model is most commonly used in the literature to model farm households' choices relating to off-farm employment (Ahearn, El-Osta, & Dewbre, 2006; El-Osta, Mishra, & Ahearn, 2004; Kimhi, 2004), and how certain policy changes, such as the existence of decoupled payments (Weber & Key, 2012) and setaside programmes (Chang & Boisvert, 2009), influence that choice. Thus far, it has not been used to describe farm households' decision-making processes with the objective of developing a farm typology.

For each decision households make they are assumed to consider the amount of utility (U) they will potentially get from each alternative outcome (j = 1,.., J) and choose the alternative that provides them with the highest level of utility:

$$Max(U_j) \tag{1}$$

[5] It is based on three related assumptions: maximising behaviour, market equilibrium and stable preferences. The latter assumption was eventually dropped.

Usually we only witness the outcomes of the choices made by farmers and not the decision-making process itself. However, according to the farm household model, utility can be derived from one of two goods: income (and the resulting ability to consume) and leisure. Hence, for any one decision made by a farm household, a single potential outcome can be viewed as the following bundle:

$$U_i = U(Y_i, T_i; Z_i) \tag{2}$$

where farmer i gains utility, U_i, from purchased goods, Y_i, and leisure time, T_i. Farm- and farmer-specific characteristics, Z_i, may influence utility directly. They may also impact on utility levels indirectly through current consumption and leisure decisions. The amount of utility that households get from an alternative bundle is dependent on their preferences. Farm households maximise their utility subject to constraints on time, income and farm production:

$$T = T_i + T_f + T_{of} \tag{3}$$

$$P_m Y_i = P_f Y_f - RX + W_{of} T_{of} + V \tag{4}$$

$$Y_f = f\left(T_f, M; Z_f, H_f\right) \tag{5}$$

Equation 3 shows the time constraint. Household members have a fixed amount of time, T, which can be allocated to home time, T_i, time spent on farm work, T_f, or time spent at off-farm work, T_{of}. The budget constraint in Equation 4 shows that the consumption of market goods, Y_i, at the price P_m is limited by the amount of available income earned from farm profits, off-farm wages and other exogenous household income. Farm profit is equal to the price of farm output, P_f, multiplied by output, Y_f, less variable cost, which is the input price vector, R, multiplied by the quantity of inputs used, X. Off farm income is the product of the hours worked off farm, T_{of}, and the wage rate, W_{of}. V contains information on other exogenous household income such as decoupled payments. Finally, the farm production constraint in Equation 5 represents the technology available to produce farm output, Y_f, where $f(.)$ is a concave production function that relates time spent doing on-farm work and the quantity of inputs used, M, to output. Exogenous farm-specific characteristics, Z_f, and human capital stock variables, H_f, both directly, and indirectly (through T_f and M), influence output production.

Every on-farm decision that farm households make is expected to be considered in this manner. The outcome of these decisions dictates farmer type. Hence, as many factors as possible contained in Equations 2, 3, 4 and 5 need to be included in the development of a typology for Irish cattle farmers.

4 Estimation framework

There are three kinds of LC models: LC regression and choice models, LC factor models and LC cluster models. The statistical procedure used in this paper is the latter. The aim of an LC cluster model is to identify clusters within the data that group together persons who share similar interest, values, characteristics and/or behaviour. These models have been used in marketing (Magidson & Vermunt, 2002) and psychology (Costa et al., 2013) literature but thus far have not been used, to the best of our knowledge, for agricultural economics research.

In this study, the LC model postulates that an error-free latent variable, L, can be used to describe different types of Irish cattle farmers. The latent variable is categorical, comprising of a set of latent classes, c = 1,…, C, each of which describes a single cattle farm type. This latent variable is not directly observed. Instead, indicator variables, j = 1,…, J, are observed. Each observed variable, j, has rj = 1,…, R possible response categories. In other words, each farmer chooses one possible response (rj) to each observed variable (j). To understand this concept, it helps to visualise a contingency table showing the frequency of all possible responses to each observed variable6:

$$W = \prod_{j=1}^{J} R_j \qquad (1)$$

where W is the number of cells in the table. Corresponding to each of the cells in the contingency cells is a complete response pattern or a vector of responses to the J variables, $y = (r_1, \ldots, r_J)$. The entire array of response patterns can be represented by the matrix Y_{WxJ}. Each response pattern is associated with $P(Y = y)^7$. The LC model estimates the probability of a particular response pattern occurring as:

[6] The contingency table for this study is too large to display.

[7] $\sum P(Y = y) = 1$

$$P(Y = y) = \sum_{c=1}^{C} \gamma_c \prod_{j=1}^{J} \prod_{r_j}^{R_j} \rho_{j,r_j|c}^{I(y_j = r_j)} \quad (2)$$

where γ_c is the probability of membership in LC c[8] and $\rho_{j\ r|c}$ is the item-response probability (I-R), meaning it represents the probability of response r being given to the observable variable (item) j conditional on membership in LC c[9]. In Equation 2, $I(y_j = r_j)$ is an indicator function, which is equal to 1 when the response to j is equal to r_j and 0 otherwise[10]. This indicator function acts as a device to pick out the appropriate ρ parameters to include in the model.

A vector of covariates, X, can be included in the model to predict LC membership using multinomial regressions. In this scenario, the probability of response pattern y occurring is conditional on the status of each covariate, x_i where $i = 1,\ldots, K$:

$$P(Y = y \mid X = x_i) = \sum_{c=1}^{C} \sum_{i=1}^{K-1} \gamma_c(x_i) \prod_{j=1}^{J} \prod_{r_j}^{R_j} \rho_{j,r_j|c}^{I(y_j = r_j)} \quad (3)$$

where

$$\gamma_c(x_i) = P(L = c \mid X = x_i) = \frac{e^{\beta_{0c} + \beta_{ic} x_i}}{1 + \sum_{c'=1}^{C-1} \sum_{i}^{K-1} e^{\beta_{0c} + \beta_{ic} x_i}} \quad (4)$$

8 $\sum_{c=1}^{C} \gamma_c = 1$

9 $\sum_{r_j=1}^{R} \rho_{j,r_j|c} = 1$ for all j

10 An implied assumption of Equation 2 is local independence – or independence between the observed variables. Without this assumption, ρ would be conditional on other factors aside from c.

In Equation 4, β_{oc} and β_{ic} are coefficients for the intercept, and covariates, for each LC c, respectively. In other words, the model returns *C-1* intercept values plus *C-1* regression coefficient values. Intercept coefficients in this paper are displayed as odds, $e^{\beta 0_c}$, meaning they represent the odds of membership in LC c in relation to the base case when X = 0. Covariate coefficients are given as odds ratios, $e^{\beta i_c}$, meaning they are estimates for the change in odds of membership in LC c in relation to the base case associated with a one-unit change in x_i (Collins & Lanza, 2010).

5 Data

All the data used in this analysis come from the NFS. The NFS was set up in 1972 and has been published annually by the Irish Food and Agriculture Authority, Teagasc, since. The objectives of the NFS, according to Hennessy, Moran, Kinsella, and Quinlan (2013), are to determine the financial situation on Irish farms by measuring levels of gross output, costs, income, investment and indebtedness across the spectrum of farming systems and sizes; to provide data on Irish farm output, costs and incomes to the EU Commission in Brussels (FADN); to measure the current levels of, and variation in, farm performance for use as standards for farm management purposes and to provide a database for economic and rural development research as well as policy analysis. At the time of writing, the most recent year available from the NFS was 2012, which is the year used in this study to represent the current status of Irish cattle farming[11].

In 2012, 922 farms participated in the NFS, representing a national population of 79,292 farms. The classification system that is currently used to identify farm enterprises in the NFS is based on the EU FADN typology set out within Commission Decision 78/463. This typology is calculated based on farms' standard outputs and indicates what the main enterprise on a farm is. Only holdings with a standard output of €8,000 or more (equivalent of 6 dairy cows, 6 ha of wheat or 14 suckler cows) were included in the 2012 NFS sample. Of the 6 systems identified by the FADN typology, two relate to drystock farming. These include farms that focus on sucklers or cattle rearing (Hennessy et al., 2013), however most farms in Ireland have some beef enterprise. To ensure all farms that contribute to Irish beef production are included in the typology, any farmer who sold an animal for beef in 2012 were included in the study sample. This resulted in a sample size of 821 farmers.

(Table 1)

After a review of related literature looking at what variables influence farmers' on-farm decision making, interviews were held with four farm advisors and three Teagasc beef specialists in addition to in-depth discussions with three farmer groups. The purpose of these meetings was to establish which factors the interviewees believed are most influential for

[11] A panel dataset was not used for two reasons. Firstly, the NFS is not balanced, so the representation of each farm over time may have been compromised. Secondly, the minimum farm size included in the NFS was altered in 2010, altering the representative population and making comparisons with previous years difficult.

Irish cattle farmers in determining how they made their on-farm decisions and therefore distinguished them as a farmer type. Variables relating to these factors, which are available from the NFS, are listed in Table 1.

(Table 2)

As Equations 3, 4 and 5 highlight, the choices that farm households can make are constrained by a number of factors. The constraining factors (covariates) used in this study are presented in Table 2. Direct payments provide information on decoupled subsidies farmers received in 2012. Support from spouse is a dummy variable indicating whether the farmer has a spouse who works on-farm. Disadvantaged areas (less severe and severe) are identified as farms with constraints on production as a consequence of environmental factors on their land. Unpaid labour units show the amount of labour supplied by family members.

Of particular interest in Table 1 and Table 2 are the magnitudes of the standard deviations (SDs) relative to the means (or proportions) in Columns 3 and 4. These high values demonstrate a large degree of variation across Irish cattle farms for all the variables and covariates used in this study. In doing so, they highlight the need for a typology for cattle farmers to better describe this variation.

6 Results

The variables in Table 1 are outcomes of choices made by each cattle farmer in the NFS in 2012[12]. To prepare these variables for the empirical model, the first 6 continuous variables in the table were transformed into categorical items. The remaining 6 variables in Table 1 were maintained as categorical binary (dummy) variables.

(Table 3)

Values for the resulting categorical items, which were created from the first 6 variables in Table 1, are shown in Column 2 of Table 3. For the variables farm gross margins, hours on-farm and stocking rate, individuals' were assigned to one of three categorical items based on whether they fell below the 33rd percentile, between the 33rd and 67th percentile or above the 67th percentile of the sample[13]. Variables for calves or weanlings sold, stores sold and finished animals sold were transformed into 3 categorical items indicating whether farmers sold a quantity of the respective animals that was zero, below the 50th percentile or (exactly or) above the 50th percentile of the sample. Finally, Off-farm job, Paid labour, Investment, AES

[12] They represent Max(U_j) in Equation 1 for 12 on-going decision-making processes made by farm households.
[13] This explains why the number of observations for the 9 categorical variables relating to these three variables are exactly (or close to) 130.

participation (AES), Training and Ratio were kept as categorical binary items indicating whether a farmer did (1) or did not (0) have activity relating to the relevant variable in Column 1 in 2012.

A total of three LCMs (with 6, 7 and 8 latent classes respectively) were estimated to determine the best model fit for the identification of categories for cattle farmers[14]. Of these, the 8-latent class model had the lowest G^2 statistic, meaning it was most likely to have produced the observed data, and the lowest Akaike Information Criterion (AIC) value, meaning it had the most optimal balance between model fit and parsimony, of the three LCMs[15] (Collins & Lanza, 2010). Hence, the 8-latent class model was chosen to define the typology for Irish cattle farmers[16].

(Table 4)

The figures in Table 4 show I-Rs estimated by the 8-latent class model, or the probability of a particular item response (r_j) being observed for a given variable (j) conditional on their covariates (Table 2). For example, the first value in the third column of Table 4 indicates that, conditional on their covariates, the likelihood of a person in LC1 earning between €0 and €32,961 in farm gross margins (of all three gross margin items[17]) in 2012 was 0.992.

For an item to be strongly associated with the underlying latent variables representing a latent class, its I-R should, ideally, be significantly different from the probability of occurrence for the entire sample (Table 3). Hence, the significance of each I-R in Table 4 is calculated as the difference between the probability of occurrence for the class in question (its I-R probability value) and the probability of occurrence for the entire sample, divided by the standard deviation (SD).

(Table 5)

[14] To study the unconditional capacity of the items to capture appropriate latent classes, these models were initially run without covariates.
[15] G^2 statistic values: 8-latent class model: 3269; 7-latent class model: 3313; 6-latent class model: 3392.
AIC values: 8-latent class model: 3547; 7-latent class model: 3550; 6-latent class model: 3589.
[16] In addition, the 6-latent class model was shown to farmers' attending a Beef Open Day in Teagasc (June 2014) and, whilst farmers' responded positively to the six classes, they felt there was need for further categories in the study.
[17] Hence, the probability values for all items corresponding to a single variable (see Table 1) sum to 1.

The inclusion of covariates in the LCM permits a simultaneous prediction of membership in each latent class conditional on the covariates and estimation of I-Rs18. The relationships between latent class membership and these covariates are displayed in Table 5 as odds ratios (ORs). ORs show how a unit change in the covariate and membership in the relevant latent class differs from a unit change in the covariate and membership in the base case, LC2. Simply put, an estimated coefficient greater (less) than 1 indicates that farmers are more (less) likely to be found in a particular latent class than LC1 when there is a positive change in the covariate. So, for example, if an OR associated with a latent class is equal to 2, it is twice as likely as the base case but if it is equal to 0.33, then it is only a third as likely.

(Table 6)

The probability distribution for each latent class is displayed on the first line of Table 6[19]. The most important point to take from the probability distribution values is that the likelihood of a farmer being found in each of the 8 classes is reasonably even, with the differences between the least likely class (LC8) and most likely class (LC7) being only 8.5%. To be able to compare across classes requires that each farmer is assigned to the class s/he has the highest probability of falling into. Hence, the second row in Table 6 shows the proportion of the sample that is most likely to fall into each of the 8 classes.

(Figure 1)

Of particular interest to this paper is how the new typology compares with the NFS classification system. Figure 1 shows which of the NFS classifications each of the 8 classes are most likely to be found in. Certain classes adhere strongly to one of the NFS classes. For example, farmers in Latent classes 1, 2, 3, 4 and 7 are all strongly associated with the NFS cattle classifications, although LC1 and LC7 are more likely to be cattle rearing, and cattle other, than not, respectively. The class that is most strongly associated with the NFS dairy classification is LC5, whilst sheep is strongest in LC6 and other LC8 (although these latter two classes appear relatively evenly spread across NFS classifications).

[18] A likelihood ratio test was run to compare the fit of the restricted latent class model (no covariates) with the unrestricted model and found that the unrestricted model was a significantly better fit for the data (chi^2 = 502.9764***).
[19] The probability distribution function for each of the 8 classes is provided in Appendix A. They are all closely clustered around the 0 and 1 values, meaning most farmers fall firmly into one class. In fact, 90.38% of farmers are at least 65% likely to fall into one class.

7 Discussion: definitions of cattle farmer types

7.1 LC1

Famers in LC1 were 99.2% likely to earn between €0 and €32,961 in farm gross margins and 67.1% likely to work between 0 and 1800 hours in 2012. They have the highest probability of falling into the lowest stocking rate category (0.116 to 1.270 cattle/ha) of all 8 types (0.761), which suggests that their cattle enterprises are extensive. This may be explained by the finding in Table 5 showing that LC1 farmers are the most likely of the 8 types to have disadvantaged land. LC1 farmers almost certainly sold some calves or weanlings, and no finished animals, as the probability of them selling 0 for each is 0.001, and 0.999, respectively. Combined with Table 3, Table 4 also shows that LC1 farmers are significantly less likely than the sample average to have paid for labour (0.150 versus 0.414) or to have invested in their land (0.413 versus 0.665). The likelihood that LC1 farmers had an off-farm job is 0.440, making it significantly higher than the sample at 0.219, but nonetheless surprisingly low for a group of farmers with extensive, low earning farms. These farmers are “extensive suckler farmers”.

7.2 LC2

Table 4 shows that farmers in LC2 almost certainly earned between €0 and €32,961 in farm gross margins (0.998) and work between 0 and 1800 hours (0.999). It also shows that they were the least likely of all 8 types to have paid for labour in 2012. These findings may be explained by the fact that they have, on average, the smallest farms in the typology as well as the highest fragmentation (Table 5). Nonetheless their stocking rates do not significantly differ from the sample averages, with them focussing on the attainment of gross outputs from their cattle enterprises more so than any other enterprises (ratio = 0.914). The likelihood of LC2 farmers having an off-farm job is significantly higher than the sample average, 0.219, at 0.712. It appears as though these farmers may be “hobbyist farmers (or those retaining ownership of their holdings)”.

7.3 LC3

LC3 farmers are the youngest of the 8 classes and, despite being likely to be married and have dependents, are the least likely to have unpaid family labour units (Table 5). In addition, the likelihood that LC3 farmers paid for labour is no lower than the sample average (Tables 3 and 4 show them to be 0.405 versus 0.414). These findings suggest that LC3 farmers paid for labour before using family labour, and therefore may not be preparing the farm for a successor. They were 63.4% likely to have farm gross margins in the mid category, €32,962 to €79,530 yet they were 99.5% likely to have on-farm working hours in the low category, 0 to 1800 hours. No conspicuous results for the sale of any number of calves/weanlings, stores or finished animals are visible in Table 4, which suggests that LC3 farmers did not specialise in the sale of a particular drystock animal. These farmers were the most likely type of the 8 to have an off-farm job (0.815) and to participate in an AES (0.756) and the second most likely to have agricultural training (0.482). They are called “opportunist farmers” because their earnings derive from a number of places, both on and off the farm.

7.4 LC4

LC4 farmers were 99.7% likely to earn between €0 and €32,961 in farm gross margins and to have worked between 1801 and 2400 hours in 2012. The number of calves or weanlings they sold did not differ from the sample average; however, the likelihood that they sold between 11 and 133 stores was significantly higher. Further investigation of this latter finding shows that over 60% of farmers in LC4 only sold between 11 and 30 stores and that the maximum number of stores any one LC4 farmer sold was 47. In other words, despite the fact that LC4 farmers have the highest probability of selling the highest category of stores of all 8 types (0.604), the largest quantities of animlas are being sold by other types. These farmers are unlikely to hold off-farm jobs (0.123), to have participated in an AES (0.177) or to invest in their land (0.289). Table 5 shows that LC4 farmers are the least likely of the 8 types to be married or to have dependents and are the second most likely to have both disadvantaged and fragmented land. Overall, these findings suggest that LC4 farmers are earning little from their farms, or elsewhere, possibly as a consequence of environmental limitations on their holdings. They are aging and are likely to be single. These are “elderly farmers selling stores”.

7.5 LC5

Table 4 shows that farmers in LC5 were 83.7% likely to earn between €79,531 and €360,987 in farm gross margins, were 61.1% likely to have worked between 2400 and 3600 hours in the year, were the least likely to have an off farm job (0.042) and were the second most likely of the 8 types to have sold between 12 and 90 calves (0.339) or weanlings in 2012. The importance of gross outputs from their cattle enterprise compared with total farm outputs is the lowest of the 8 types (ratio = 0.085), yet LC5 farmers’ cattle enterprises are 65.6% likely to fall into the highest stocking rate category (1.781 to 4.292 cattle/ha). They are the most likely type to have paid for labour (0.677). Table 5 shows that these farmers have the second largest farms on average of all 8 classes and are the least likely to have disadvantaged land. These findings suggest that LC5 farmers are mainly dairy farmers and the calves they produce are a product of their dairy enterprise. Figure 1 provides confirmation of this observation, as it shows that LC5 farmers are mainly classified as dairy farmers by the NFS. Hence, these are “dairy farmers”.

7.6 LC6

LC6 farmers are 78.0% likely to earn between €32,962 and €79,530 in farm gross margins (the mid category). A significant proportion of these earnings are expected to come from other enterprises besides cattle because the importance of gross outputs from cattle to LC6 farmers is statistically less than the sample average (ratio = 0.409 versus 0.501 for the sample average). These farmers were 48.1% likely to participate in an AES, which is significantly higher than the sample average. They are also significantly less likely than the sample average to sell 0 calves or weanlings or stores (0.334 versus 0.532, and 0.338 versus 0.457, respectively), meaning they are more likely to sell these animals than not. Table 5 shows that LC6 are the second most likely of the 8 classes to have disadvantaged land, although they are only the third most likely to have a high degree of fragmentation and they have the third largest farms. Overall, these findings suggest that LC6 farmers face some environmental challenges on their holdings and take a mixed approach towards farming. These are “on-farm diversifiers”.

7.7 LC7

Those in LC7 were 61.8% likely to earn between €32,962 and €79,530 in farm gross margins, 47.9% likely to have worked between 1801 and 2400 hours and 44.0% likely to have cattle stocking rates between 1.271 and 1.780 cattle/ha, meaning they fall into the mid ranges for the first three variables in Table 4. LC7 farmers were the least likely to have an off farm job (0.076) and they are unlikely to have sold either calves or weanlings or stores (0.889 and 0.856, respectively). However, farmers in this class are 70.6% likely to have sold between 17 and 1080 finished animals in 2012. Further examination of this latter result reveals that only one farmer in this class sold more than 200 finished animals in LC7; hence, they show specialisation as finishers, but are not producing at as large a scale as others in the NFS sample. LC7 farmers are as likely as the sample average to invest in their land. Other points worth noting about LC7 farmers is that they are the eldest of the 8 groups and are unlikely to be married or to have dependents (Table 5). Therefore, although they are likely to be earning a reasonable amount from their specialist farms, there may be a successor issue for LC7 farmers. These are "bachelor finishers".

7.8 LC8

Farmers in LC8 were the most likely of all 8 classes to earn between €79,531 and €360,987 in farm gross margins (0.853) and the second most likely to both work between 2400 and 3600 hours per year (0.498) and to have drystock stocking rates of between 1.781 and 4.292 cattle/ha (0.577). They are unlikely to have sold either calves or weanlings or stores (probabilities for 0 animal categories are 0.840 and 0.756, respectively) but are 99.5 % likely to have sold between 17 and 1080 finished animals in 2012. Further investigation of this finding shows that all 6 farmers in the sample who sold greater than 200 finished animals in 2012 (201, 206, 219, 228, 270 and 1080 animals, respectively) were in this group. Table 5 shows that LC8 farmer were unlikely to have disadvantaged land and that they had the largest holdings of all 8 classes. A large number of these farmers were classified as other (predominantly tillage) by the NFS. Hence, they are "finishing with tillage farmers".

8 Conclusions

In an attempt to quantify some of the variation that exists across Irish cattle farming, this working paper has identified 8 types of beef producer in the country. These types have been grouped according to economic, demographic and farm-level variables to account for the fact that farmers do not only make management decisions based on the farming business, but also based on how the outcome will impact on the farm household.

The 8 types of cattle producers have been named dairy farmers, finishing with tillage farmers, bachelor finishers, elderly farmers selling stores, extensive suckler farmers, hobbyist farmers (or those retaining ownership of their holdings), opportunist farmers and on-farm diversifiers. Overall, 5 of these producer types adhere closely with the NFS classification system for farms (derived by FADN), whereas the remaining 3 do not. This shows the need for a nomenclature that accounts for factors other than farm level production when attempting to classify beef producers.

An area of particular interest for policy makers concerned with Irish cattle farmers is the beef supply chain. The high degree of variation across farmers highlighted by this paper leads to an uncertain and uneven supply of animals to marts, for export and to meat processors. For this reason, the next phase of this work is concerned with an assessment of the role of each of these 8 types in the beef supply chain. This goal will be achieved using Animal Identification and Movement (AIM) data to see where the various producers buy and sell their animals.

9 Acknowledgements

We would like to give a special thank you to Prof. Eddie O'Riordain and the staff at Teagasc, Grange, for their help with the identification of factors influencing cattle farmers' on-farm decisions. Further help was also gleaned from Teagasc beef advisers John Horgan, Liz Duffy and Vivian Silke. Thank you. Finally, we would like to acknowledge the quality of the data gathered by those in the NFS and Brian Moran for his guidance with its use.

10 References

Ahearn, M., El-Osta, H., & Dewbre, J. (2006). The impact of coupled and decoupled government subsidies on off-farm labor participation of U.S. farm operators. *American Journal of Agricultural Economics, 88*(2), 393-408.

Alvarez-Lopez, C., Riveiro-Valino, J., & Marey-Perez, M. (2008). Typology, classification and characterization of farms for agricultural production planning. *Spanish Journal of Agricultural Research, 6*(1), 125-136.

Becker, G. (1993). Nobel lecture: the economic way of looking at behavior. *Journal of Political Economy, 101*(3), 385-409.

Bowler, I., Gordon, C., Crockett, A., Ilbery, B., & Shaw, A. (1996). The development of alternative farm enterprises: a study of family labour farms in the Northern Pennines of England. *Journal of Rural Studies, 12*(3), 285-295.

Chang, H., & Boisvert, R. (2009). Are farmers' decisions to work off the farm related to their decision to participate in the conservation reserve program. *Applied Economics*(41), 71-85.

Collins, L., & Lanza, S. (2010). Chapter 3: The relation between the latent variable and its indicators. In L. Collins & S. Lanza (Eds.), *Latent class and latent transition analysis with applications in the social, behavioral and health sciences*. New Jersey, US: John Wiley and Sons, Inc.

Costa, P., Santos, N., Cunha, P., Palha, J., & Sousa, N. (2013). The use of Bayesian latent class cluster models to classify patterns of cognitive performance in healthy aging. *PLOS ONE, 8*(8), e71940.

Crowley, C., Walsh, J., & Meredith, D. (2008). *Irish farming at the millenium - a census atlas*. National University of Ireland, Maynooth: National Institute for Regional and Spatial Analysis.

DAFF. (2014). Food Harvest 2020: a vision for Irish agri-food and fisheries. Retrieved 15th of May, 2014, from http://www.agriculture.gov.ie/media/migration/agri-foodindustry/foodharvest2020/2020FoodHarvestEng240810.pdf

Daskalopoulou, I., & Petrou, A. (2002). Utilising a farm typology to identify potential adopters of alternative farming activities in Greek agriculture. *Journal of Rural Studies, 18*, 95-103.

Davies, B., & Hodge, I. (2012). Shifting environmental perspectives in agriculture: repeated Q analysis and the stability of preference structures. *Ecological Economics, 83*, 51-57.

De Lauwere, C. (2005). The role of agricultural entrepreneurship in Danish agriculture of today. *Agricultural Economics, 33*, 229-238.

De Lauwere, C., Van Asseldonk, M., Van't Riet, J., De Hoop, J., & Ten Pierick, E. (2012). Understanding farmers' decisions with regard to animal welfare: the case of changing to group housing for pregnant sows. *Livestock Science, 143*, 151-161.

Edwards-Jones, G. (2006). Modelling farmer decision-making:concept, progress and challenges. *Animal Science, 82*(6), 783-790.

El-Osta, H., Mishra, A., & Ahearn, M. (2004). Labor supply by farm operators under "decoupled" farm program payments. *Review of Economics of the Household, 2*, 367-385.

Fish, R., Seymour, S., & Watkins, C. (2003). Conserving English landscapes: land managers and agri-environmental policy. *Environment and Planning A, 35*, 19-41.

Hennessy, T., Moran, B., Kinsella, A., & Quinlan, G. (2011). National Farm Survey 2010. Dublin: Rural Economy Research Centre (RERC) Teagasc.

Hennessy, T., Moran, B., Kinsella, A., & Quinlan, G. (2013). National Farm Survey 2012. Dublin: Rural Economy Research Centre (RERC) Teagasc.

Hennessy, T., & Rehman, T. (2008). Assessing the impact of the 'Decoupling' refrom of the Common Agricultural Policy on Irish farmers' off-farm labour market participation decisions. *Journal of Agricultural Economics, 59*(1), 41-56.

Howley, P., Donnellan, T., & Hanrahan, K. (2009). Do decoupled payments affect farm behaviour? Examinging the implications of the move towards decoupled payments on agriculture. *The Rural Economy Research Centre Working Paper Series, 09-WP-RE-01*.

Kimhi, A. (2004). Family composition and off-farm participation decisions in Israeli farm households. *American Journal of Agricultural Economics, 86*(2), 502-512.

Lapple, D., & Van Rensburg, T. (2011). Adoption of organic farming: are there differences between early and late adoption? *Ecological Economics, 70*(7).

Lobley, M., & Potter, C. (2004). Agricultural change and restructuring: recent evidence from a survey of agricultural households in England. *Journal of Rural Studies, 20*, 499-510.

Macken-Walsh, A., Crosson, P., & Murray, A. (2012). A Qualitative Study of Irish Beef Farmers’ Production Decisions: Summary and Implications for Extension. ISBN 978-1-84170-605-4: Teagasc, Oakpark, Carlow.

Magidson, J., & Vermunt, J. (2002). A nontechnical introdution to latent class models. Statistical Innovations White Paper #1.

Magne, M., Cerf, M., & Ingrand, S. (2012). Understanding beef-cattle farming management strategies by identifying motivations behind farmers' priorities. *Animal, 6*(6), 971-979.

Murphy, G., Hynes, S., Murphy, E., O'Donoghue, C., & Green, S. (2011). Assessing the compatibility of farmland biodiversity and habitats to the specifications of and agri environmental scheme using a multinomial logit approach. *Ecological Economics, 71*, 111-121.

Murphy, G., Hynes, S., O'Donoghue, C., & Murphy, E. (2014). An investigation into the type of farmer who chose to participate in REPS and the role of institutional change in influencing scheme effectiveness. *Land Use Policy*(39), 199-210.

Reidsma, P., Tekelenburg, T., van den Berg, M., & Alkemade, R. (2006). Impacts of land-use change on biodiversity: an assessment of agricultural biodiversity in the European Union. *Agriculture, Ecosystems and Environment, 114*, 86-102.

Shucksmith, M., & Herrmann, V. (2002). Future changes in British agriculture: projecting divergent farm household behaviour. *Journal of Agricultural Economics, 53*(1), 37-50.

Smyth, P., Butler, A., & Hennessy, T. (2009). Explaining the variability in the economic performance of Irish dairy farmers 1998-2006. *Journal of International Farm Management, 4*(4), 1-18.

Valbuena, D., Verburg, P., & Bregt, A. (2008). A method to define a typology for agent-based analysis in regional land-use research. *Agriculture, Ecosystems and Environment, 128*, 27-36.

Van Doorn, A., & Bakker, M. (2007). The destination of arable land in a marginal agricultural landscape in South Portugal: an exploration of land use change determinants. *Landscape Ecology, 22*, 1073-1087.

Van Notten, P., Rotmans, J., Van Asselt, M., & Rothman, D. (2003). An updated scenario typology. *Futures, 35*, 423-443.

Weber, J., & Key, N. (2012). How much do decoupled payments affect production? An instrumental variable approach with panel data. *American Journal of Agricultural Economics, 94*(1), 52-66.

Willock, J., Deary, I., Edwards-Jones, G., Gibson, G., McGregor, J., Sutherland, A., . . . Grieve, R. (1999). The role of attitudes and objectives in farmer decision making: business and environmentally-oriented behviour in Scotland. *Journal of Agricultural Economics, 50*(2), 286-303.

Tables

Table 1: NFS variables used for the development of a drystock farmer typology

Variable	**Description**	**Mean/Proportion**	**Standard Deviation**
Farm gross margin	Farm gross margin (€)	71298.67	61411.05
Hours on-farm	Hours worked on-farm	2089.17	711.45
Stocking rate	Cattle per cattle forage area	1.56	0.60
Calves/Weanlings	Number of calves or weanlings sold	8.10	14.69
Stores	Number of stores sold	8.03	14.11
Finished	Number of finished animals sold	19.81	50.47
Off-farm job	Has off farm employment	1.37	0.73
Paid labour	Amount of paid labour (labour units)	1.59	0.49
Investment	Investment in land improvement (€)	1.33	0.47
AES	Participated in agri-environmental scheme	1.61	0.49
Training	Received formal agricultural training	1.71	0.45
Ratio	Ratio of gross outputs from the cattle enterprise to total gross outputs	1.50	0.50

N = 821. SD: standard deviation. D: dummy variable. [a]One labour unit is calculated in the NFS as being at least 1800 hours worked on the farm by a person over 18 years of age. Persons under 18 years are given labour unit equivalents (Hennessy, Moran et al. 2013).

Table 2: Covariates used in the LCM

Covariate	**Description**	**Mean/Proportion**	**Standard Deviation**
Farm size	Total area farmed (ha)	61.85	39.38
Disadvantaged	Farm has land with limited agricultural capacity	1.28	0.45
Fragments	Number of fragments of land on the farm	3.47	2.32
Unpaid family labour units	Mean amount of unpaid labour in 5 years (labour units)	1.25	0.49
Married	Farmer is married	1.24	0.43
Dependents	Household has child/children under 18	1.62	0.49
Age	Farmers' age (yrs)	55.58	11.35

N = 821. SD: standard deviation. D: dummy variable. [a]One labour unit is calculated in the NFS as being at least 1800 hours worked on the farm by a person over 18 years of age. Persons under 18 years are given labour unit equivalents (Hennessy et al., 2013).

Table 3: Items used for the development of a drystock farmer typology (first 8 variables)

Variable	Item	Obs	Pr(Occurrence)
Farm gross margin	€0 to €32,961	274	0.334
	€32,962 to €79,530	274	0.334
	€79,531 to €360,987	273	0.333
Hours on-farm	0 hrs to 1800 hrs	286	0.348
	1801 hrs to 2400 hrs	267	0.325
	2400 hrs to 3600 hrs	264	0.322
Stocking rate	0.116 cattle/ha to 1.270 cattle/ha	274	0.334
	1.271 cattle/ha to 1.780 cattle/ha	274	0.334
	1.781 cattle/ha to 4.292 cattle/ha	273	0.333
Calves/Weanlings	0 animals	437	0.532
	1 to 11 animals	196	0.239
	12 to 90 animals	188	0.229
Stores	0 animals	375	0.457
	1 to 10 animals	231	0.281
	11 to 133 animals	215	0.262
Finished	0 animals	324	0.395
	1 to 16 animals	249	0.303
	17 to 1080 animals**	248	0.302
Off-farm job	Farmer has off-farm job	180	0.219
	Farmer has no off-farm job	641	0.781
Paid labour	Paid for labour	340	0.414
	Did not pay for labour	481	0.586
Investment	Invested in land	546	0.665
	Did not invest in land	275	0.335
AES	Farmer participated in an AES	318	0.387
	Farmer participated in an AES	503	0.613
Training	Farmer participated in agricultural training	237	0.289
	Farmer did not participate in agricultural training	584	0.711
Ratio	At least 35%*** of farmers' gross outputs are from their cattle enterprise	411	0.501

N = 821. SD: standard deviation. D: dummy variable. [a]One labour unit is calculated in the NFS as being at least 1800 hours worked on the farm by a person over 18 years of age. Persons under 18 years are given labour unit equivalents (Hennessy et al., 2013). **Only one farmer in the sample sold 1080 finished cattle. After that, 6 farmers in the sample sold between 200 and 270. *** 35% is the sample mean.

Table 4: Item-response probabilities for the 8-latent class model

Item	**Category**	**LC 1**	**LC 2**	**LC 3**	**LC 4**	**LC 5**	**LC 6**	**LC 7**	**LC 8**
		I-R (SD)	*I-R (SD)*	*I-R (SD)*	*I-R (SD)*	*I-R (SD)*	*I-R (SD)*	*I-R (SD)*	*I-R (SD)*
Farm gross margin	€0 to €32,961	0.992***	0.998***	0.338	0.997***	0.000***	0.202*	0.381	0.001***
		(0.037)	(0.000)	(0.153)	(0.005)	(0.000)	(0.068)	(0.069)	(0.000)
	€32,962 to €79,530	0.007***	0.000***	0.634**	0.001***	0.162**	0.780***	0.618***	0.145**
		(0.037)	(0.000)	(0.149)	(0.005)	(0.073)	(0.069)	(0.069)	(0.085)
	€79,531 to €360,987	0.000***	0.000***	0.027***	0.000***	0.837***	0.017***	0.000***	0.853***
		(0.000)	(0.000)	(0.025)	(0.000)	(0.074)	(0.054)	(0.000)	(0.085)
Hours on-farm	0 hrs to 1800 hrs	0.671***	0.999***	0.995***	0.382	0.111***	0.201**	0.303	0.125***
		(0.104)	(0.000)	(0.018)	(0.100)	(0.031)	(0.072)	(0.053)	(0.034)
	1801 hrs to 2400 hrs	0.269	0.000***	0.004***	0.478*	0.276*	0.496**	0.479***	0.375
		(0.071)	(0.000)	(0.018)	(0.095)	(0.036)	(0.078)	(0.054)	(0.053)
	2400 hrs to 3600 hrs	0.059***	0.000***	0.000***	0.138***	0.611***	0.301	0.217**	0.498***
		(0.055)	(0.000)	(0.000)	(0.071)	(0.042)	(0.063)	(0.045)	(0.055)
Stocking rate	0.116 cattle/ha to 1.270 cattle/ha	0.761***	0.224	0.449	0.442	0.026***	0.488*	0.382	0.067***
		(0.115)	(0.104)	(0.115)	(0.110)	(0.022)	(0.099)	(0.057)	(0.028)
	1.271 cattle/ha to 1.780 cattle/ha	0.151***	0.414	0.295	0.443	0.317	0.329	0.440**	0.354
		(0.049)	(0.118)	(0.074)	(0.139)	(0.046)	(0.065)	(0.054)	(0.053)
	1.781 cattle/ha to 4.292 cattle/ha	0.087**	0.360	0.254	0.114***	0.656***	0.182**	0.176***	0.577***
		(0.096)	(0.111)	(0.088)	(0.080)	(0.054)	(0.069)	(0.047)	(0.057)
Calves/Weanlings	0 animals	0.001***	0.698*	0.567	0.648	0.469*	0.334**	0.889***	0.840***
		(0.000)	(0.101)	(0.110)	(0.222)	(0.041)	(0.087)	(0.042)	(0.041)
	1 to 11 animals	0.482***	0.232	0.219	0.306	0.191*	0.266	0.110***	0.122***
		(0.089)	(0.076)	(0.074)	(0.090)	(0.030)	(0.061)	(0.042)	(0.035)
	12 to 90 animals	0.516***	0.069**	0.212	0.044	0.339***	0.399**	0.000***	0.036***
		(0.089)	(0.079)	(0.076)	(0.182)	(0.039)	(0.069)	(0.000)	(0.020)
Stores	0 animals	0.644	0.524	0.474	0.001***	0.278***	0.338*	0.657***	0.756***

Item	Category	LC 1	LC 2	LC 3	LC 4	LC 5	LC 6	LC 7	LC 8
		I-R (SD)	*I-R (SD)*	*I-R (SD)*	*I-R (SD)*	*I-R (SD)*	*I-R (SD)*	*I-R (SD)*	*I-R (SD)*
		(0.202)	(0.132)	(0.104)	(0.001)	(0.039)	(0.078)	(0.066)	(0.054)
	1 to 10 animals	0.355	0.400	0.152**	0.393	0.352*	0.404*	0.184**	0.100***
		(0.202)	(0.097)	(0.063)	(0.238)	(0.047)	(0.064)	(0.046)	(0.036)
	11 to 133 animals	0.000***	0.074**	0.373	0.604*	0.369**	0.256	0.158**	0.143***
		(0.000)	(0.095)	(0.090)	(0.238)	(0.042)	(0.061)	(0.049)	(0.044)
Finished	0 animals	0.999***	0.232	0.440	0.732***	0.381	0.657***	0.002***	0.001***
		(0.000)	(0.136)	(0.107)	(0.132)	(0.047)	(0.067)	(0.003)	(0.000)
	1 to 16 animals	0.000***	0.535**	0.353	0.266	0.556***	0.338	0.291	0.002***
		(0.000)	(0.115)	(0.094)	(0.133)	(0.042)	(0.064)	(0.065)	(0.001)
	17 to 1080 animals*	0.000***	0.232	0.206*	0.000***	0.061***	0.003***	0.706***	0.995***
		(0.000)	(0.089)	(0.068)	(0.001)	(0.035)	(0.013)	(0.065)	(0.002)
Off-farm job	Farmer has off-farm job	0.440*	0.712***	0.815***	0.123	0.042***	0.151	0.076***	0.084***
		(0.147)	(0.102)	(0.080)	(0.080)	(0.030)	(0.061)	(0.034)	(0.031)
Paid labour	Paid for labour	0.150***	0.052***	0.405	0.219**	0.677***	0.247**	0.241***	0.674***
		(0.057)	(0.046)	(0.087)	(0.087)	(0.042)	(0.068)	(0.052)	(0.070)
Investment	Invested in land	0.413***	0.630	0.588	0.289***	0.891***	0.605	0.600	0.793***
		(0.084)	(0.104)	(0.077)	(0.100)	(0.028)	(0.080)	(0.055)	(0.044)
AES	Farmer participated in an AES	0.363	0.233*	0.756***	0.177**	0.407	0.481*	0.300*	0.358
		(0.142)	(0.086)	(0.103)	(0.083)	(0.040)	(0.066)	(0.056)	(0.052)
Training	Farmer participated in agricultural training	0.057***	0.223	0.482*	0.020***	0.529***	0.200*	0.085***	0.408**
		(0.048)	(0.093)	(0.106)	(0.026)	(0.049)	(0.049)	(0.040)	(0.057)
Ratio	At least 35%* of farmers' gross outputs are from their cattle enterprise	0.769***	0.914***	0.702**	0.807***	0.085***	0.409*	0.797***	0.516
		(0.067)	(0.074)	(0.080)	(0.078)	(0.034)	(0.070)	(0.044)	(0.062)

LC: Latent class, I-R: Item-response probability, SD: standard deviation.*: significantly different from 0.5 at 10%; **: significantly different from 0.5 at 5%; ***: significantly different from 0.5 at 1%. NFS frequency weights used.

Table 5: Factors influencing class membership

Covariate	**LC 1**	**LC 3**	**LC 4**	**LC 5**	**LC 6**	**LC 7**	**LC 8**
	OR	*OR*	*OR*	*OR*	*OR*	*OR*	*OR*
Married	2.212	1.676	0.477	3.335	1.358	0.654	2.233
Disadvantaged	63.175***	1.092	4.236*	0.424	3.574*	0.945	0.473
Total Area Farmed	1.153**	1.206***	1.101*	1.247***	1.231***	1.207***	1.273***
Age	1.044	0.973	1.124*	0.979	1.044	1.139***	1.011
Dependents	0.386	2.095	0.140*	0.760	0.721	0.325	0.820
Unpaid family labour units	4.511	0.184	23.83**	94.72***	97.07***	26.50***	94.33***
Fragments	0.834*	0.616***	0.984	0.799*	0.742*	0.819*	0.838

OR: Odds ratio. Values in parentheses are Z values. Base case is Latent class 2. *: significantly different from the base case at 10%; **: significantly different from the base case at 5%; ***: significantly different from the base case at 1%.

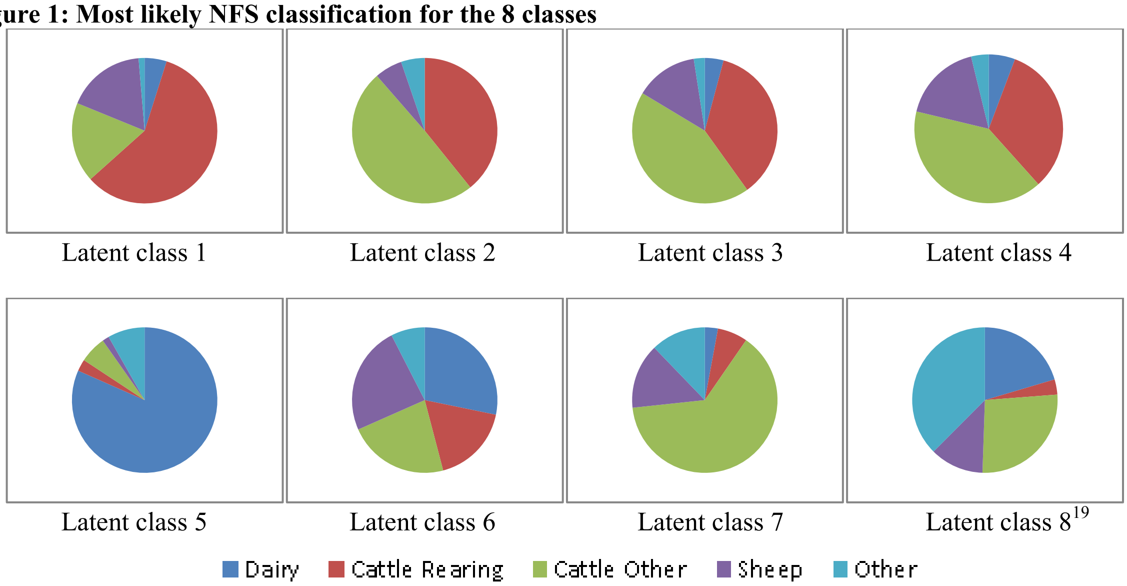
Table 6: Likelihood that cattle farmers in 2012 fell into each latent class

	Latent class 1	**Latent class 2**	**Latent class 3**	**Latent class 4**	**Latent class 5**	**Latent class 6**	**Latent class 7**	**Latent class 8**
Probability distribution of class	0.151	0.107	0.098	0.115	0.149	0.137	0.164	0.079
Percentage of farmers most likely to be found in class[20]	0.118	0.046	0.080	0.071	0.227	0.155	0.156	0.147

[20] NFS weights have been used

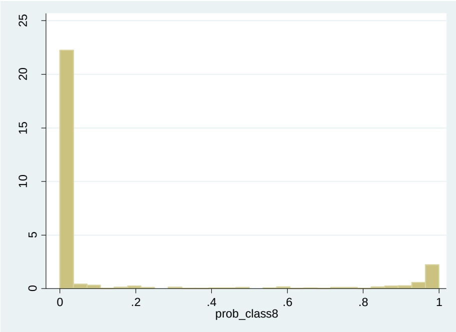
Figures

Figure 1: Most likely NFS classification for the 8 classes

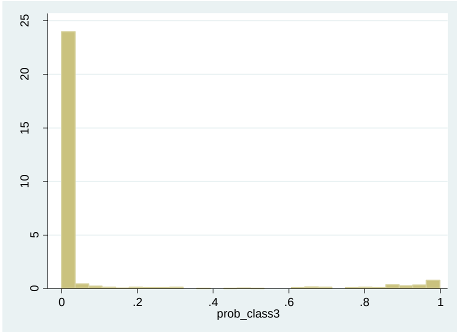


Appendix A

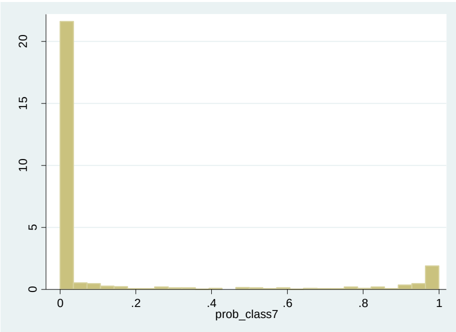
Figure A1: Probability distribution functions for the 8 latent classes



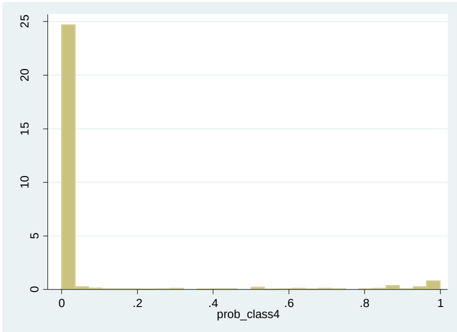
Latent class 1



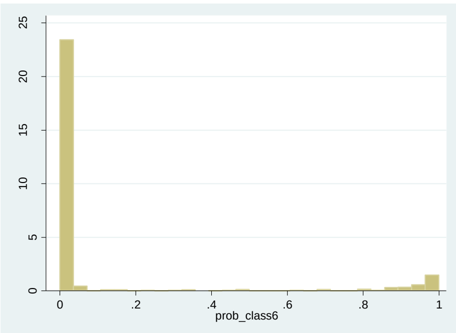
Latent class 2



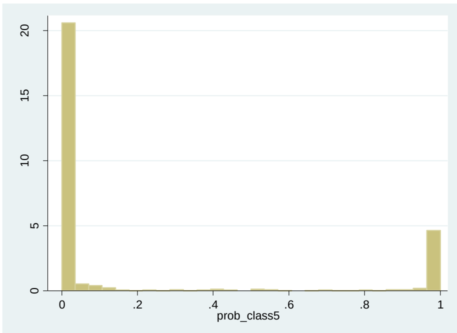
Latent class 3



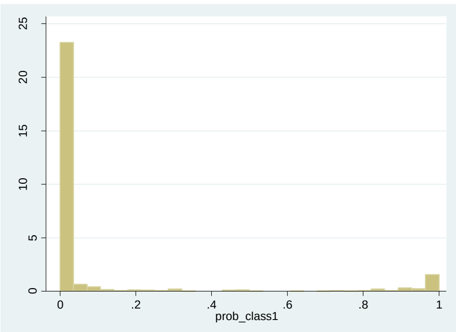
Latent class 4



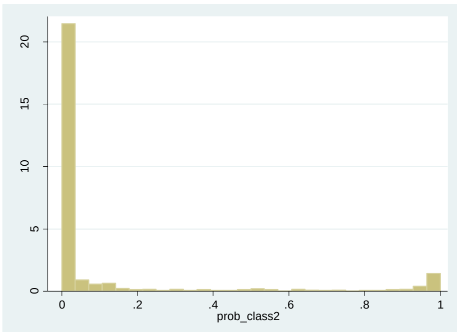
Latent class 5



Latent class 6



Latent class 7



Latent class 8