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The role of differing farming motivations on the adoption of nutrient management practices

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ABSTRACT

This study examined nutrient management practice adoption across a cohort of farmers in the Republic of Ireland with particular emphasis on the role played by different farming motivations. Results of a count data model indicated a number of distinct farming motivations are positively related to farmers' behaviour in the adoption of nutrient management best practices. Specifically farmers more motivated by classifications of 'farm stewardship', 'ecocentric' and 'productivist' considerations were more likely to adopt a greater number of the nutrient management best practices under review. Conversely, the results also indicated that 'anthropocentric' considerations were important to some farmers and this had a negative effect on adoption. A number of demographic and structural variables such as age, off-farm employment status, contact with extension services were found to be significantly related to the probability of adoption of nutrient management practices examined. This analysis highlights important considerations for targeting farmer cohorts for forward land-use planning with regard to tailoring policy measures and incentives in onward reviews of environmental directives and schemes.

KEYWORDS: Nutrient management; practice adoption; farmer motivations

1. Introduction

Farm and field level nutrient management best practice have been shown to significantly improve both farm level profitability (Buckley and Carney, 2013) as well as end of catchment water quality outcomes (Rao *et al*., 2009). Best practice in the area of nutrient management promotes strict management of nutrients (nitrogen (N) and phosphorus (P) mainly) on land to reduce the risk of nutrient mobilisation in runoff pathways to water bodies. The risk to water bodies from excessive N and P supply is over nourishment, or eutrophication, and this can cause biodiversity and amenity impairment (Van Grinsven *et al*., 2013). According to the European Environment Agency (2012), despite some progress, diffuse pollution from agriculture is still significant in more than 40% of Europe's water bodies in rivers and coastal waters, and in one third of the water bodies in lakes and transitional waters.

As a mitigation measure for managing diffuse pollution from agricultural land, farm and field level nutrient management is considered one of the most cost-effective and is embedded in good agricultural guidelines and regulations (Zhang *et al*., 2012). Indeed, Wright *et al*., (2011) found that in Denmark half of the reduction in N leaching for achievement of Water Framework Directive objectives (deemed necessary from agriculture) could be achieved by low cost win-win good agricultural practices at farm level.

However, much like participation in wider agri-environmental and conservation schemes, policymakers often express frustration at the observed levels of adoption of nutrient management practices (Pannell *et al*., 2006). This frustration is even more apparent when increased adoption rates have the potential to lead to a double dividend of increased economic returns to agricultural production while reducing the risk of nutrient transfer to the aquatic environment.

Ideally, policymakers would have a complete understanding of what motivates farmers to adopt desirable nutrient management practices (NMPs) and could then deliver the appropriate set of incentives and messages to amendable individual producers (Prokopy *et al*, 2008). There is a large and increasing literature which suggests farmers' behaviours result from complex processes influenced by a range of socio-economic, psychological and social variables (Willock *et al*. 1999a; 1999b; Pannell *et al*., 2006; Rehman *et al*., 2007; Greiner *et al*., 2009). To-date the literature has focused on the role of environmental attitudes in farmers' decision to adopt best practices in the area of the environment; this paper

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is an exploratory analysis and builds on this literature by specifically exploring other positive and negative motivations underlying nutrient management practice adoption. This paper has the following objectives i) to examine the effect of different underlying farming attitude based motivations on NMP adoption and ii) examine farmer personal and farm structural factors on NMP adoption. The paper proceeds as follows, firstly a review of the practice adoption literature and farmer motivations in this area is presented then the methodology for this study is outlined, results are then presented and some conclusions and discussion is offered.

2. Background

Best practice adoption

There is a growing literature surrounding best practice adoption by farmers and the factors that affect their management behaviour. A variety of socio-demographic factors such as age, education, off-farm employment or identification of a successor have been found to be significantly related to the probability of adopting best management practices (Rahelizatovo and Gillespie 2004; Prokopy *et al*., 2008; Ghazalian *et al*., 2009; Gedikoglu *et al*., 2011; Genskow, 2012). Farm structural and business variables identified to be important include farm size, production intensity, level of diversification and compatibility with current systems (Monaghan *et al*., 2007; Isgin *et al*., 2008; Prokopy *et al*., 2008; Ghazalian *et al*., 2009; Lapple and Van Rensburg, 2011). A number of studies have also highlighted the importance of various factors related to the provision of relevant information needed for nutrient best management such as contact with extension or government agents and or participation in a farmer network or watershed groups as influential in best management practice adoption (Rahelizatovo and Gillespie 2004; Paudel *et al*., 2008; Lemke *et al*., 2010; Baumart-Gertz *et al*., 2012).

The characteristics of the best management practice itself can also affect the probability of adoption as issues such as complexity, familiarity, trialability, cost effectiveness, uncertainty or perceived usefulness have been found to influence technology adoption (Kaiser *et al*., 1999; Flett *et al*., 2004; Pannell *et al*., 2006; Gillespie *et al*., 2007; Monaghan *et al*., 2007; Rehman *et al*., 2007; Ingram, 2008; Vermeire *et al*., 2009; Lemke *et al*., 2010). Finally, positive environmental attitudes and or environmental awareness have been found to influence best management practice adoption (Prokopy *et al*., 2008; Lemke *et al*., 2010).

A limited number of studies have focused exclusively on adoption of NMPs or associated technology adoption. Monaghan *et al*. (2007) found the issue of cost, complexity, compatibility with the current farm system and a perceived uncertainty of actual environmental benefits were key barriers to adoption of some NM technologies in New Zealand. Gedikoglu *et al*. (2011) found that adoption of injecting manure into the soil is positively and significantly impacted by off-farm employment of the farm operator, but off-farm employment had no effect on adoption of record keeping. Ghazalian *et al*. (2009) found that farms with larger animal production enterprises are more apt to implement manure management practices as were those belonging to an agro-environment club. Genskow (2012) found that nutrient management planning courses can lead to changes in farmer nutrient management behaviours but not always toward reducing nutrients. Vermeire *et al*. (2009) found that the successful implementation of desirable animal manure measures was influenced by uncertainty and/or the absorptive capacity of farmers towards new ways of nutrient management in general.

Farmer Motivations

While farmers' production strategies are influenced by technical aspects related to agricultural production and farm structure, differences in farming motivations also play an important role in farmer decision making (Darnhofer *et al*., 2005). Specifically, while business related motivations such as maximising profits will be important to farmers, it may not in many instances be their core motivation for farming. Social scientists have increasingly identified typologies of farmers based on different farming motivations and there is strong evidence from a wide range of studies that there are distinct behavioural categories, some driven more by business and economic motives and others more by environmental or productivist objectives. Pannell *et al*., (2006) suggested that farmers will adopt a new technology/farm practice when he/she perceives that the innovation in question will enhance the achievement of their personal goals. Farmers in turn are influenced by a multiplicity of goals and a myopic view of the profit maximisation goal as driving farm decisions may misrepresent farmers behaviour (Basarir and Gillespie, 2006; Pannell *et al*., 2006; Gillespie and Mishra, 2011, Lokhorst *et al*., 2011).

In this study, through presenting farmers with various attitude based statements different sets of farming motivations are identified which, it is hypothesised, will affect the probability of farmers adopting the nutrient management practices examined. First, in line with much previous research which suggests that productivist motivations are important to famers, a distinction is made between the goals of profit and output maximisation. While agricultural policy may have shifted from production oriented to more decoupled forms of payment, farmers still tend to overwhelmingly obtain a productivist mind set (Gorton *et al*., 2008).

The potential role of environmental values has previously received considerable attention in explaining farmers' environmental related farm practices (Kantola *et al*., 1983; Lynne and Rola, 1988; Beedell and Rehman, 2000; Greiner *et al*., 2009). While some studies have found a discrepancy between environmental attitudes and conservation-oriented management (see for example Plieninger *et al*., 2012), the general finding is that farm operators with more positive environmental attitudes are more likely to engage in conservation behaviour. However, adoption of NM best practices has resource use efficiency and agronomic benefits in addition to environmental ones. These motivations for NM best practice adoption have not received anything like the same attention and are a primary focus of this research.

3. Methodology

Data

The data for this analysis were derived from a survey of farmers within twelve river catchments located throughout the Republic of Ireland and across a range of soils and land use gradient. Geographic Information Systems multi-criteria decision analysis was employed to select these case study catchments, ten of which ranged mostly from 4 km^2 to 12 km^2 and two were approximately 30 km^2. The criteria used for selection included maximisation of agricultural intensity (based on percentage arable or forage area and livestock grazing intensity), minimisation of non-agricultural land uses (forestry, residential housing density) and the selection of a range of soil and geology types that were indicative of high N or P transport risk. The method for catchment selection is further described in detail by Fealy *et al.* (2010). These catchments were selected to represent the range of intensive grassland and arable agricultural interests in the Republic of Ireland across a soil and physiographic gradient that defines potential risk of P and / or N transfers. Consequently, they tend to represent more intensive areas of agricultural production.

A questionnaire was designed to collect data from farmers across a range of topics including attitudes to farming and the environment, farm structures and profile, socio-demographics, contact with extension services and adoption of a range of nutrient management best practices. This questionnaire aimed to establish a baseline in terms of nutrient management practices, assess farmer willingness to provide ecosystem services and explore farmer opinion on regulations post EU Nitrates Directive implementation across the Republic of Ireland. The questionnaire was administered by a team of professional recorders to a total of 402 farmers across the 12 catchments in 2010 with a base year of 2009. For the purposes of this analysis the sample size is restricted to systems which generate and store organic manures so the effective sample size for this analysis is 271 farmers. Table 1 outlines the farm profile of the sample.

In consultation with farm extension agents ten nutrient management practices were selected for investigation. These encompassed the nutrient management planning, application and recording best practice continuum (Beegle *et al.*, 2000). The criteria for each practice is outlined in Table 2 and each practice takes a binary yes/no form, hence a farmer undertaking all would achieve a score of 10. Other NM practices were not considered in this analysis as a higher level of data resolution would be necessary for exploration then was available through the questionnaire instrument.

It should be noted here that elements of NMPs 1 and 2 are mandatory in the Republic Ireland for some farmers. If a farmer is allowed a derogation to farm at a higher stocking rate under Nitrates Directive regulations, then it is mandatory to perform a periodic soil test and develop a nutrient management plan (Wall *et al.*, 2012). Additionally, soil testing is part of CAP funded agri-environment based scheme(s) in the Republic of Ireland. However, there is evidence from the sample that farmers were undertaking these actions for regulatory compliance and not actually consulting when making nutrients management decisions. So only where farmers expressly indicated referring to a soil test result or a nutrient management plan were they deemed to have engaged with best practices.

Modelling the intensity of practices adoption

As the number of practices adopted is a non-negative integer, the application of standard ordinary least-squares regression (based on an assumption of a continuous dependent variable) is not appropriate. Given that the dependent variable is a non-negative integer, a count data model was used to assess intensity of practice adoption. A count data model predicts the number of times an event occurs (Cameron and Trevedi, 1998) where the dependant variable is measured by the number of nutrient management practices undertaken by a farmer in the survey year which is a discrete non-negative integer value count. It is common in the literature to use the Poisson regression model as a starting point (Lord and Mannering, 2010). As outlined by Cameron and Trevedi (1998) the Poisson model can be defined as follows:

$$f(y_i - x_i) = \frac{e^{-\mu_i}\mu_i^{yi}}{y_i!},\ y_i = 0,1,2,\ldots, \quad (1)$$

where y_i are the number of nutrient management practices adopted by the farmer and x_i are a vector of explanatory variables that affect practice adoption. The μ_i parameter represents the mean number of expected events and can be expressed as:

Table 1: Farm profile of the sample

	Mean	Range
Farm Size (utilizable hectares)	62.2	6.1 – 412.8
Crops (hectares):		
Grassland	50.2	0 – 230.0
Arable	12.0	0 – 363.8
Livestock:		
Dairy cows LU's	25.8	0 – 275.0
Cattle LU's	53.5	0 – 230.0
Sheep flock (ewes)	27.1	0 – 700.0
Main Farm Enterprise*	**% Sample**	
Dairying	33%	
Livestock rearing	62%	
Arable	5%	

*Typology based on EU Farm Accountancy Data Network methodology classification (A complete description of the Farm Typology system is given in Commission Regulation (EC) No 1242/2008)

Table 2: Description of nutrient management best practices

Nutrient Management Practices
1. *Soil testing* - This variable takes a value of 1 if a farmer has soil tested at least once in the previous 5 years and indicated using the results for nutrient management.
2. *Nutrient management plan* – This variable takes a value of 1 if a farmer has a de-facto nutrient management plan based on soil testing and indicated using this plan for nutrient management.
3. *Estimation of nutrient content of organic manures* - This variable takes a value of 1 if the farmer indicated using scientific guidelines to estimate the N and P content of organic manure pre-application.
4. *Chemical fertiliser calibration* – This variable takes a value of 1 if the chemical fertiliser spreader is calibrated to apply specific quantities at the field level. This variable is constraint to 0 in the absence of reference to a soil test or nutrient management plan.
5. *Organic manure calibration* – This variable takes a value of 1 if the organic manure spreader is calibrated to apply specific quantities at the field level. This variable is constraint to 0 in the absence of reference to a soil test or a nutrient management plan.
6. *Springtime manure application* – This variable takes a value of 1 if at least 50 per cent of organic manure is applied in the spring season.
7. *Organic manure application method* – This variable takes a value of 1 if the farmer indicates using a trailing shoe, band or injection method of application.
8. *Liming* – This variable takes a value of 1 if the farmer indicates applying lime to land on a regular basis. This variable is constrained to 0 in the absence of reference to a soil test.
9. *Chemical fertiliser recording* - This variable takes a value of 1 if chemical fertiliser applications at the field level are being recorded.
10. *Organic manure recording* - This variable takes a value of 1 if organic manure applications at the field level are being recorded.

$$\mu_i = E[y_i|x_i] = \exp\left(x_i'\beta\right) \tag{2}$$

Where the logarithm of the conditional mean is linear in the parameters In $E[y_i|x_i] = x_i'\beta$. Assuming independent observations the log-likelihood can be expressed as:

$$In\ L(\beta) = \sum_{i=1}^{n} y_i x_i'\beta - \exp\left(x_i'\beta\right) - In\ y_i! \tag{3}$$

The Poisson model properties require the mean and variance of y_i to be equal. Often in count data this assumption is violated as there often tends to be over/under dispersion leading to underestimation of standard errors, overestimation of chi-squared statistics and inefficiency of estimates (Cameron and Trevedi, 1998). Where the mean variance condition is not satisfied a more flexible modelling of the variance such as the negative binomial model which allows for the presence of over dispersion maybe necessary. The Poisson model is generally easy to estimate but in addition to over/under dispersion it can be adversely affected by low sample means and can produce biased results in small samples (Lord and Mannering, 2010). This will be examined in greater detail below in the context of this research.

Farmer Motivations

In the survey questionnaire, respondents were read out a list of statements and asked to state how much they agreed or disagreed with these set of statements on a scale from 1 (completely disagree) to 8 (completely agree) as recommended by Garforth *et al.*, (2006). The statements drew on a variety of previous work where attitudinal statements were used to capture diverse farming motivations (Duram 1997; Willock, 1999b; Ryan 2003; Maybery, 2005; Brodt *et al.*, 2006; Barnes *et al.*, 2007; Davis and Hodge, 2007; Lapelle and Kelly, 2013). Using principal component analysis (PCA), these data was reduced to a number of latent constructs reflecting diverse farming motivations.

PCA was employed to extract underlying latent constructs. Factor analysis involves data reduction and operates by examining the pattern of correlations (or covariances) among a number of variables. PCA transforms a set of correlated variables into a smaller number of uncorrelated factors or variables (Kline and Wichelns, 1998). Factor loading coefficients were used to derive standardized factors for the sample population. Factor scores are advantageous as they can be employed in regression analysis in place of the original attitudinal statements, with the knowledge that the meaningful variation in the original data has not been lost but that the derived variables are uncorrelated thus preventing any potential multi-collinearity problems.

Explanatory variables

A number of different underlying farming motivations as well as farmer personal and farm structural factors were hypothesized to influence the uptake of nutrient management practices examined. Table 3 provides an overview of the explanatory variables included in the regression analysis.

It is hypothesized that information and knowledge transfer around the adoption of the prescribed practices is most likely to come from contact with an agricultural advisor and participation in a network such as a farmer discussion group. Farmer discussion groups are facilitated by an agricultural advisor; hence farmers in these groups would also by definition have regular contact with an agricultural advisor. Consequently, two dummy variables were included in the analysis, the variable ‘contact with an advisor’ took a value of 1 if a farmer had engaged an agricultural advisor in the previous 12 months and the variable ‘advisor & discussion group’ took a value of 1 if the respondent is a participant in a farmer discussion group.

Table 3: Explanatory variables that were included in the model

Variable	Variable Description	Mean	Min	Max
Farm Stewardship motivations	Derived factor score (see Table 4)	0	−3.2	0.9
Eco-centric motivations	Derived factor score (see Table 4)	0	−4.3	2.0
Productivist motivations	Derived factor score (see Table 4)	0	−5.9	1.6
Anthropocentric motivations	Derived factor score (see Table 4)	0	−2.3	3.0
Contact with farm advisor	0=No contact with an advisor or discussion group. 1=Engaged with an agricultural advisor in the previous 12 months.	0.45	0	1
Contact with farm advisor & discussion group	0=No contact with an advisor or discussion group. 1=Participant in a farmer discussion group facilitated by an agricultural advisor.	0.23	0	1
Age	1=under 36 years; 2=36-65; 3=+65 years.	2.0	1	3
Partial farmyard manure system	0=No FYM was generated on farm. 1=Some FYM generated on farm.	0.18	0	1
Full farmyard manure system	0=No FYM was generated on farm. 1= Only FYM generated on farm.	0.09	0	1
Off-farm employment	0=Not employed off-farm 1=Employed off-farm	0.25	0	1
Total organic N kgs Ha^{-1}	Kilogrammes of organic nitrogen per hectare.	124.5	11.6	322.0
Farm size	Area farmed in hectares	62.1	6.1	412.8

Demographic and farm structural variables included in the analysis were age of the farmer, off-farm employment status, type of organic manure storage system, livestock production intensity and farm size. Older farmers tend to be more conservative and farmers engaged in off-farm employment may have less time to dedicate to on-farm management activities. Animal waste is stored in either liquid (slurry) or more solid forms (farmyard manure based on straw bedding). Farmyard manure (FYM) is more difficult to apply evenly, it takes longer to breakdown and to be absorbed into the soil and the nutrient content also tends to be more variable. This variable tends to be reflective of livestock housing facilities as older facilities would generally tend to hold animal waste as FYM. More solid based FYM storage systems do not as readily lend themselves to some of the practices under review given that FYM is not as easy to handle and apply as liquid slurry based systems. Consequently two dummy variables were included in the analysis, one named 'partial-FYM' took a value of 1 if FYM and slurry were generated and a second variable 'FYM' took a value of 1 if only FYM was generated.

Production intensity has been shown to influence best practices adoption (Lapple and Van Rensburg, 2011). Hence, a variable labelled organic N (ON) production is included in the analysis; this is an indicator of livestock farming intensity and is measured in kg ON ha^{-1}. This is estimated based on average numbers and type of animal held on farm and applying standard coefficients (e.g. 1 dairy cow is equivalent to 85 kg ON) for different livestock types (as set out in Nitrates Directive regulations (Government of Ireland, S.I. 601 of 2010). Finally, farm size in hectares was included in the analysis.

4. Results

Farmer Motivations

Following a PCA a total of four factors emerged. The explained proportion of the total variation of the original variables was 65%. A Kaiser-Meyer-Olkin measure of factor suitability was 0.81, indicating the use of factor analysis on this dataset to be appropriate (Kaiser, 1974). Using Bartlett's measure of Sphericity the null hypothesis was rejected that the correlation matrix is an identity matrix and the alternative hypothesis was accepted that there is a significant relationship between the variables ($p < 0.0001$). A reliability test using Cronbach's alpha was applied to assess the internal consistency and reliability of the derived factor variables. Values above 0.5 are considered acceptable as evidence of a relationship (Nunnally, 1967), whereas values above 0.7 are more definitive (Peterson, 1994). The factor loadings in Table 4 represent correlations between all respondents' answers to each attitudinal statement with the derived component scores. There is a high degree of consistency in responses to the attitudinal statements used to derive the factor variables as indicated by a Cronbach's Alpha of 0.95 and 0.75 for factors 1 and 2 and just over 0.5 for factors 3 and 4.

The PCA resulted in four factors with an eigenvalue greater than one and as such were chosen for further analysis. These four latent constructs (factors) reflect diverse farming motivations.

The statements that had high loadings for factor 1 were strongly associated with general principles of good farm management such as making best use of farm resources, maximising yields and farm profits and minimizing risk in the area of the environment. This factor included statements indicating the importance of managing and storing manure correctly and avoiding a cross compliance violation – both involve risk management and have financial consequences under EU Nitrates based regulations if found in breach. As such, this factor variable representing good farm business management and was labelled '*farm stewardship*'. The statements that had high loadings on factor 2 were related to farming in a manner that protects the environment and was hence labelled as '*ecocentric*'. The third factor variable reflects productivist motivations and statements that were important here reflect the importance to which farmers place on maximising farm

Table 4: Farmer attitude factors and component statements

Statements	Farm Stewardship	Ecocentric	Productivist	Anthro-pocentric
Maximizing and making best use of my farm resources is important to me.	**0.96**	−0.05	0.02	−0.00
Storing and using slurry and manures correctly is important to me.	**0.93**	−0.06	0.00	0.01
Achieving the highest yield possible from my livestock/ crops is important to me.	**0.92**	−0.06	0.03	0.02
Avoiding a cross compliance violation is important to me.	**0.88**	0.08	−0.04	−0.01
Maximising farm profits is important to me.	**0.85**	−0.12	0.12	−0.00
If it reduces pollution a farmer should change or adapt his/her farm practices.	−0.05	**0.84**	0.05	−0.05
It is important to take the environment into consideration, even if it lowers farm profits.	−0.13	**0.77**	−0.15	−0.05
Farmers have to play their part in reducing environmental pollution.	−0.04	**0.75**	0.25	−0.11
It is appropriate that farmers should be held responsible for agricultural related water pollution.	0.05	**0.64**	0.21	−0.12
Monitoring farm production levels is important.	0.09	0.21	**0.75**	−0.14
A farmer must be oriented towards production to survive and be successful.	0.03	−0.04	**0.73**	0.06
Good quality farmland not in production is being wasted.	−0.02	0.11	**0.60**	0.13
Maximizing farm profits is more important than protecting the environment.	−0.05	−0.20	0.15	**0.73**
Any increase in pollution is insignificant compared to the benefits of increasing production.	−0.09	−0.09	−0.07	**0.71**
Damage to the environment is beyond a farmer's control.	0.20	−0.11	0.19	**0.60**
Eigen values	4.3	2.7	1.6	1.3

output. Therefore this factor was labelled '*productivist*' motivations. The final factor was labelled *anthropocentric* as it consisted of statements that place the farmer's needs ahead of those of the environment. The higher a farmer's score on each of these factor variables, then the higher their overall level of agreement with the statements that make up that factor.

Intensity of NMP adoption

Table 5 reports on the adoption of the ten nutrient management practices under review. Results indicate that recording of chemical fertiliser applications (74%) and majority springtime application of organic manures (70%) were the most popular practices across the sample, while use of a nutrient management plan (27%) and newer organic manure application methods (5%) were the least popular.

Table 6 reports on the intensity of NMP adoption. A total of 1% of the sample (3 farmers) didn't undertake any of the practices while the same proportion undertook all 10 practices. The mean number of practices undertaken across the sample was 5.26 with a variance of 5.67. This satisfies the mean variance and low-sample mean conditions necessary for the Poisson model as outlined in section 3.2 (Lord and Mannering, 2010). The Poisson model was hence adopted in this analysis to explore intensity of practice adoption.

Table 7 reports the results of a Poisson count data model on the number of practices adopted. Results indicate that all the derived factor variables significantly

Table 5: Type of nutrient management practices undertaken by farmers

Nutrient Management Practice	Numbers adopting	Percent Adopting
Chemical fertiliser recording	201	74%
Springtime organic manure application	191	70%
Soil testing	180	66%
Chemical fertiliser field calibration	170	63%
Organic manure recording	156	58%
Liming	140	52%
Organic manure field calibration	130	48%
Estimation of nutrient content of organic manures	128	47%
Nutrient management plan	72	27%
Organic manure application – Trailing shoe, band or injection.	14	5%

(N=271)

Table 6: Number of nutrient management practices undertaken by farmers

Number of practice	Number of farmers undertaking practice(s)	Percent of farmers undertaking practices
0	3	1%
1	14	5%
2	21	8%
3	29	11%
4	41	15%
5	43	16%
6	30	11%
7	23	8%
8	47	17%
9	18	7%
10	3	1%
Mean	5.26	
Standard deviation	2.38	

affect the number of best management practices adopted by farmers. Specifically, there is a significant and positive association between both *farm stewardship* and *productivist* motivations with the number of nutrient management practices adopted. Environmental values also appear to be important when it comes to explaining adoption practices. Farmers with an *ecocentric* value orientation were likely to adopt a higher number of nutrient management practices. On the other hand, farmers identified as having *anthropocentric* orientations were more likely to place greater importance on economic over environmental issues and were less likely to adopt the nutrient management practices under review.

Contact with an agricultural advisor and advisor contact plus participation in a farmer discussion group had a positive effect on the overall number of NMPs adopted. Farm structural variables were also found to influence intensity of practice adoption. Age (5% level), off-farm employment (5% level) and FYM storage systems were all negatively and significantly related to intensity of NMP adoption. Farm size and livestock production intensity were associated with higher adoption rates, but the effect was not found to be significant in this instance. The Wald chi-squared statistic for the model shows that, taken jointly, the coefficients for this model specification are significant at the 1% level. The model predicts the mean number of practices

Table 7: Results of Poisson regression for nutrient management practice adoption

	Parametric estimates	Marginal effects
Farm stewardship	0.08** (0.03)	0.38
Ecocentric	0.08*** (0.03)	0.42
Productivist	0.07** (0.03)	0.37
Antropocentric	−0.04* (0.02)	−0.21
Advisor contact	0.20*** (0.06)	1.01
Advisor contact & discussion group	0.20*** (0.07)	1.09
Age	−0.116** (0.05)	−0.59
Partial FYM system	−0.13* (0.07)	−0.63
Full FYM system	−0.26** (0.12)	−1.17
Off-farm employment	−0.17** (0.07)	−0.85
Total Organic N Ha^{-1}	0.001 (0.00)	0.003
Farm size	0.001 (0.00)	0.003
Constant	1.72*** (0.14)	
Log pseudolikelihood = −578.2		
Wald chi-squared = 117.5		

***1% level, **5% level, *10% level, †Discrete changes (from 0 to 1) for these variables adopted to be 5.26 which is the same as the mean number of actual practices adopted (Table 6). The model predicts the actual number of practices adopted for 20 per cent of the sample and within +/- 1 practices for a further 35 per cent of the sample. Hence the model predicts accurately or within +/- 1 practice for 55 per cent of the total sample. Additionally, the model predicts within +/- 2 practices for a further 22 per cent of the sample.

Table 7 also reports marginal effects for each independent variable with all other variables held at their means. Results indicated that farmers with off-farm employment were likely to adopt just under 1 (0.85) less NMPs on average. Age also had a negative impact on adoption rates with NMPs undertaken on average declining by 0.59 per increasing age category. Fewer of the NMPs under review were adopted where farmyard manure was the more dominant method of organic manure storage. Where all organic manure was stored in the more solid FYM form the number of NMPs adopted declined by 1.17 compared to fully liquid slurry storage systems. Contact with an agricultural advisor and advisor contact plus participation in a farmer discussion group had a positive overall relationship with NMP uptake as respectively each class of contact increased the number of practices adopted by circa 1-1.1.

5. Discussion and conclusions

Demographics and farm structures have long been established to influence best practice adoption in the literature, yet solutions to increasing best practice adoption rates among farmers remain elusive. In keeping with the substantive body of previous work on practice adoption a number of farm structural variables in this study were found to affect the number of NMPs adopted by farmers. Age and off-farm employment were found to constrain best practice adoption. The effect of off-farm employment status could be due to time constraints of the individual farmer in that the use of certain NMPs can be relatively labour intensive. This means that irrespective of any potential economic benefits, some farmers may simply not have the time to implement certain nutrient management practices. Older farmers tend to be more conservative in relation to the uptake of new management practices and results from this study are consistent with this. Common Agricultural Policy pillar two co-funded based incentives for installation of young farmer and a retirement scheme for older farmer have existed in the Republic of Ireland since the MacSharry reform in 1992 until a suspension in 2008. Yet the average age of farmers across the Republic of Ireland has increased from 51 years in 2000 to 54 years in 2010 (CSO 2002; 2012). Recent CAP reforms have included additional direct payments for young farmers and potentially more could be done in this area given that 28% of single farm payment recipients were 65 years or older while only 5% were 35 or under at the end of this period (Murphy, 2012). FYM systems of organic manure storage were negatively associated with the number of NMPs adopted in this study. These less fluid systems of organic manure storage tend to be associated with older housing facilities and do not lend themselves as readily to the practices examined. Significant capital investment would be required to convert to more liquid systems of manure storage and policymakers could offer incentives in this area to promote substitution towards more liquid based systems of organic manure storage.

Results from this study indicate higher adoption rates were associated with contact with an agricultural advisor or advisor contact plus participation in a farmer discussion group network. The causality of this relationship is unclear as more progressive farmers maybe more likely to engage with these extension based contacts in the first instances. However, there is an information burden associated with some of the practices under review and these extension contacts maybe assisting to address the information burden associated with implementation of some of the NMPs examined. Additionally, peer influence from agricultural advisors or other farmers may influence adoption rates. Policymakers in the Republic of Ireland have acknowledged this by providing incentives for farmers to join farmer discussion groups where adoption of new techniques is a requirement for incentive based payments (DAFM, 2013; 2014). A longer term analysis of adoption outcomes and persistence of practice adoption of discussion group participant will attest to the success of these incentives.

To date much of the focus has been on the role of *ecocentric* motivations on farmers' conservation behaviour and results here also indicate this motivation is an important factor in explaining the number of nutrient management practices adopted. However, findings from this study introduce other motivations that drive NMP adoption. All of the practices under review have potential positive profitability and production potential in addition to environmental benefits and results here indicate that farm stewardship (or business) as well as productivist motivations significantly affect the probability of farmers adopting NMPs. Underlining the business, productivist and environmental benefits of NMPs can potentially play an important role in farmer decision making processes as highlighting these specific benefits can assist farmer to identify with the one that is in keeping with their own motivations and self-identity. Promoting and re-enforcing the multi-functional benefit of these practices among farmers with either farm stewardship, ecocentric or productivist motivations could increase adoption rates and embed these practices into farmer routines. Conversely, farmers with anthropocentric based motivations were likely to adopt a lower number of practices and are less likely to be open to this message – suggesting a different policy approach based more on regulation or compulsion. Research in other jurisdictions has shown that low cost win-win type nutrient management practices as mainly examined in this study can greatly assist in achieving environmental policy objectives in the area of water quality (Wright *et al.*, 2011). Appealing to farmers' farm stewardship, productivist or ecocentric motivation could assist adoption in this area as could incentives through agri-environment schemes (regulatory based approaches are also open to policymakers). However, exclusively relying on adoption of these practices is unlikely to be enough to sufficiently reduce diffuse pollution from agriculture in certain catchment areas for achievement of objectives under the EU Water Framework Directive. It maybe that in addition of NM best practices adoption, critical source areas, where the risk of nutrient transfers from agricultural production to the aquatic environment is greatest, need to be identified and adaptive land management strategies implemented on these land parcels to better manage this risk maybe necessary. However, policymakers ought to be guided by a better understanding of farmer motivations and the constraints faced by farmers in adopting NMP and be able to tailor policy measures for maximum effectiveness on this basis.

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