Understanding farmers' intentions to follow a nutrient management plan using the theory of planned behaviour

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1. Introduction

Farmer decision making surrounding the use of agricultural nutrient inputs, such as chemical fertiliser and manure, is a critical issue and of significant importance to policy makers (Sutton *et al.,* 2013; McGlynn *et al.,* 2018). Nutrient application to agricultural fields has contributed to substantial improvements in crop yields, which have led to a significant increase in the ability of the earth to sustain more humans (Smil, 2002). However, inefficient or over-use of nutrient inputs has led to significant negative environmental and social impacts (Tilman, 1999; Jones *et al.,* 2014; Wagena and Easton, 2018). On the other hand, under-application of nutrients can contribute to declining levels of soil fertility and below expected crop yields (Bai *et al.,* 2013) and, ultimately, an under-utilisation of productive agricultural land. Both over and under-application of nutrients to crops can also lead to financial losses to farmers (Buckley and Carney, 2013). Therefore, from both a policy and societal perceptive, it is of paramount importance that farmers manage nutrient inputs properly and efficiently in order to minimise the risk of nutrient loss to the environment, whilst also ensuring that natural resource use is optimised and appropriate soil fertility levels are maintained (Jakrawatana *et al.,* 2017; Macintosh *et al.,* 2019).

To mitigate the negative impacts associated with inefficient nutrient use and improve farm incomes, farmers are encouraged to adopt various recommended management strategies (Price *et al.,* 2011; Micha *et al.,* 2018). One important and widely promoted management practice is nutrient management planning (Osmond *et al.,* 2015; Ulrich-Schad *et al.,* 2017). Nutrient management planning is a process which involves using farm-specific data to formulate a written plan (document) also known as a nutrient management plan (NMP), typically with an agricultural advisor (Beegle *et al.,* 2000). The purpose of an NMP is to ensure that nutrients are applied in the right quantities, at the right time, in the right place and using the right source (Genskow, 2012; Roberts and Johnston, 2015). Use of NMPs have been associated with environmental and financial benefits due to improvements in the way in which fertiliser and manure is managed on farms (Thomas *et al.,* 2007; Amon-Armah *et al.,* 2013). However, despite proven benefits and considerable promotion, development of NMPs remains below expectations globally (Lawley *et al.,* 2009; Buckley *et al.,* 2015; Osmond *et al.,* 2015; Ulrich-Schad *et al.,* 2017; Brown *et al.,* 2019). Moreover, a situation has been observed whereby farmers who develop a NMP do not necessarily follow the plan (Osmond *et al.,* 2015). Therefore, the focus of this study is on farmers' intentions to follow a NMP rather than a mere examination of the development of a NMP.

Several socioeconomic variables, such as farm system, farm size and farmer age, are suggested in the literature to examine the low levels of uptake of management practices, such as NMPs (Prokopy *et al.,* 2008; Baumgart-Getz *et al.,* 2012; Brown *et al.,* 2019). However, there remains a lack of clear evidence as to why farmers choose to follow a NMP (Ulrich-Schad *et al.,* 2017). Moreover, there is a general dis-satisfaction across the literature with the ability of previous studies to provide a comprehensive understanding of farmer decision making (Edwards-Jones, 2006; Feola *et al.,* 2015; Zeweld *et al.,* 2017). This is possibly due to the poor level of conceptualisation, inconsistent measurement and lack of a theoretical basis for the inclusion of socio-psychological issues, such as attitudes and social pressure, in the analysis of farmer decision making (Burton, 2004, Hansson *et al.,* 2012; Borges and Oude Lansink, 2016). Once such aspects are taken into account, the influence of socio-economic variables on adoption tends to lose explanatory power (Poppenborg and Koellner, 2013). For this reason, there has been a growing shift towards incorporating theoretical frameworks from social psychology to improve the understanding of farmer decision making and to use these

insights to better inform policy design (Borges *et al.,* 2014; Adnan *et al.,* 2017; Floress *et al.,* 2017). One such theoretical model that has received considerable interest in the literature is the Theory of Planned Behaviour (TPB) (Ajzen, 1991).

The TPB suggests that an individual's decision to engage in a particular behaviour is primarily driven by their intentions, which are in turn affected by three independent constructs: attitude, subjective norm (social pressure) and perceived behavioural control (ease/difficulty) (Ajzen, 1991). There is wide support for the TPB across the literature (Armitage and Conner, 2001; Fielding *et al.,* 2005; Hansson *et al.,* 2012; Läpple and Kelley, 2013; Hyland *et al.,* 2018; Adnan *et al.,* 2018; Rezaei *et al.,* 2018; Wang *et al.,* 2019). Despite this, there are a number of limitations of past applications of the TPB in an agricultural context. Firstly, whilst a number of authors, such as Sok *et al.* (2016) and Morais *et al.* (2018), have examined inter-relationships between the TPB constructs, these studies focus on examining correlations instead of causal pathways. That is, Sok *et al.* (2016) and Morais *et al.* (2018) did not investigate the specific direction of influence between the TPB constructs and the likely reasons for these relationships. Secondly, previous studies within an agricultural context often fail to explore how institutional factors may influence farmers' attitudes, subjective norms and perceived behavioural control (Bijttebier *et al.,* 2018). Institutional variables, such as communication, extension, education and policy are potential levers that can stimulate behavioural change (Barnes *et al.,* 2013).

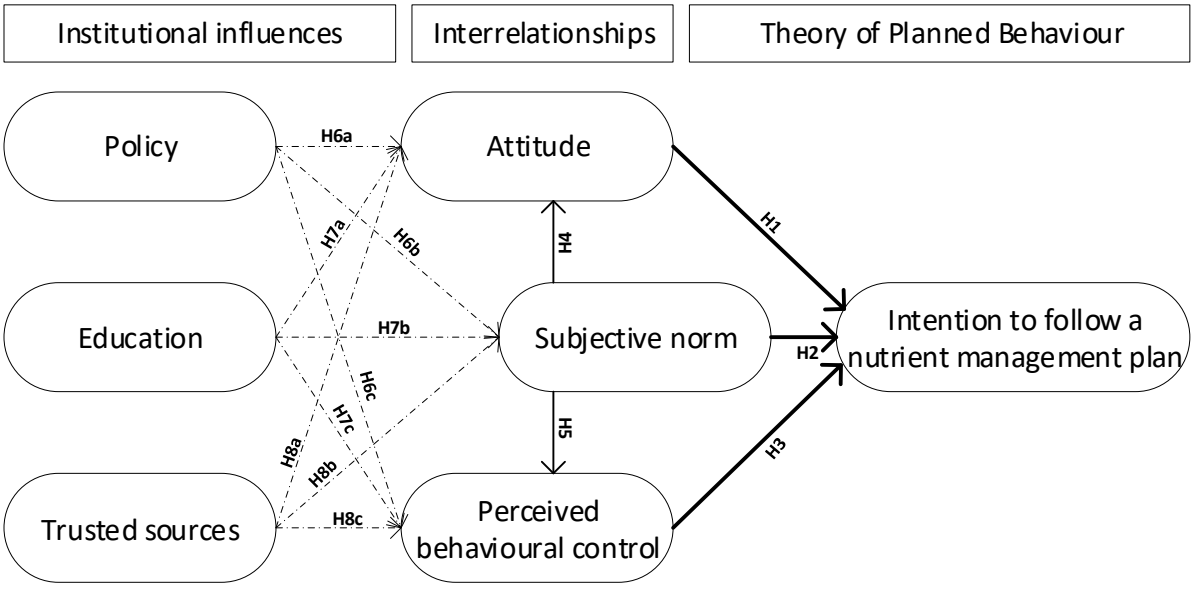
This study extends the literature by providing an understanding of the causal relationships between, and institutional influences on, the TPB constructs in relation to farmers' intentions to follow a NMP. This method enables the provision of a more comprehensive insight into farmer decision making which can be used to inform policy that is designed to encourage further use of NMPs at a global scale.

The objectives of this study are as follows: 1) to identify the effect of attitude, subjective norm and perceived behavioural control on farmers' intentions towards following a NMP, 2) to explore relevant causal inter-relationships between the TPB constructs and 3) to investigate institutional influences on farmers' attitudes, subjective norm and perceived behavioural control. These objectives are fulfilled by analysing Irish survey data collected as part of a wider research project (see Daxini *et al.,* 2018 for further detail).

2. Theoretical framework and hypotheses

In order to address the three main research objectives of this paper, we develop a theoretical framework based on the TPB (Ajzen, 1985; Ajzen, 1991).

Figure 1: Conceptual framework based on the TPB



The TPB, which is an extension of the Theory of Reasoned Action (TRA) (Fishbein and Ajzen, 1975), attempts to explain and understand why an individual may undertake a certain behaviour (McEachan *et al.,* 2016). According to the TPB, intention is the most important predictor of behaviour, which relates to an individual's motivation or willingness to invest effort in performing the behaviour (Ajzen, 2002; Bamberg *et al.,* 2007). The greater the intention, the more likely an individual is to enact the behaviour. Intention, in turn, is determined by three socio-psychological constructs: attitude, subjective norm and perceived behavioural control (Ajzen, 1991).

In line with the TPB (Ajzen, 1991), attitude is defined as a positive or negative evaluation of performing a given behaviour. Thus, the intention of farmers to follow a NMP will increase if they perceive that using this practice is useful and beneficial and will lead to positive results for them. Subjective norm encapsulates the level of social pressure or expectations felt by an individual from significant reference persons to engage or not to engage in a particular behaviour. It is argued that people tend to conform to subjective norms due to a fear of social exclusion (Bamberg and Möser, 2007). Thus, if farmers feel that people whose opinion they value confirm a given behaviour then their own intention to perform the behaviour should increase (Rezaei *et al.,* 2018). Finally, perceived behavioural control is an individual's perception of the ease or difficulty related to their performing a given behaviour, which is also related to the presence of facilitating conditions, sometimes referred to as situational constraints (Ajzen, 2002; Bamberg and Möser, 2007). This construct reflects the extent to which an individual perceives that the behaviour in question is under his/her volitional control (Ajzen, 1991). Therefore, farmers' intentions to follow a NMP should increase as the degree of their perceived control over performing this behaviour becomes greater (Adnan *et al.,* 2017). As a general rule of thumb, the more positive the attitude, subjective norm and perceived behavioural control, the greater the likelihood of adopting the behaviour in question (Ajzen, 1991).

Previous research has shown that attitude, subjective norm and perceived behavioural control are positively associated with farmers' intentions to adopt riparian zone management in Australia (Fielding *et al.,* 2005), improved grassland management in Brazil (Borges *et al.,* 2014) and on farm food safety management in Iran (Rezaei *et al.,* 2018). However, Wauters

et al. (2010) only found attitude to be an important factor determining farmers' intentions to adopt soil management practices in Belgium. Elsewhere, Hyland *et al.* (2018) confirmed the importance of attitude and perceived behavioural control, but did not find subjective norm to be a significant determinant of farmers' intentions to adopt grazing management practices in Ireland. Typically, the influence of the TPB constructs on intentions varies depending on the behaviour and context under study (Ajzen, 1991). Finally, although not applying the TPB, various studies have also confirmed the importance of farmers' attitudes (Flett *et al.,* 2004; Reimer *et al.,* 2012), social pressures (Welch and Marc-Aurele, 2001; Ribaudo and Johansson, 2007; Yoshida *et al.,* 2018) and perceptions of control or efficacy (Zhang *et al.,* 2016; Wilson *et al.,* 2018) in the decision to adopt various nutrient management practices.

Founded on the assumptions of the TPB and based on the literature above, we develop the following hypotheses:

H1. Attitude has a positive influence on farmers' intentions towards following a NMP.

H2. Subjective norm has a positive influence on farmers' intentions towards following a NMP.

H3. Perceived behavioural control has a positive influence on farmers' intentions towards following a NMP.

Inter-relationships between the TPB constructs

Whilst the TPB framework has three independent socio-psychological constructs that influence intentions, results from previous studies also indicate that the TPB constructs are correlated (Trafimow and Finlay, 2001; Bamberg and Möser, 2007; Quintal *et al.,* 2010 Borges and Oude Lansink, 2016; Morais *et al.,* 2018). Here, we focus on examining two key causal relationships between the TPB constructs which pertain to the influence of subjective norms on attitude and perceived behavioural control. We specifically focus on these two relationships and directions of influence, rather than between other constructs or directions, due to wide theoretical and empirical support for these specific causal pathways (Oliver and Bearden, 1985; Taylor and Todd, 1995; Bamberg *et al.,* 2007; Bamberg and Möser, 2007; Quintal *et al.,* 2010; Peters *et al.,* 2011; López-Mosquera *et al.,* 2014; Park and Ha, 2014; Rezaei *et al.,* 2019; Ru *et al.,* 2019).

Kallgren *et al.* (2000) suggest that the influence of subjective norms on behaviour possibly relies less on individual's fear of social sanctions but on their use of subjective norms as an easy source of information on how others validate particular behavioural options. Therefore, the influence of subjective norm on attitude is in line with the notion that individuals may use subjective norms for evaluating how advantageous the adoption of a given behaviour would be (Bamberg and Möser, 2007). Thus, people tend to take into consideration the view of important referent groups when forming their own attitudes towards a given behaviour (Burton, 2004; Quintal *et al.,* 2010; López-Mosquera *et al.,* 2014). While the opposing relationship is that attitudes can influence subjective norms, it has been demonstrated that it is more probable that attributes of the external social environment will influence attributes of the individual (Ryan, 1982; Quintal *et al.,* 2010). Schaak and Mußhoff (2018) found that subjective norms positively influenced farmers' perceptions of the benefits of management practices in Germany. Therefore, the fourth hypothesis is as follows:

H4. Subjective norm has a positive influence on attitude towards following a NMP.

In a similar fashion, it is also likely that subjective norms will influence individuals' perceptions of how easy or difficult it is to perform a given behaviour (Quintal *et al.,* 2010). Bamberg and Möser (2007) suggest that subjective norms also provide individuals with guidance or information as to whether the behaviour is likely to be easy to perform. Thus, subjective norms have an influence on individuals' perceptions of control over performing the behaviour (Bamberg *et al.,* 2007). For instance, positive encouragement or approval from significant others can lead to a sense of confidence (control) over performing a particular behaviour (Nair and Little, 2016; Ru *et al.,* 2019). Numerous studies have also shown that subjective norms, influences individuals' perceptions of confidence and potential external impediments to acting, thus confirming that subjective norms influence perceived control over performing a given behaviour (Quintal *et al.,* 2010; Peters *et al.,* 2011; Sánchez *et al.,* 2018). Overall, this suggests that external social pressure originating from what others believe, can influence individuals' perceptions of the ease or difficulty in acting and facilitate the way in which individual's act (López-Mosquera *et al.,* 2014) and, therefore we assume the following hypothesis:

H5. Subjective norms have a positive influence on perceived behavioural control over following a NMP.

Influence of institutional variables on the TPB constructs

In order to promote behavioural change, the mere knowledge of the influence of the TPB constructs on intentions is not always sufficient (Ajzen, 2011; Bijttebier *et al.,* 2018). Rather, an understanding of the key variables which are likely to influence farmers' attitudes, subjective norms and perceived behavioural control must also be developed. Such variables can include policy, education and trusted information sources (Bosch *et al.,* 1995; Blackstock *et al.,* 2010; Aarts and Lokhorst, 2012; Lam *et al.,* 2017). We treat these variables as 'institutional variables' which leads to the development of H6, H7 and H8 which are presented below.

Policy

Certain nutrient management policies, such as the Nitrates Directive (ND) in the European Union (EU), require certain farmers to develop a NMP on a mandatory basis (European Comission, 1991). Whilst research has shown that policy can increase the number of NMPs that are developed (Savage and Ribaudo, 2013; Perez, 2015), this does not always translate into use of such plans (Osmond *et al.,* 2015). It thus remains inconclusive as to whether policy, which requires the mandatory development of NMPs, is an effective tool for encouraging farmers to follow such plans. Therefore, it is interesting to explore the potential effect of policy on attitude, subjective norm and perceived behavioural control in order to inform more effective policy design.

Buckley (2012) found that a number of farmers, who displayed positive attitudes towards the ND policy in Ireland, believed that the policy had led to positive farm management benefits and agreed that the policy had made them more aware of the nutrient requirements of their crops and stimulated them to improve the way in which they plan the use of fertilisers on their farm. Elsewhere, Macgregor and Warren (2015) found that over time, farmers' attitudes towards the ND regulation improved in Scotland. Farmers who are subject to policy requirements, which require them to develop a NMP on a mandatory basis, may also feel a higher degree of social pressure to follow the plan. Policy makers can make the development of a NMP mandatory by using policy compliance as a tool and imposing financial penalties

on those farmers who do not develop a plan if they are required to do so. However, monitoring the use of NMPs is difficult and hard to regulate (Perez, 2015). Nevertheless, farmers who are obliged to develop a NMP on a mandatory basis may feel a higher degree of social pressure to follow the plan. This pressure may arise from the desire of the farmer, who is subject to policy compliance requirements, to go above and beyond the requirements in order to receive the approval and respect of significant others with whom they interact (Grasmick & Bursik, 1990). Examples of likely sources of such social pressure include other farmers subject to mandatory policy requirements, agricultural advisors, the media and family. Moreover, over time, such desires may have a socialising effect on the farmers who develop a NMP on a mandatory basis which may lead to a shift in norms and further normative commitment towards following a NMP (Winter & May, 2001). Finally, farmers subject to mandatory policy requirements are also often provided with additional education and training regarding the use of NMPs, which tends to have a positive influence on the use of NMPs due to improved confidence and technical ability in relation to use (Osmond *et al.,* 2015). Thus, we assume the following hypotheses:

H6a Policy has a positive influence on farmers' attitude towards following a NMP.

H6b Policy has a positive influence on subjective norm.

H6c Policy has a positive influence on farmers' perceived behavioural control over following a NMP.

Formal education

Formal education has the ability to foster positive attitudes towards the use of nutrient management practices, as it helps to increase understanding of complex issues (Bosch *et al.,* 1995). Education can also foster positive attitudes by helping to dispel myths about the outcomes of performing a given behaviour. For Bourdieu (1986), education is a form of cultural capital, while Burton and Paragahawewa (2011) observe a connection between education and the level of cultural capital possessed by an individual. Cultural capital contributes to status generation, often through improved management skills (Burton, 2014). Education can thus lead individuals to be drawn into behaving in ways that are socially acceptable. Finally, education is also known to increase efficacy of farm management through improvement in technical abilities or improvements in understanding of management issues such as nutrient management planning (Burton, 2014). Thus we hypothesise that:

H7a Education has a positive influence on farmers' attitude towards following a NMP.

H7b Education has a positive influence on subjective norm.

H7c Education has a positive influence on farmers' perceived behavioural control over following a NMP.

Trusted information sources

Information sources that farmers trust, such as agricultural advisors, other farmers, family and the media, play an important role in shaping farmers' attitudes and perceptions towards the adoption of management practices (Sutherland *et al.,* 2013; Hunecke *et al.,* 2017; Liu *et al.,* 2018). Trust is an important concept as it is viewed as a catalyst that encourages the conversion of information into usable knowledge (Fisher, 2013). Moreover, the ability to

change attitudes and the success of information interventions depends on individual's trust in the source of the message (Blackstock *et al.,* 2010). Therefore, the type of information sources that are trusted by farmers and their likely influence on perceptions towards management practices, are also important to consider (Gervais *et al.,* 2001; Genius *et al.,* 2006; Stuart *et al.,* 2014). For example, trust in a professional agricultural advisor would generally be reassuring and have a strong, positive influence on attitudes, social pressure felt and perceptions of control over following a NMP (Genius *et al.,* 2006; Wilson *et al.,* 2018). Whereas, this effect may not be as strong for the media or other farmers, who might have mixed opinions regarding the use of NMPs. For example, Zeweld *et al.* (2017) found that technical training and important referent groups, such as family, neighbours and friends, increased farmers' levels of social pressure to adopt sustainable management practices, whereas the media did not have a significant influence. Zeweld *et al.* (2017) also demonstrated a positive influence between technical training and farmers' attitudes towards such practices. We therefore propose the following hypotheses:

H8a Farmers' levels of trust in information sources is positively and significantly associated with their attitudes towards following a NMP.

H8b Farmers' levels of trust in information sources has a positive and significant influence on subjective norm.

H8c Farmers' levels of trust in information sources has a positive and significant correlation with perceived behavioural control over following a NMP.

3. Methodology

Survey

The data used for the purpose of this study were derived using the same survey and sample of Irish farmers described in Daxini *et al.* (2018). A structured survey was designed to collect information pertaining to the socio-demographic characteristics of the sample, trusted information sources and a series of items were used to measure the TPB constructs. The content of the survey was developed based on a literature review of past TPB research in an agricultural domain (e.g. Läpple and Kelley, 2013; Borges *et al.,* 2014; Micha *et al.,* 2015; Lalani *et al.,* 2016; van Dijk *et al.,* 2016), previous survey experience of the authors and a series of preliminary interviews (Francis *et al.,* 2004; Sutton *et al.,* 2004). These interviews were conducted with farmers and agricultural advisors prior to the development of the survey and were designed to reveal key attitudes and perceptions towards following a NMP. Prior to the administration of the survey, a pilot test was conducted and, as a result, minor amendments were made to the wording of some of the questions.

The data were collected between the months of January to April 2017 using face-to-face interviews with farmers. Survey recorders read out the questions to respondents who were the main decision maker on the farm. A total of 1009 farmers were interviewed. To ensure that the sample of farmers was representative, the survey company first stratified the sample by Electoral Divisions (Howley, 2013). At each sampling point, the interviewer followed a quota controlled system based upon the known proportion of farm systems and sizes within each area. Interviewers then continued to interview farmers until they filled their quotas. Quota controlled sampling is a non-probability sampling method which guarantees that the sample has the same proportions of individuals as the entire population in relation to a set of specified characteristics (Elder, 2009). For the purpose of this study, the quota was designed

in order to ensure that the sample was representative of Irish farming by farm systems and sizes. The quotas used for the purpose of this study were based on known national population figures in relation to specific farm types (Hennessy and Moran, 2015).

Variables

Theory of Planned Behaviour (TPB)

The TPB constructs (attitude, subjective norm, perceived behavioural control and intention) are considered to be latent constructs and therefore must be measured using multiple items (Hair *et al.,* 2010). By using multiple items, the measurement error of a particular variable is minimised and the statistical estimation of the associations between the variables improved (Borges and Oude Lansink, 2016). The items were based on information collected during the development of the survey. Overall, 14 items are used to measure the TPB constructs: attitude, subjective norms, perceived behavioural control and intentions. These items are all anchored on a 5-point Likert scale from strongly disagree (1) to strongly agree (5), which are regarded as short enough to allow respondents to distinguish meaningfully between the categories (Hansson *et al.,* 2012).

Policy

A policy variable is developed which describes farmers who are required to develop a NMP on a mandatory basis. In Ireland, these farmers include those who receive a 'derogation' (allowance) under the ND to farm at a higher stocking rate or participate in the 'Green Low Carbon Agricultural Environment Scheme' (GLAS). A dummy variable is developed to reflect farmers who participate in policy (1) against those who do not (0).

Formal education

Education is measured on a 5-point Likert scale with increasing levels of formal educational attainment from primary level (1), some secondary level (2), completed secondary level (i.e. obtained leaving certificate) (3), professional diploma (4) and higher education (5).

Trusted information sources

As discussed previously, farmers are influenced by a range of information sources. In order to understand the influence of different information sources, farmers were asked to respond on a 5-point Likert scale from very unlikely (1) to very likely (5) to the question: "how likely are you to follow advice from the following people/sources regarding nutrient management on your farm?" The response options included: 'family'; 'discussion group'; 'agricultural advisor'; 'other farmers'; 'scientific literature'; 'farming press and magazines'; 'information events' such as farm walks, open days and demonstration events and the 'media' such as TV and radio. It is important to identify the underlying structure and commonalities in trust preferences. To achieve this aim, we employed a principal component analysis (PCA) which was rotated using the varimax method.

The suitability of the data for PCA is initially checked using a Kaiser-Meyer-Olkin measure, giving a value of 0.86, indicating suitability (Kaiser, 1974). Furthermore, the Bartlett's test of Sphericity gave a value of 0.0000, which suggests that there is a significant relationship between the variables. The decision regarding the number of components to retain is based on evaluating the eigen values, where values above 1 should be retained (Hair *et al.,* 2010).

Based on the eigen values we retain a total of two components. We also decide to allow items to load onto components (factor loadings) with coefficients of above 0.3 (see Table 1) (Hair *et al.*, 2010). Finally, the internal consistency of the components is checked using Cronbach's alpha. The values of each component are both over the recommended threshold value of 0.5 (Nunnally, 1978). The final components can be used as independent variables in the SEM in place of the original items, with the knowledge that significant variation in the original data has not been lost, but that the derived variables are uncorrelated thus avoiding any possible issues with multicollinearity (Howley, 2013).

Table 1: Principal components - trusted information sources (factor loadings >0.3 highlighted in bold).

Trusted source	Technical information	Social information
Family	-0.05	**0.43**
Agricultural advisor	**0.46**	-0.07
Discussion group	**0.48**	0.00
Other farmers	-0.05	**0.51**
Scientific literature	**0.34**	0.14
Farming press	0.08	**0.47**
Information event	**0.40**	0.11
Media	-0.02	**0.54**
Agricultural training course	**0.51**	-0.08
Eigen value	4.3	1.1

The results of the PCA (Table 1) are interpreted on the basis of the type of information source that farmers are more likely to trust. Component one reflects farmers who are more likely to trust advice from 'technical' sources of information, which includes agricultural advisors, discussion groups, agricultural training courses and information events. On the other hand, component two comprises farmers who are more likely to trust advice from 'social' sources which includes other farmers, family, agricultural press and the media. Subsequently we label component one as 'technical information' and component two as 'social information'. Importantly, this leads to a modification of the hypothesised conceptual framework which decomposes the variable 'trusted sources' into two separate forms of 'trusted sources' which are: 'technical information' and 'social information'.

Following the results of the PCA we revise H8a, H8b and H8 and the additional H9a, H9b and H9c are also formulated as follows:

H8a: Farmers' levels of trust in technical information sources are positively and significantly correlated with farmers' attitudes towards following a NMP.

H8b: There is a positive and significant correlation between farmers' levels of trust in technical information sources and subjective norms.

H8c: Farmers' levels of trust in technical information sources has a positive and significant influence on farmers' perceived behavioural control over following a NMP.

H9a: Farmers' levels of trust in social information sources has a positive influence on farmers' attitudes towards to following a NMP.

H9b: The higher the level of farmer's trust in social information sources, the more positive their level of subjective norm will be.

H9c: Farmers' levels of trust in social information sources has a positive and significant influence on farmers' perceived behavioural control over following a NMP.

Data analysis

Structural equation modelling (SEM) is adopted to test the proposed research hypotheses. SEM is a commonly used technique to test models with observed and latent variables (Toma *et al.*, 2013). A two-step procedure is adopted to test the research hypotheses (Anderson and Gerbing, 1988). In the first step, confirmatory factors analysis (CFA) is used to assess the fit of the measurement model and assess the reliability and validity of the constructs. In the second step, the structural model is used to test the hypothesised relationships. Because the skew and kurtosis statistics demonstrated deviations from normality assumptions, the model is estimated using the Satorra–Bentler method which is robust against violations of non-normality (Satorra and Bentler, 1994; Kline, 2011).

4. Results

Socio-economic characteristics of the sample

The majority (51%) of respondents in the sample are cattle farmers, 26% are dairy, 17% are sheep and around 6% are tillage. The median farm size is 31 to 50 hectares. In terms of age, the median is 51 to 64 years old. These figures are in line with national averages (Hennessy and Moran, 2015). The farmers in the sample have a high level of farming experience with a mean of 36 years of experience. In relation to the highest level of formal education attained, around 16% have a primary level of education, 30% have some secondary level of education, 34% have formally completed secondary level (leaving certificate obtained), 13% have received a professional diploma and only 7% have acquired a university degree. Due to policy requirements, 42% of farmers are obliged to develop a NMP on a mandatory basis. In terms of intentions, on average, 67% of farmers either agree or strongly agree that they have an intention to follow a NMP in the near future.

Descriptive statistics of the measured items

Table 2 presents an overview of the measured items and illustrates that farmers show a moderately positive intention to follow a NMP. The three items used to measure intention have a mean of 3.65. In general, farmers also show a positive attitude towards following a NMP, with a mean score of 3.98 for the items used to measure attitude. Farmers stated that they felt a moderately high level of social pressure to follow a NMP with a mean of 3.71 between the items used to measure subjective norm. Finally, in relation to perceived behavioural control, farmers revealed a positive level of control with a mean of 3.91 among the items used to measure this construct.

Table 2: Descriptive statistics of the items used to measure the TPB constructs and results of the measurement model

Item measure	Mean	Standard deviation	Item loadings	CR	AVE
Attitude				**0.96**	**0.86**
In your opinion, following a NMP is: a good idea?	4.01	0.67	0.93***		
In your opinion, following a NMP is: useful?	4.00	0.67	0.94***		
In your opinion, following a NMP is: reliable?	3.98	0.68	0.91***		
In your opinion, following a NMP is: important?	3.94	0.75	0.92***		
Subjective norm				**0.92**	**0.80**
When it comes to following a NMP, most people whose	3.80	0.74	0.87***		

opinion I value regarding farming: would approve if I do so?					
When it comes to following a NMP, most people whose opinion I value regarding farming: encourage me to do so?	3.62	0.89	0.91***		
When it comes to following a NMP, most people whose opinion I value regarding farming: think that I should do so?	3.71	0.81	0.90***		
Perceived behavioural control				**0.87**	**0.68**
When it comes to following a NMP: I am confident in my ability to do so?	3.97	0.74	0.87***		
When it comes to following a NMP: it is easy to do so?	3.87	0.77	0.82***		
When it comes to following a NMP: I have a clear understanding of how to do so?	3.95	0.79	0.79***		
Intention				**0.97**	**0.93**
When it comes to following a NMP in the near future: I intend to do so?	3.62	1.02	0.98***		
When it comes to following a NMP in the near future: it is likely that I will do so?	3.63	1.01	0.98***		
When it comes to following a NMP in the near future: I would consider doing so?	3.71	0.98	0.94***		

Notes: CR = Composite reliability, AVE = Average variance extracted. ***P < 0.01.

Measurement model

The results of the CFA (Table 2) show that all of the standardised factor loadings are statistically significant ($p < 0.01$) and are all above the recommended threshold value of 0.70 (Hair *et al.,* 2010). In terms of model fit, given the over-sensitivity of the chi-square test to sample size, we utilise other fit statistics which account for the bias against large samples (de Leeuw *et al.,* 2015; Martinovska Stojcheska *et al.,* 2016). These fit indices include the Comparative fit index (CFI = 0.993), Tucker-Lewis index (TLI = 0.991), Root mean square error of approximation (RMSEA = 0.031) and Standardized root mean square residual (SRMR = 0.023). Each of these values conforms with recommended limits (CFI/TLI > 0.95; RMSEA/SRMR < 0.08) and therefore we conclude that the model has good fit to the data (Hu and Bentler, 1995; Hair *et al.,* 2010).

All of the latent constructs are assessed for both reliability and validity. Reliability is associated with the internal consistency of the multiple indictors used to measure each construct (López-Mosquera *et al.,* 2014). The composite reliability (CR) scores are between 0.87 and 0.97, which are all above the acceptable value of 0.70 (Hair *et al.,* 2010). Validity is associated with the degree to which the observed variables accurately measure the intended construct (Li *et al.,* 2018). We measure validity using both convergent and discriminant validity (Fornell and Larcker, 1981). The average variance extracted (AVE) is estimated for each construct to measure convergent validity. The AVE value must exceed a threshold value of 0.50 (Hair *et al.,* 2010). All AVE scores are between 0.68 and 0.93, suggesting suitable convergent validity. Discriminant validity is confirmed as the AVE values for each construct are found to be greater than the square of the corresponding inter-construct correlations (see Table 3) (Sharifzadeh *et al.,* 2017).

Table 3: Inter-construct squared correlations and AVE (along the diagonal)

Factor	ATT	SN	PBC	INT
ATT	**0.86**			
SN	0.34	**0.80**		
PBC	0.52	0.35	**0.68**	
INT	0.47	0.44	0.53	**0.93**

Notes: ATT = Attitude; SN = Subjective norm; PBC = Perceived behavioural control; INT = Intention.

We also check for multicollinearity between the variables in the model by computing variance inflation factors (VIF). A maximum VIF value of 3.43 is found, which is below the recommended threshold value of 10 which suggests that multicollinearity is not an issue in our model (Hair *et al.*, 2010).

Structural model

The goodness of fit indices of the structural model are as follows: CFI (0.970), TLI (0.961), RMSEA (0.072) and SRMR (0.079). The fit indices are within the recommended thresholds and therefore they indicate suitable model fit (Hair *et al.*, 2010). Table 4 shows the results of the hypothesis testing results which are presented as standardised path coefficients which show the significance and strength of association between the variables in the hypothesised relationships (Hair *et al.*, 2010). In terms of the influence of attitude, subjective norm and perceived behavioural control on intention, each construct has a positive and significant influence on intentions. This leads us to accept H1, H2 and H3. However, the coefficients also reveal that perceived behavioural control has the greatest effect on intentions (0.37) followed by subjective norm (0.30) and then attitude (0.28).

In relation to the inter-relationships between the TPB constructs, subjective norm is positively and significantly associated with attitude (0.47). Likewise, subjective norm positively influences perceived behavioural control (0.46). Thus the results of the inter-relationships examined between the TPB constructs leads us to accept H4 and H5.

The results also indicate that the institutional variable policy, has a significant effect on attitude (0.09), subjective norm (0.11) and perceived behavioural control (0.14). This offers support for H6a, H6b and H6c. Education is only significantly and positively related to perceived behavioural control, although the magnitude of the influence is relatively small (0.08). Thus, we accept H7c but reject both H7a and H7b. The effect of trust in technical information sources on attitude (0.14) and perceived behavioural control (0.16) is positive and significant, however this variable has the largest influence on subjective norm (0.46). This leads us to accept H8a, H8b and H8c. Finally, trust in social information sources is positively and significantly associated with attitude (0.09) and a relatively larger influence is found on subjective norm (0.11) compared to attitude. Based on this result we reject H9c but accept H9a and H9b.

Table 4: Hypothesis testing results

Hypotheses	Path	Standardized estimate	S.E	P	Result
TPB					
H1	ATT → INT	0.28	0.03	***	Accept
H2	SN → INT	0.30	0.05	***	Accept
H3	PBC → INT	0.37	0.04	***	Accept
Inter-relationships					
H4	SN → ATT	0.47	0.04	***	Accept
H5	SN → PBC	0.46	0.04	***	Accept
Institutional influences					
H6a	Policy → ATT	0.09	0.03	***	Accept
H6b	Policy → SN	0.11	0.03	***	Accept
H6c	Policy → PBC	0.14	0.03	***	Accept
H7a	Education → ATT	0.00	0.02	NS	Reject
H7b	Education → SN	-0.02	0.03	NS	Reject
H7c	Education → PBC	0.08	0.03	**	Accept

H8a	Trust (Technical information) → ATT	0.14	0.04	***	Accept
H8b	Trust (Technical information) → SN	0.46	0.04	***	Accept
H8c	Trust (Technical information) → PBC	0.16	0.04	***	Accept
H9a	Trust (Social information) → ATT	0.09	0.04	**	Accept
H9b	Trust (Social information) → SN	0.11	0.04	***	Accept
H9c	Trust (Social information) → PBC	0.05	0.04	NS	Reject

Notes: ATT = Attitude; SN = Subjective norm; PBC = Perceived behavioural control; INT = Intention; NS = Not significant. **p < 0.05, ***p < 0.01.

5. Discussion and conclusion

Understanding the socio-psychology of the decision making process of farmers is critical to encouraging further use of beneficial management practices, such as nutrient management planning (Blackstock *et al.,* 2010; Okumah *et al.,* 2018). However, without understanding the complexity of the formation of attitudes and perceptions and how institutional variables (e.g. policy, education and information sources) may contribute to these formations, it is difficult to design effective policy and behavioural change solutions (Fleming *et al.*, 2010; Bijttebier *et al.,* 2018). The results of this study show that the majority of the hypotheses are validated which confirms the importance of considering both internal (attitudes and perceptions) and external (policy and information) drivers of farmers' decision making processes (Edwards-Jones, 2006; Feola and Binder, 2010; Mills *et al.,* 2018).

The results demonstrate that perceived behavioural control is the most important determinant of intentions to follow a NMP, which implies that farmers' perceptions of the level of easiness, self-confidence and degree of control over following a NMP is important in determining the intention to follow one. Nutrient management planning is a technical management practice which requires specialist knowledge, skill and attention to detail and therefore is often considered to be among the more complex of farm management practices (Beegle *et al.,* 2000; Walters and Shrubsole, 2014). Madden *et al.* (1992) suggest that perceived behavioural control typically plays a significant role in determining intention to perform a given behaviour when engagement in that behaviour is difficult. Whilst agricultural advisors typically support farmers in an EU context, not all farmers engage with advisors and therefore they may not feel competent or confident to follow a NMP (Kania *et al.,* 2014). This could lead to a continued reliance on intuitive judgement instead of using formalised NMPs (Nuthall and Old, 2018). Previous studies have also shown that perceived behavioural control and efficacy are particularly important determinants of nutrient management practice adoption (Wilson *et al.,* 2014; Zhang *et al.,* 2016; Wilson *et al.,* 2018).

Previous studies have found subjective norm to be a particularly important determinant of farmers' intentions towards adopting, for example, improved grassland management (Borges *et al.,* 2014), diversified agricultural production (Senger *et al.,* 2017) and grazing management practices (Schaak and Mußhoff, 2018). The results of this study also confirm the important influence of subjective norm on farmers' intentions to follow a NMP. This means that farmers who feel a higher degree of social pressure or approval to follow a NMP are more likely to do so. This may be due to a fear of social exclusion from not conforming to what is deemed to be good practice (Bamberg and Möser, 2007). Burton (2004) explains that subjective norms influence intentions and behaviours because individuals do not make decisions without considering their actions in relation to that of others, nor are individuals independent of social and cultural influences. Moreover, the highly influential role of subjective norms in our study may be related to an increase in focus on improving nutrient management on farms in recent years, which may have stimulated an increase in social

pressure on farmers to voluntarily use best management practices, such as NMPs (Savage and Ribaudo, 2013; Reimer *et al.,* 2018).

The influence of attitude on intentions is positive and significant which implies that farmers who view the outcomes of following a NMP more favourably, are more likely to have a positive intention to follow a plan. This result supports previous TPB studies which found attitude to be an important determinant of farmers' intentions to adopt various agricultural practices (Wauters *et al.,* 2010; Zeweld *et al.,* 2017; Hyland *et al.,* 2018). However, it has been well-established that attitudes are not, in themselves, adequate for the prediction of individual's intentions (Floress *et al.,* 2017). Our result also implies that farmers' evaluation of the importance and benefits of following a NMP are perhaps less important than their ability and the social pressure felt towards following a NMP. For example, Trafimow and Finlay (2001) argue that depending on the behaviour in question, people can be more attitude-driven or subjective norm driven. When it comes to following a NMP, farmers are perhaps more motivated by external social pressures over their own internal opinions (attitude). Burton (2004) suggests that people often push aside their personal opinions and rational considerations in favour of the views of important referent groups. Our result also resonates with the findings of Yoshida *et al.* (2018) who demonstrated that farmers often forgo their own attitudes in favour of external social pressures and demands on production.

A number of inter-relationships are also examined between the TPB constructs. As mentioned previously, the results confirm the positive significant influence of subjective norm on attitude, thereby confirming the results of previous studies (Bamberg and Möser, 2007; Zhang *et al.,* 2017; Rezaei *et al.,* 2019). This suggests that farmers' attitudes towards following a NMP are represented by social considerations. Petty and Cacioppo (1996) put forward the argument that individuals' attitudes are influenced by other individuals and the environment around them. Likewise, Quintal *et al.* (2010) assert that individuals consider others' expectations when they form their personal attitudes. It is likely that farmers are using subjective norms as a source of information to evaluate how advantageous following a NMP may be, which may be contributing to attitude formation (Bamberg and Möser, 2007). This relationship may be further explained by the fact that there is no absolute definition of what a correct attitude is (Fetsinger, 1954), and therefore, individuals' views of what important referent groups expect of them may influence their attitudes towards a certain practice (Park and Ha, 2014).

Subjective norm is also found to positively and significantly influence perceived behavioural control. This means that farmers who feel a higher degree of social pressure and/or encouragement to follow a NMP are more likely to perceive a greater degree of control over doing so. The result supports the notion that that external social pressure or encouragement arising from the opinions of others can facilitate perceptions of how easy or difficult farmers feel, in this case, it is to follow a NMP (Bamberg and Möser, 2007). Thus, in terms of following a NMP, it is probable that farmers are evaluating how easy it is to do so through an evaluation of other farmers' perceptions (Bamberg *et al.,* 2007). Quintal *et al.* (2010) also suggest that the exertion of social pressure on individuals to behave in a certain way can influence their understanding of the barriers to carrying out the behaviour in question. Therefore, positive encouragement or approval from individuals whose opinions are valued by farmers, may result in an increase in confidence in following a NMP due to a decrease in the perceptions of the magnitude of the barriers that may exist (Nair and Little, 2016; Ru *et al.,* 2019). The effect of subjective norm on perceived behavioural control has also been confirmed by previous studies (Peters *et al.,* 2011; Park and Ha, 2014; Rezaei *et al.,* 2019).

Farmers who are obliged to develop a NMP on a mandatory basis are more likely to feel a higher degree of social pressure and level of control over following the plan. One potential explanation for these results relates to the nature of policy requirements in Ireland. Farmers must have a NMP developed by a qualified agricultural advisor to comply with GLAS or ND derogation requirements. Furthermore, farmers participating in GLAS must attend specific agricultural training courses where nutrient management planning forms a part of the course (DAFM, 2017). Previous research has shown that engagement with advice and support systems can help stimulate interest, responsibility and a sense of personal and social norm (Dwyer *et al.,* 2007; Mills *et al.,* 2016) as well as improve control over following a NMP (Osmond *et al.,* 2015). Policy also has significant positive influence on farmers' attitudes towards following a NMP, but this relationship is weak.

A positive, but weak, association is found between education and perceived behavioural control. Nutrient management planning is a technical process and requires attention to detail and the ability to comprehend the complexities associated with optimising nutrient use (Beegle *et al.,* 2000). A probable explanation for this result is that education increases efficacy of farm management through an enhancement of technical skills and familiarity required to use technical innovations, such as NMPs (Burton, 2014).

The findings also suggest that trust in technical sources of information has a critical influence on subjective norm followed by perceived behavioural control and attitude; whereas, trust in social sources has a positive influence on subjective norm and attitude only. Importantly, trust in technical sources has a higher magnitude of influence on the TPB constructs than social sources. This suggests that expertise and professional sources are more crucial in terms of the development of farmers' perceptions, than generalist sources such as family and the media. Blackstock *et al.* (2010) suggest that the higher the credibility of the advice source, (such as people from farming backgrounds or trusted networks), the higher the persuasion factor will be. O'Keefe (2016) argues that highly credible sources, such as approved advisors, are often important when messages or procedures are complex. Following a NMP requires the initial collection and then synthesis of farm specific data such as stocking rate, soil fertility and yield potential (Beegle *et al.,* 2000). Thus, technical assistance is often crucial, especially in terms of the synthesis, interpretation and formulation of a NMP and guidance for following the plan (Osmond *et al.,* 2015).

This study extends the literature by examining the socio-psychological determinants of farmers' intentions to follow a NMP whilst also examining the causal relationships between, and institutional influences on, the TPB constructs. We argue that this approach is better suited to understanding the complexities of farmer decision making and prescribing potential policy and behavioural change intervention strategies.

The main policy implication emerging from the results relates to the importance of perceived behavioural control and subjective norm which was not only shown to directly influence farmers' intentions but also farmer's attitudes and perceptions of control over following a NMP. Thus, we suggest that it is crucial that policy makers continue to explore novel ways of improving farmers' own capabilities over following a NMP and increasing social pressure on farmers to follow a NMP as a way to establish long term norms. Overall, in line with others (Feola *et al.,* 2015; Wang *et al.,* 2019), we stress the importance of continuing to develop an understanding of farmer psychology in relation to the use of management practices that have the ability to provide both environmental and financial benefits. Without doing so, solutions may be prescribed that are not geared towards maximising the influence they have on farmers' perceptions towards the use of such innovations.

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