Dutch dairy farmers’ intentions to adopt climate mitigation measures: understanding the associations of social-psychological factors on different behavioural stages.

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Abstract

Mitigating greenhouse gas emissions is essential for tackling climate change. This empirical study tests the statistical relationship of a rich set of social-psychological and socio-demographical factors with individual farmer’s stage membership (pre-decision, pre-action, action, post-action) in adopting on-farm climate mitigation measures. Online questionnaires were sent to 300 specialised Dutch dairy farmers registered with the Farm Accountancy Data Network. A total of 100 complete survey records were analysed using an ordered probit regression model. Our findings suggest that negative emotion associated with taking no climate mitigation measures, action planning and coping planning have significant and positive associations with farmers’ stage membership in adopting climate mitigation measures. Additionally, farmers below 50 years old with basic agricultural education and farms with high livestock intensity are found to be significantly associated with later stages than the pre-decisional stage. This study provides pointers for ‘soft’ behavioural policy design and contributes by studying the association of social-psychological factors with farmers’ pro-environmental behaviours. Further research should test the causal impact of negative emotion, action planning and coping planning on farmers’ adoption behaviour of climate mitigation measures.

1. Introduction

Tackling climate change is a challenge for many sectors. Given that agricultural production contributes to global anthropogenic greenhouse gas (GHG) emissions noticeably (IPCC, 2019), farmers' adoption of climate mitigation measures is crucial to reduce the agricultural GHG emissions. The Netherlands as the second largest agricultural food exporter in the world is famous for its high intensity and efficient production. Yet, the Dutch agriculture sector faces many interrelated environmental and economic challenges and climate change is no exception (Jongeneel & Gonzalez‑Martinez, 2021). The Dutch government has developed national climate agreement (Klimaatakkoord) to comply with the Paris Agreement on climate. Given the 49% national reduction of GHG emissions target, the Dutch agriculture sector still has to reduce its emissions by 11% until the year 2030 (van Grinsven, van Eerdt, Westhoek, & Kruitwagen, 2019). Two major GHG emissions from the agriculture sector are methane and nitrous oxide which mainly originate from livestock production and agricultural land. Until now, the adoption of climate mitigation measures is largely based on farmers' voluntary behaviour. The question raises as to what extent Dutch farmers' already adopt climate mitigation measures and what factors could explain farmers' voluntary pro-environmental behaviour. Detailed insights into the factors and processes underlying farmers' adoption behaviour of climate mitigation measures could shade lights on effective interventions.

Many psychologists and sociologists have explored the drivers and barriers of direct or indirect pro-environmental actions and several underlying theoretical frameworks have evolved over time (Kollmuss & Agyeman, 2002; Steg & Berg, 2013). From the early nineties to now, the theory of planned behaviour (TPB) has been frequently applied in explaining and predicting human behaviour (Sok, Borges, Schmidt, & Ajzen, 2021). The TPB model basically postulates that an actor's intention is likely to predict new behaviour when the actor's actual control over the new behaviour is high (Ajzen, 1991). However, it has been criticized for ignoring time-related behavioural changes (Bamberg, 2013a) and its inability to predict the extent to which intention translates into behavioural change (Bamberg, 2013a; Bijttebier et al., 2018; Hijbeek et al., 2018; Werner et al., 2017). To address this problem, Bamberg, Fujii, Friman, and Gärling (2011) have proposed the self-regulated stage model of behavioural change (SSBC) as a new theoretical framework for understanding behavioural changes in different stages, and eliciting systematic interventions. In the SSBC, behavioural change toward pro-environmental behaviour takes place in four stages (pre-decisional, pre-actional, actional, and post-actional) which are affected by constructs taken from the norm-activation model and the theory of planned behaviour (Keller, Eisen, & Hanss, 2019).

So far, only two studies have explored Dutch farmers' adoption behaviour of climate mitigation measures. Moerkerken, Blasch, van Beukering, and van Well (2020) have concluded that farmers' openness to change is the strongest predictor of Dutch farmers' willingness and actual adoption of climate mitigation measures. Gomes and Reidsma (2021) have identified drivers and barriers for Dutch farmers' adoption of soil GHG mitigation practices. However, both Moerkerken et al. (2020) and Gomes and Reidsma (2021) did not explore the effects of farmers' social-psychological factors on their adoption behaviour.

We aim to bridge this literature gap by exploring Dutch dairy farmers' adoption behaviour of climate mitigation measures using the SSBC model. The objectives of this empirical study are to first estimate farmers' current adoption level with climate mitigation measures, and secondly to test the statistical relationship of a rich set of social-psychological and socio-demographical factors with individual farmer's stage membership (pre-decision, pre-action, action, post-action) in adopting on-farm climate mitigation measures.

This paper has two contributions to the existing literature. Firstly, the analysis contributes by testing the roles of a rich set of socio-psychological and socio-demographical factors on Dutch dairy farmers' adoption of climate mitigation measures. Secondly, despite the SSBC model being a rather recent development (Bamberg, 2013a, 2013b), the SSBC has been successfully applied in many different contexts, and behaviour and has received empirical supports (Keller et al., 2019). To the best of our knowledge, the current study is the first in applying the SSBC model in the context of farmers' adoption of climate mitigation measures.

The remainder of this paper is organised as follows. Section 2 provides an in-depth explanation of the theoretical model. The conceptual framework and hypotheses are followed in section 3. Section 4 contains the methodology of this study. Results are reported in section 5 and the discussion and conclusion are followed in section 6 and 7.

2. Theoretical model

Various factors influence the transition into a more environmentally friendly behaviour. Transition is a complex process that involves lots of activities and tasks. It therefore happens over time (Keller et al., 2019). To respond to this complex transition process, environmental psychology theories that focus on modelling behavioural change have been increasingly developed in the direction of a stage model (Bamberg, 2013b; Keller et al., 2019; Schwarzer, 2008).

The self-regulated stage model of behavioural change

In the past 30 years, two theoretical models for studying people's sustainable behavioural change have dominated the literature (Steg & Berg, 2013). One is the theory of planned behaviour (TPB) by Ajzen (1991) which suggests that the actor's behaviour is predicted by the actor's intention, and the other is the norm activation model (NAM) by Schwartz and Howard (1981) which stresses the role of personal moral norm in activating behavioural change (Steg & Berg, 2013). The application of these theories range from farmers' adoption of sustainable farming practices (Sok et al., 2021), to consumers' food choice (Scalco, Noventa, Sartori, & Ceschi, 2017) and transportation choices (Han, 2021) among others. Although the theory of planned behaviour is a well-established theory, it faces two main criticisms. First, the often observed low empirical intention-behaviour relationship (Armitage & Conner, 2001) casts doubt on whether changing one's intention will actually lead to real behavioural change (Bamberg, 2013b). Second, the emotional or value-related determinants of behaviour are often neglected (Harland, Staats, & Wilke, 1999; Kaiser & Gutscher, 2003).

In response to the 'intention-behaviour gap' problem, Bamberg (2013b) has introduced the stage model of self-regulated behavioural change (SSBC) which explicitly brings along the temporal aspect of behavioural change based on the model of action phases (Gollwitzer, 1990). The main assumption in SSBC is that people can change their current behaviour (which has negative impacts on the environment) if they have the motivation to do so, despite their everyday routines and habits. This process of behavioural change involves several stages from abstract motivation to goal setting to concrete behavioural change which may or may not involve the volitional stage (Klöckner, 2017). Specifically, an actor has to go through four time-ordered qualitatively different stages: pre-decisional (1), pre-actional (2), actional (3), and post-actional (4) (Gollwitzer, 1990). Each stage contains specific tasks and the transition between each stage is marked by crossing the threshold in that specific intention (Table 1).

In response to the second criticism, Bamberg (2013a) integrated socio-psychological constructs from the TPB and NAM as well as four other theory based constructs to create a comprehensive set of explanatory variables for explaining behavioural change in the stage model. This is also in line with the suggestion from two meta-analyses which both indicate the constructs from TPB & NAM should be viewed as significant predictors of pro-environmental behaviours (Bamberg & Möser, 2007; Gardner, 2008).

Table 1: Stage model with transition points and psychological tasks.

4 Stages	3 Transition points	Psychological task
Pre-decisional (1)	Goal intention ('be' goal)	Re-evaluation of actual behaviour
Pre-actional (2)	Behavioural intention ('do' goal)	Selection of new behavioural alternative
Actional (3)	Implementation intention ('control' goal)	Implementation of new behaviour
Post-actional (4)		Habitualization of new behaviour

Based on (Bamberg, 2013a, 2013b; Ohnmacht, Thi Thao, Schaffner, & Weibel, 2018)

Socio-psychological factors related to stages

In the pre-decisional stage, the model aims to explain what motivates individuals to re-evaluate their current behaviour. The NAM addresses precisely this aspect. The NAM assumes that when individuals are aware of the negative impacts of their current behaviour on the environment and also accept their responsibility for causing the damage, they may have negative emotions associated with the negative consequences (Schwartz & Howard, 1981).

These negative feelings might trigger their personal norms which is the felt obligation to behave more in line with personally important moral standards. Simultaneously, the perceived social norm, which is what important social reference persons expect the individuals to do, may contribute to activating their personal norms. Moreover, the activation of personal norms leads to anticipated positive emotion when individuals behave more in line with their personal norm. The personal norms and the anticipated positive emotions are assumed as the direct predictors of goal intention. In addition, perceived goal feasibility plays an vital role in determining whether individuals will actually commit to the new goal. For instance, if individuals perceive their goal feasibility as low, they might choose "escape" to decrease negative emotions (Bamberg, 2013b; Schwartz & Howard, 1981).

In the pre-actional stage, the SSBC model implies an individual will actively compare the pros and cons between different behaviour alternatives, and this stage shall result in a behavioural intention that reflects an individual's self-commitment to the chosen behaviour option (Bamberg, 2013b). The SSBC model suggests that attitude and perceived behaviour control towards the chosen behaviour are the predictors for the behavioural intention (Bamberg, 2013a). These two constructs in stage 2 are taken from TPB (Ajzen, 1991).

In the actional stage, the model aims to explain what factors help in setting up an implementation intention. Gollwitzer and Sheeran (2006) suggest that the engaging in mental planning might be one factor. Schwarzer (2008) further suggests separating mental planning in action planning and coping planning: action planning focuses on planning the ‘how to’ of implementing the selected behaviour, while coping planning implies an individual has to come up with plans to solve potential obstacles during the implementation stage. Moreover, Schwarzer (2008) points out the maintenance self-efficacy which is a person’s confidence in maintaining her chosen behaviour, may also impact one’s implementation intention. Bamberg (2013b) therefore combined these three constructs as predictors for the implementation intention.

In the post-actional stage, the model aims to explain what helps in habituating the new behaviour. Forming a new behaviour needs not only a strong implementation intention, but also a person’s skills and strategies in resisting the temptations or recovering from potential set-backs (Bamberg, 2013b; Lewin, Dembo, Festinger, & Sears, 1944). The recovery self-efficacy which is a person’s confidence in resuming a difficult behaviour after a set-back, may increase the chance of forming a new behaviour (Bamberg, 2013b; Schwarzer, 2008).

Socio-demographic factors as control variables

In this study, socio-demographic factors are included as control variables, which is in line with literature on technology adoption in agriculture (Kreft, Huber, Wuepper, & Finger, 2021; Moerkerken et al., 2020). Although the literature shows mixed results of the impacts of these socio-demographic factors on farmers adoption behaviour (Knowler & Bradshaw, 2007; Lastra-Bravo, Hubbard, Garrod, & Tolón-Becerra, 2015; Mozzato et al., 2018), these factors usually consist of farmer’s demographic characteristics as well as farm financial & structural features (Knowler & Bradshaw, 2007; Kreft et al., 2021; Mozzato et al., 2018; Serebrennikov, Thorne, Kallas, & McCarthy, 2020). This study uses farmer age, education level, annual farm income and livestock density as control variables.

The age of the farmer approximates the farming experience and planning horizon. Older farmers with more experience and younger farmers with a long planning horizon are both expected to be more willing to adopt innovative technologies (Foguesatto, Borges, & Machado, 2020). The empirical studies from Chatzimichael, Genius, and Tzouvelekas (2014) showed that age has an inverted U shape relationship with farmers’ adoption behaviour of organic farming. This means the chance of farmers adopting new technologies increases up to a certain age, and then the chance decreases. The lower adoption rate from young farmers could be due to the lack of farming experience, and the lower adoption rate from older farmers might be due to the increasing risk aversion as one approaches retirement (Chatzimichael et al., 2014; Foguesatto et al., 2020).

The education level of the farmer is a proxy for more environmental awareness and more knowledge about climate threat. Positive associations between education level and farmers’ inclination to adopt environmentally friendly farming practices are often observed (Foguesatto et al., 2020; Mozzato et al., 2018).

Farm financial features refer to farm economic size. Positive effects of farm total income on adopting environmentally friendly farming practices have been observed in northern Europe (Mozzato et al., 2018). Farm structural characteristics generally include farm size (in ha), farm type and livestock density (Kreft et al., 2021; Mozzato et al., 2018; Serebrennikov et al., 2020). For this study, we only focus on livestock density among the common structural factors. The larger the livestock density, the more likely for the adoption of manure treatment technologies have been observed before (Case, Oelofse, Hou, Oenema, & Jensen, 2017; Gebrezgabher, Meuwissen, Kruseman, Lakner, & Oude Lansink, 2015).

3. Conceptual framework and Hypotheses

Based on Prochaska, DiClemente, and Norcross (1993), the main social-psychological drivers of behaviour change can be divided into cognitive and behavioural factors. Cognitive factors include attitude, social norm, personal norm, emotions and perceived goal feasibility; and behavioural factors include perceived behavioural control, action planning, coping planning, maintenance self-efficacy and recovery self-efficacy (Bamberg, 2013a; Ohnmacht et al., 2018). Whereas cognitive factors are more important in initiating the behaviour change process (first two stages), the behavioural factors are important during the entire process of behavioural change (Ajzen, 1991; Bamberg, 2013b; Lippke, Nigg, & Maddock, 2007; Prochaska et al., 1993).

The conceptual framework of this study has been adapted from the SSBC model (Bamberg, 2013a, 2013b) into the context of farmers adoption behaviour of climate mitigation measures (Figure 1). The cognitive factors and behavioural factors are the factors explaining the stage membership according to the stage model (Bamberg, 2013a, 2013b), with the four stages illustrated respectively on the bottom of Figure 1.

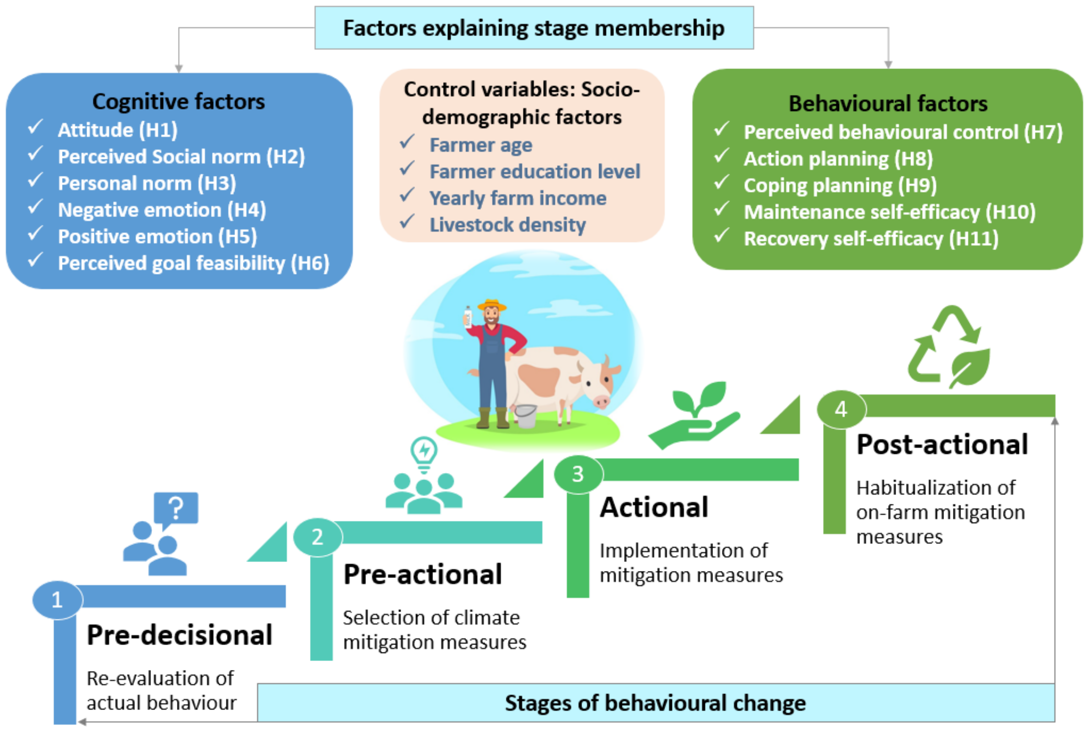

Figure 1: Conceptual framework of explanatory factors on farmers adoption behaviour of climate mitigation measures (adapted from Bamberg (2013b)).

In the pre-decisional stage, the farmers try to re-evaluate their actual behaviour; in the pre-actional stage, the farmers will select potential climate mitigation measure; in the actional stage, the farmers will implement the selected mitigation measure; and in the post-actional stage, the farmers will continue implement the selected mitigation measure in a habitual way. Factors explaining the stage membership are listed at the top of Figure 1. There are eleven hypotheses in this study which are listed in detail in Table 2. The corresponding hypotheses numbers are added in brackets after the related theoretical constructs in Figure 1.

Table 2: Hypotheses.

<table>
<tr><td>H1: The more positive the attitude of adopting climate mitigation measures,</td><td rowspan="11">the more likely that the farmer entrepreneur belongs to a later stage.</td></tr>
<tr><td>H2: The stronger the perceived social norm for reducing on-farm GHG emissions,</td></tr>
<tr><td>H3: The stronger the personal norm for reducing farming related GHG emissions,</td></tr>
<tr><td>H.4: The stronger the negative emotion if not taking any mitigation measures,</td></tr>
<tr><td>H5: The stronger the positive emotion if successfully reduced the GHG emissions,</td></tr>
<tr><td>H6: The stronger the perceived goal feasibility of reducing the on-farm emissions,</td></tr>
<tr><td>H7: The stronger the perceived behavioural control of the selected mitigation measure,</td></tr>
<tr><td>H8: The more action planning undertaken for implementing the mitigation measure,</td></tr>
<tr><td>H9: The more copping planning undertaken for implementing the mitigation measure,</td></tr>
<tr><td>H10: The stronger the maintenance self-efficacy,</td></tr>
<tr><td>H11: The stronger the recovery self-efficacy,</td></tr>
</table>

4. Methodology

This empirical study tests the association of a rich set of social-psychological and socio-demographical factors with individual farmer's stage membership (ordered categorical data) using the framework of SSBC model by applying an ordered probit regression (Verbeek, 2017).

Questionnaire design

An online questionnaire based on the SSBC model was disseminated to specialised dairy farmers participating in the Dutch Farm Accountancy Data Network (FADN) between 28 July 2021 and 16 September 2021. The FADN is an European instrument to evaluate the income of farms and the impacts of the Common Agricultural Policy (van der Meer, 2019). In FADN, specialised dairy farms are defined as those whose revenues from sales of milk, milk products and turnover and growth of cattle contain at least two thirds of their total revenues. In total, 300 farmers received the survey and farmers filled out the online questionnaires voluntarily; 122 farmers replied of which 108 complete records were suitable for data analysis. The survey response rate is about 40.67% and the completion rate is 36% which is relatively high compared to other survey studies. Matching socio-demographic data of survey participants was provided by Wageningen Economic Research which is responsible for the Dutch FADN data collection. After merging the survey results and matching socio-demographic data, 100 observations were left for the data analysis.

Survey questions were formulated based on previous literature (Bamberg, 2013a, 2013b; Ohnmacht et al., 2018) and adapted to the context of adopting climate mitigation measures in the Dutch dairy sector. Participants were asked to what stage of the behavioural change they would assign themselves. In addition, eleven socio-psychological factors were measured in statement questions using five-point Likert scales (1 = strongly disagree to 5 = strongly agree). Questions for factors belong to the pre-decisional stage were asked in relation to reduce farming related GHGs emissions in general. Those factors include negative emotion, positive emotion, social norm, personal norm and perceived goal feasibility. Since farmers had to select the most preferred climate mitigation measures to adopt in the pre-actional stage already. Questions for remaining factors belonging to the 2nd, 3rd and 4th stages were asked in relation to the chosen mitigation measure of survey respondent. The questionnaire was pretested for clarity, plausibility and acceptability both internally and by three professional dairy farmers. Their feedback was included in the final version of the online survey (see Appendix A). The list of climate mitigation measures presented to survey respondents to select from is based on the report from Zijlstra et al. (2019).

Appendix A presents the operationalization of theoretical constructs as well as measurement type and level. Cronbach's alpha and average inter-item correlation were used to estimate

Note: The total number of Dutch dairy farms is 15,261 in 2021 according to the centraal Bureau voor de Statistiek. The recommended sample size for this study is 375 dairy farmers according to the Raosoft sample size calculator with a 5% margin of error. However, it was infeasible for us to reach more than 375 farmers as we only had access to 300 Dutch dairy farmers registered with the FADN.

the reliability of the latent variable with 2 sub-indicators, composing social norm, personal norm, attitude and perceived behavioural control. An acceptable Cronbach's alpha is larger than 0.7 according to Nunnally (1978). In our sample data, only personal norm was acceptable with alpha equals 0.738 (Appendix A). However, alpha is largely dependent on the total number of sub-indicators per latent variable. Given that we only had 2 sub-indicators per latent construct, it is also recommended by Pallant (2013) to check the inter-item correlation for the sub-indicators. And the acceptable range for inter-item correlation is 0.2 to 0.4. Three latent constructs (social norm, personal norm, and attitude) measured with 2 sub-indicators were reliable according to the calculation of inter-item correlations (Appendix A), with only the inter-item correlation for perceived behavioural control slightly under 0.2. In the end, the results from the question "Adopting my chosen GHGs mitigation option would be ... for me. (1 very difficult...5 very easy)" was used to represent the construct perceived behavioural control and the other question was dropped for the data analysis.

Ordered probit model

Farmers' self-elicited stage membership in adopting climate mitigation measures, which can be pre-decisional, pre-actional, actional or post-actional, has a meaningful order in the dependent variable. An ordered probit model, which is estimated using the maximum likelihood method, is suitable to evaluate the association of socio-psychological and socio-demographic factors with farmers' stage membership (Verbeek, 2017).

The ordered probit model is based on a latent response variable y_i^*, which can be defined as a function of observed independent variables x_i and an error term ε_i that is independent from x_i and follows a standard normal distribution N[0,σ2], as follows:

$$y_i^* = \beta x_i + \varepsilon_i$$

The relationship between the four possible outcomes y_i which is the stage membership and the latent variable y_i^* is given by:

$y_i = 1 \;\; if\; y_i^* \leq \mu_1,$

$y_i = 2 \;\; if\; \mu_1 \leq y_i^* \leq \mu_2,$

$y_i = 3 \;\; if\; \mu_2 \leq y_i^* \leq \mu_3,$

$y_i = 4 \;\; if\; \mu_3 \leq y_i^*$

Where $\mu's$ are cut-off points representing the ordinal categories in which the latent variable falls into, and are to be estimated jointly with the β. β is a vector of coefficients for the socio-psychological and socio-demographic factors.

Descriptive analysis and sample characteristics

The total sample size for analysis is 100 Dutch dairy farmers. The share of farmers' self-reported stage membership with adopting on-farm climate mitigation measures were as follows: half of the sample assigned themselves to post-actional stage, 35% of the sample assigned themselves to pre-actional stage, 8% assigned themselves to actional stage and 7% assign themselves to pre-decisional stage. Sample characteristics were summarized in Table 3. On average, farmers were about 57 years old. Sample farmers had an average livestock density of 2.1 head/hectare and an average yearly farm income of 66,652 euros. Since family farm income took large values it was decided to divide their original values was by 10,000. In terms of education level, 89% sample farmers had a full agricultural education, 4% sample farmers had basic agricultural education and 7 of them only had experience in practice with farming.

Table 3: Sample characteristics.

Variable	**Min**	**Mean**	**Max**	**Note**
Age	35.99	56.89	79.15	Years
Livestock density	0.62	2.10	5.35	Livestock unit/hectare
Annual farm income	-6.7531	6.6652	70.5931	10,000 euros
Basic agricultural education	0	0.04	1	Dummy variable
Full agricultural education	0	0.89	1	Dummy variable
Total observations: 100.				

5. Results

Before running the ordered probit model, correlations between independent variables were checked. The correlation matrix (see Appendix B) indicates that there is no correlation greater than Spearman r = 0.7, suggesting that multicollinearity is not likely to be problematic and that there is no need to omit variables from the model.

The results from the ordered probit model are summarized in Table 4. From the set of cognitive factors, only the negative emotion had a positive significant association with stage membership (β = 0.423, $p < 0.05$). We do not reject hypothesis H4 which states that the stronger the negative emotion if not taking any mitigation measures is associated with a later stage in the SSBC model. Our data suggests that positive emotions, perceived social norm, personal norm, perceived goal feasibility and attitude are not significantly associated with stage membership. Therefore, we reject hypotheses H1, H2, H3, H5 & H6. From the set of behavioural factors, action planning has a positive significant association with stage membership (β = 0.387, $p < 0.05$). Hence, we do not reject hypothesis H8 that more action planning undertaken for implementing the mitigation measure is associated with a later stage in the SSBC model. Besides, coping planning has a positive significant association with stage membership at $p < 0.1$. We do not reject H9 that the more copping planning undertaken for implementing the mitigation measure, the more likely that the farmer entrepreneur belongs to a later stage. Our data shows that perceived behavioural control, maintenance self-efficacy and recovery self-efficacy are not significant explanatory variables for stage membership. Hence, hypotheses H7, H10 & H11 are rejected.

From the socio-demographic factors, age has a significant inverted U shape relationship with farmers' adoption behaviour of climate mitigation measures (at the critical 5% level). Our data suggests that the optimal age for Dutch dairy farmers to adopt on-farm climate-mitigation measures is 50 years. Farmers who are younger than 50 years are associated with an increasing likelihood of adopting climate mitigation measures as they get older; farmers who are older than 50 years are associated with a decreasing likelihood of adopting those measures. Regarding education levels, farmers who have basic agricultural education are more likely to be in the later stages (β = 0.379, $p < 0.01$) than farmers with only practical farming experience. On the other hand, farmers with full agricultural education are less likely to be in the later stages (β = - 0.183, $p < 0.01$) than farmers with only practical farming experience. Moreover, livestock density has a positive and significant association with stage membership of adopting climate mitigation measures (β = 0.337, $p < 0.1$). Farm yearly income is not significantly associated with stage membership.

The last column in Table 4 reports the odds ratio of the independent variables. For every one unit increase in farmers negative emotion, the odds of being in a later stage increases with

52.7%, ceteris paribus. In addition, for every one unit increase in action planning, the odds of being in a later stage increases with 47.2%, ceteris paribus. For every one unit increase in copping planning, the odds of being in a later stage increases with 43.6%, ceteris paribus. In terms of education level, if a farmer has a basic agricultural education, the odds of being in a later stage increases with 46.1%, ceteris paribus. However, if a farmer has a full agricultural education, the odds of being in a later stage decreases with 83.3%, ceteris paribus. Lastly, for every one unit increase in livestock density, the odds of being in a later stage increases with 40.1%, ceteris paribus.

Table 4: Ordered probit model results for adopting climate mitigation measures.

	Dependent variable: Stage membership	
	Coefficients (SE)	Odds ratio
Cognitive factors		
Positive emotion	-0.186 (0.186)	0.831
Negative emotion	0.423** (0.178)	1.527**
Perceived social norm	0.110 (0.208)	1.116
Personal norm	0.185 (0.215)	1.203
Perceived goal feasibility	0.288 (0.177)	1.334
Attitude	-0.283 (0.226)	0.754
Behavioural factors		
Perceived behavioural control	0.163 (0.214)	1.177
Action planning	0.387** (0.169)	1.472**
Coping planning	0.362* (0.218)	1.436*
Maintenance self-efficacy	-0.144 (0.191)	0.866
Recovery self-efficacy	-0.283 (0.196)	0.754
Socio-demographic factors		
Age	0.107** (0.041)	1.113**
Age squared	-0.001** (0.0005)	0.999**
Basic agricultural education	0.379*** (0.025)	1.461***
Full agricultural education	-0.183*** (0.051)	0.833***
Yearly family farm income	-0.004 (0.013)	0.996
Livestock density	0.337* (0.175)	1.401*
Intercepts		
1|2	4.09***(0.00)	
2|3	5.70***(0.00)	
3|4	5.95***(0.00)	
Observations	100	
Note:	*p<0.1 **p<0.05 ***p<0.01	
	Residual Deviance: 186.666; AIC: 226.666	

6. Discussion

This study contributes to the literature on adoption of climate mitigating measures by highlighting the statistical associations between a rich set of socio-psychological factors and socio-demographical factors on stage membership in the context of Dutch dairy farming. Our empirical results show that most of the socio-psychological factors have positive associations with the stage membership which is in line with the prior expectations from the SSBC model. Among these positively associated socio-psychological factors, negative emotion and action planning are significant at a 5% critical level and coping planning is significant at a 10% critical level. Positive associations of negative emotions with pro-environmental behaviour have been found in similar studies before (Harth, Leach, & Kessler, 2013; Mallett, 2012). Also Rees, Klug, and Bamberg (2015) demonstrated empirically that negative moral emotions (e.g. guilt and shame related to human-caused environmental damages) strongly predict actual pro-environmental behaviour with an experimental approach. Perceived social norm, personal norm, perceived goal feasibility, and perceived behavioural control had positive statistically insignificant associations with stage membership.

Regarding socio-demographical factors, the priori expected relationship of age and livestock density with stage membership are supported by our data. The optimal age to adopt climate mitigation measures is 50 years and farmers who are younger than 50 years are more likely to adopt mitigation measures as they get older till the age of 50 years. Besides, farmers who have a higher livestock density are more likely to have already adopted climate mitigation measures, i.e. be in a later stage of the SSBC model. Interestingly, the results of education level are not exactly in line with prior expectations. Our results suggest that farmers with basic agricultural education instead of full agricultural education are more likely to be in later stages than early stages. The possible explanation could be that there are relatively more farmers having full agricultural education in our sample than farmers having basic agricultural education (79 versus 4). Among these 79 farmers, many may not have placed mitigating GHGs emissions as their current priority regarding farm management.

Unlike negative emotion (feeling bad if farmers take no measures to reduce farming related GHGs emissions), positive emotion (feeling good if farmers succeed in reducing GHGs emissions) has an insignificant negative association with stage membership. We can only comment that testing positive emotion and negative emotion separately is needed for future research as there is a clear difference between them. We cannot derive implications from the negative association between positive emotion and stage membership as the relationship is statistically not significant.

Maintenance self-efficacy and recovery self-efficacy also have insignificant negative associations with the stage membership. These negative associations contradict with the prior expectations based on the SSBC model as well as previous findings in the same context. For instance, self-efficacy has a positive association with New Zealand farmers' adoption of mitigation measures (Niles, Brown, & Dynes, 2016); similarly, a positive association between self-efficacy and adoption of mitigation measures is found for farmers in Switzerland (Kreft et al., 2021). However, these correlations based on our sample are not statistically significant. Similarly, the farmer's attitude has a negative though insignificant association with stage membership. Nevertheless, a similar negative correlation has been observed before (Nguyen & Drakou, 2021).

This study has several limitations. First, the sample size of this study is small compared with other cross-sectional studies using the SSBC model. Second, although we encouraged farmers to provide honest answers in the introduction of the online questionnaire, survey results may still suffer from response bias as some farmers probably do not want to appear as not willing to take up climate mitigation measures. From the stage membership, 42 farmers allocate themselves to the first two stages and 58 farmers allocate themselves to the last two stages. The data in this study is not really skewed to the later stages, hence this limitation can be neglected to a certain extent. Third, despite the SSBC model aims to depict the temporal aspects of decision making process, it still results in a simplified and linear reflection of decision making process. Complex interdependencies and feedback loops between different model variables are left undetectable (Keller et al., 2019).

7. Conclusion

This empirical study aims to explore the statistical associations of a rich set of socio-psychological and socio-demographical factors with farmers' adoption of climate mitigation measures. Online survey based on the self-regulated stage model of behavioural change was send to Dutch dairy farmers registered with FADN. In summary, half of the sample farmers assigned themselves to post-actional stage, 35% of them were in pre-actional stage, 8% of them were in actional stage and 7% of them were in pre-decisional stage. Our regression results show that negative emotion associated with taking no climate mitigation measures, action planning and coping planning have significant and positive associations with farmers' stage membership in adopting climate mitigation measures. Furthermore, farmers below 50 years old with basic agricultural education and farms with high livestock intensity are found to be significantly associated with later stages in the SSBC model. Behavioural factors will enrich economic analysis of farmers' decision making and will lead to more realistic and effective policy targeting agri-environmental issues (Dessart et al., 2019). This empirical study provides some pointers for designing 'soft' behavioural policy interventions targeting farmers' adoption of climate mitigation measures.

Policy makers should consider making farmers' negative emotions associated with not taking climate mitigation measures more salient through communication campaigns. Besides, confronting farmers with the negative consequences on climate from their farming practices could also evoke negative moral emotions like guilt or shame (Rees et al., 2015). Additionally, policy makers could try to find ways to facilitate farmers' action planning and coping planning for reducing farming related GHGs emissions. Lastly, farmers below 50 years old, with basic agricultural education level and farms with high livestock density should be targeted.

Future research should focus on testing the role of negative emotion, action planning and coping planning on farmers' adoption of climate mitigation measures in a causal relationship. What's more, instead of current adoption level, we will test the associations of these socio-psychological and socio-demographical factors on farmers' future adoption behaviour. In addition, we will also test the effects of these factors on different stages of the SSBC model.

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Appendix A: survey questions & measurement.

Focus	Survey questions and Measurement type & level
Dependent variable	
Stage Model	**Ordered – 4 Stages (participants choose the statement fits his/her goal the most)**
1. Pre-decisional	*a-I am not planning to take any on-farm GHGs emissions mitigation measure and also see no reason why I should do it.*
	b- I am not planning to take any on-farm GHGs emissions mitigation measure because it *would be impossible for me to do so currently.*
2. Pre-actional	*c- I would like to reduce my on-farm GHGs emissions, but now I am not sure about how I can reduce it, or when I should do so.*
3. Actional	*d- I already know which mitigation measures I want to use for my farm, but, I have not put this into practice yet.*
4. Post-actional	*e- I have already taken measures to reduce GHGs emissions on my farm via mitigation measures. I shall maintain or further reduce my already low level of on-farm GHGs emissions for the coming 3 years.*
Socio-psychological variables (Independent Variables)	
Negative emotion	Q1: I feel bad if I take no measures to reduce my farming related GHGs emissions. *(1 strongly disagree... 5 strongly agree)*
	Ratio (1 ordinal five-point Likert scale treated as equidistant)
Positive emotion	Q1: I feel happy if I succeed in reducing my on-farm GHGs emissions. *(1 strongly disagree... 5 strongly agree)*
	Ratio (1 ordinal five-point Likert scale treated as equidistant)
Social norm	Q1 (SNB): People I am dealing with (e.g. fellow farmers and business partners) expect me to reduce my on-fam GHGs emissions. *(1 strongly disagree... 5 strongly agree)*
	Q2 (SNF): People who are important to me (e.g. family/friends), think that I should take measures to reduce my on-farm GHGs emissions. *(1 strongly disagree... 5 strongly agree)*
	Ratio (mean-index consisting of 2 ordinal five-point Likert scales treated as equidistant), Cronbach's alpha = 0.613, average inter-item correlation = 0.22.
Personal norm	Q1 (PN1): Regardless of what other people do, my values and principles oblige me to reduce farming related GHGs emissions. *(1 strongly disagree... 5 strongly agree)*
	Q2 (PN2): I think that reducing GHG emissions is the right thing to do for me. *(1 strongly disagree... 5 strongly agree)*
	Ratio (mean-index consisting of 2 ordinal five-point Likert scales treated as equidistant), Cronbach's alpha = 0.738, average inter-item correlation = 0.295.
Perceived goal feasibility	Q1: How feasible is it for you to reach your future goal in reducing on-farm GHGs emissions within the coming 3 years? *(1 strongly disagree... 5 strongly agree)*

	Ratio (1 ordinal five-point Likert scale treated as equidistant)

Here we present you a list of on-farm GHGs mitigation options. We would like you to **tick the option you prefer the most** for reaching your **future** on-farm emission reduction goal. *You can tick one option.*

Mitigation option	Tick here ☑
Less young stock	
Higher milk production per cow	
Increase feed efficiency (less losses, more frequent feeding)	
Decrease artificial N-fertilizer	
Increase legumes in grass	
Renewable energy production (solar, biogas, wind)	
Increase maize share in ration	
Decrease concentration share in ration	
Use of renewable energy	
Reduce renewal rate of grassland	
Energy saving technologies	
Emission-reducing floor	
Any other measures than the ones mentioned above	
No measures	

Attitude	Q1 (AT_bene): Adopting my chosen GHGs mitigation option on my farm is advantageous for me. *(1 strongly disagree... 5 strongly agree)*
	Q2 (AT_imp): It is important to me that the measure I have chosen to reduce greenhouse gas emissions is applied to my company *(1 strongly disagree... 5 strongly agree)*
	Ratio (mean-index consisting of 2 ordinal five-point Likert scales treated as equidistant), Cronbach's alpha = 0.66, average inter-item correlation = 0.25.
Perceived behaviour control	Q1 (PBC_easy): Adopting my chosen GHGs mitigation option would be ... for me. *(1 very difficult...5 very easy)*
	Q2 (PBC_high): I do not depend on anyone to implement the measure I have chosen to reduce greenhouse gas emissions. *(1 strongly disagree... 5 strongly agree)*
	Ratio (mean-index consisting of 2 ordinal five-point Likert scales treated as equidistant), Cronbach's alpha = 0.467, average inter-item correlation = 0.155.
Action planning	Q1: I have already run through my head on how to best carry out my plan of implementing my chosen GHGs mitigation option. *(1 strongly disagree... 5 strongly agree)*
	Ratio (1 ordinal five-point Likert scale treated as equidistant)
Coping planning	Q1: I have already figured out how I will solve potential problems and obstacles during the implementation of my chosen measure to reduce greenhouse gas emissions. *(1 strongly disagree... 5 strongly agree)*

	Ratio (1 ordinal five-point Likert scale treated as equidistant)
Maintenance self-efficacy	Q1: I am capable of maintaining implementation of my chosen GHGs mitigation option despite potential barriers. *(1 strongly disagree... 5 strongly agree)*
	Ratio (1 ordinal five-point Likert scale treated as equidistant)
Recovery self-efficacy	Q1: I rely on my ability to successfully implement measures to reduce greenhouse gas emissions in the event of setbacks. *(1 strongly disagree... 5 strongly agree)*
	Ratio (1 ordinal five-point Likert scale treated as equidistant)

Appendix B: correlation matrix.