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Research article

A discrete choice experiment exploring farmer preferences for insurance against extreme weather events

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ABSTRACT

Agriculture represents one of the most vulnerable sectors to extreme weather events that are projected to increase with climate change. Insurance has been advocated as a more efficient means to ensure financial security to farmers, than post-disaster aid for damages. A potential drawback of insurance however, is that unless carefully designed it could dis-incentivise farmers to engage in wider farm adaptation measures or lead to more risk-taking behaviour. This paper analyses the attractiveness of publicly-backed climate risk insurance offerings to farmers and explores their preferences for elements of insurance schemes that do not negatively affect incentives for wider farm adaptation. Specifically, a discrete choice experiment is used to reveal Irish farmers' preferences for multi-annual insurance contracts and weather-indexed versus traditional indemnity insurance and cost. Results indicate that a majority of farmers are willing to buy publicly-backed insurance for protection from extreme weather events. Younger farmers, farmers who currently have farm insurance, farmers from certain geographical locations and farmers who have been previously affected by extreme weather events are more likely to buy insurance. With respect to the design of insurance schemes, farmers prefer multi-annual coverage versus annual renewal. They also prefer indexed-insurance and have a strong preference for cheaper coverage. Despite the important role that insurance could play in protecting farms financially from damage caused by extreme weather events, few studies have examined preference for weather-indexed insurance within a European context. New evidence on farmer preferences and intended behaviours is therefore critical to inform policy in this area.

1. Introduction

Agriculture is a vital economic sector and global food demand is expected to increase by 70% in the coming decades (Wrenford and Topp, 2020; EEA, 2019). At the same time, the agricultural sector faces significant challenges over the coming decades from the effects of climate change. One of the identified risks of climate change on agricultural activity is the forecasted increase in extreme weather events including more frequent and higher intensity heat waves/droughts, cold spells, extreme precipitation, storms and storm surges and high levels of solar radiation (IPCC, 2012), with high levels of damage and remediation costs. Global insurer 'Munich Re' has estimated that the worldwide economic cost of natural disasters from extreme weather events increased from $25 billion per year during the 1980s to $175 billion in 2016 (Munich Re, 2017).

According to the Intergovernmental Panel on Climate Change (IPCC), there has been a change from 'disaster management' of extreme weather events which prevailed until the beginning of the 1990s to 'disaster risk management', which now tends to dominate discussions and actions (IPCC, 2012). Disaster risk management consists of policies and strategies to reduce the risk of disasters and to strengthen the resilience and reduction of disaster losses. An area that has been identified as a component of disaster risk management for extreme weather events is insurance, with the IPCC and other agencies identifying the need for innovative public-private partnerships to develop robust insurance products (e.g. IPCC, 2012; OECD, 2009; Munich Climate

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Insurance Initiative; UNU, 2020).

In certain countries such as the United States (U.S.) and Canada, agricultural insurance markets are well-established particularly for globally traded tillage crops (where farmers can receive insurance against low yields and prices because of extreme weather) and are the primary tool for reducing farmers' exposure to risk (Fleckenstein et al., 2020; Meuwissen et al., 2018). Within Europe, while some countries have their own well-established insurance schemes, particularly for crops, only relatively recently did explicit risk management become part of the Common Agricultural Policy (CAP), with the introduction of a risk management layer in 2008 for certain targeted sectors (Meuwissen et al., 2018). This was replaced by support for risk management in the 2nd CAP pillar for 2014–2020, where member states were allowed to allocate part of the European Agricultural Fund for Rural Development to provide financial contributions to insurance premiums, mutual funds and income stabilisation tools. However, take up of these measures is generally low to date and funding for the second pillar is much lower compared to the first pillar, which incorporates direct payment to farmers (Coletta et al., 2019; Meuwissen et al., 2018).

In general, traditional indemnity-based insurance suffers from asymmetrical information problems, moral hazard, adverse selection and high transactions costs (Conradt et al., 2015). As noted by Surminski (2016), having insurance can lead to more risky behaviour, a decline in risk reduction investments or a delay in implementation of prevention measures. Fankhauser and McDermott (2014) find a negative relationship between the extent of insurance cover and the demand for adaptation in the context of losses from disaster events internationally.

There is growing interest in developing innovative insurance products for extreme weather events that do not hamper incentives to undertake risk reduction or adaptation measures, in the context of crop insurance, the most popular includes area-based yield insurance and weather-indexed insurance. In area-based yield insurance, payouts are based on village level yields whereby the policy holders receives an indemnity when the village yields falls below a specified threshold (Budhathoki et al., 2019). Weather-indexed insurance pays on the basis of an index, such as rainfall being below a threshold in a defined geographic area, as measured by a local weather station or satellite (Castells-Quintana et al., 2018). Therefore, a loss adjustor does not need to visit a farm to determine the premium or assess damages; insurance claims are paid if weather (such as rainfall) is below or above some pre-specified threshold. According to Clement et al. (2018) weather-indexed insurance reduces moral hazard, as individuals cannot influence the amount of compensation and it can reduce transaction costs, as there is no lengthy verification process. Importantly, therefore, this type of insurance reduces incentives for moral hazard behaviour, as pay-out is based on an external objective measurement. There is a potential drawback to weather-indexed insurance, however as payment is based on an external source, it may not accurately reflect damages to specific farms (idiosyncratic or basis risk) leading to under or over compensation (Clement et al., 2018). Thus if a weather event did not trigger a payout, it could undermine confidence in the scheme (ADB, 2019). Moreover, Fuchs and Wolff (2011) analysed weather-indexed insurance in Mexico and found several unintended spillover effects of this type of insurance for crops. Budhathoki et al. (2019) found that low take up of indexed insurance in Nepal could be explained by a number of factors including lack of understanding, a lack of trust in the insurance providers, cash constraints and complex administrative procedures. Several studies have examined potential mechanisms to overcome some of the problems with basis risk associated with traditional weather-indexed insurance (Leppert et al., 2021; Bucheli et al., 2020).

A number of studies have also identified the benefits of multi-year insurance contracts for extreme weather events (e.g. Goss and O' Neill, 2010; Michel-Kerjan and Kunreuther, 2011; Maynard and Ranger, 2012; Chen and Goodwin, 2015). As noted by Maynard and Ranger (2012), multi-annual insurance could have significant benefits for climate change adaptation by providing greater incentives for the insured to invest in cost-effective adaptation or resilience measures. A similar argument is made by Kunreuther et al. (2009) who argue that with multi-year contracts, the benefits to investment in risk reduction measures are more visible, providing financial security and guaranteed insurance coverage. Kunreuther and Michel-Kerjan (2009) argue that the United States National Flood Insurance Program should be redesigned to include multi-annual coverage to encourage the uptake of more adaptation measures and provide greater financial security for insured parties. Moreover, they note that with annual renewal of insurance, offering insurance discounts for measures that reduce risks might not be sufficient to encourage risk reduction investments. However, with longer-term insurance contracts, reduction in insurance premiums could be sufficient to spur investment in such measures (Kunreuther and Michel-Kerjan, 2011).

Insurance schemes are increasingly being used as a means of coping with weather risk for agriculture, both in wealthier countries such as the U.S, as well as in developing countries where government backed schemes are becoming more common (see ADB, 2019). The development of crop insurance markets has resulted in a large literature exploring factors that impact on farmer's decisions to use insurance to manage risks (e.g. Blank, S. C. and McDonald, 1996; Knight and Coble, 1997; Coble et al., 1996; Ellinger, P.N. and Schnitkey, 2004; Sherrick et al., 2004; Glauber, 2004; Cabas et al., 2008; Garrido, and Zilberman, 2008; Enjolras, G and Sentis, 2011; Enjolras et al., 2012; Finger and Lehmann, 2012; DiFalco et al., 2014; Du et al., 2017; Musshoff et al., 2017; Vargas et al., 2016; Clarke, 2016; Daluis et al., 2020).

Despite the significant literature examining determinants of crop insurance, few studies have examined preferences for weather-indexed insurance within the European Union (EU). Liesivaara and Myyrä (2014) examined preferences among Finnish farmers for the design of a crop insurance scheme and they found that farmers preferred indexed insurance over farm specific insurance, despite not having any experience with this type of insurance previously. In a laboratory experiment to investigate German farmers' willingness to adopt weather-indexed insurance, Musshoff et al. (2017) found that demand decreases as the premium increases, demand falls if farmers perceive that other parties are earning too much, and communicating to farmers that index insurance has been subsidised raises demand, even if insurance costs are kept constant. Jørgensen et al. (2020) examined Danish farmers' willingness to engage in wider adaptation (related to measures to improve soil health) as a precondition to access market insurance for coverage for adverse climatic events. In assessing preferences for yield area or rainfall (indexed insurance), they found that farmers did not significantly prefer one type over another. While DiFalco et al. (2014) did not specifically examine preferences for weather-indexed insurance, they did find that demand for crop insurance among Italian farmers is likely to increase in response to increasing adverse climatic conditions. Other studies that have also examined preferences for weather indexed insurance in developing countries where there are less other income support tools available to farmers for disaster events (e.g., Hill et al., 2013; Castellani et al., 2014; Akter et al., 2016; Senapati, 2020).

The overarching aim of the study is to provide insights for policymakers on how to help farmers manage risks associated with extreme weather events through determining farmer's preferences for climatic related insurance and what features farmers most value for these types of insurance. Given that many of the studies published so far focus on examining farmer preferences for weather indexed insurance in low income countries, this study examines preferences amongst farmers for weather-indexed insurance within an OECD country, where there is significantly less research to date. Specifically this paper conducts an empirical analysis to examine farmer preferences for the use of EU-backed farm insurance measures against extreme weather events in managing weather-related risks. While tillage farmers have been dealing with weather shocks for many years, given the projected increases in extreme weather events, this study was interested in examining preferences for insurance among farmers across the range of farm systems. A discrete choice experiment (DCE) methodology is used to establish farmers' preferences for multi-annual insurance coverage, traditional indemnity versus weather-indexed insurance and insurance costs. A number of interactions are included to explain observed heterogeneity related to preferences for multi-annual insurance and weather-indexed insurance. A multivariate analysis is undertaken to examine the characteristics of farmers who are not willing to buy insurance for protection against extreme weather events. Of particular interest is the examination of farmers' preferences for innovative elements of insurance design (including multi-annual and weather-indexed insurance), that offer the opportunity for farmers to avail of insurance coverage that may also incentivise the undertaking of wider farm risk reduction measures to ensure better farm adaptation to extreme weather events.

The paper uses data from a representative sample of 270 farmers in Ireland. In Ireland, agricultural insurance schemes were traditionally under-developed, as Irish farmers relied significantly on direct payments through the single farm payment under the CAP as a method to stabilise income. (DAFM, 2010). However, a private non-subsidised insurance market has developed for farm insurance, with most farmers having some type of farm insurance. Currently, farm insurance typically covers farm property (including dwelling house), agricultural vehicles, livestock and public liability and personal accident insurance. Within Ireland, as in many other countries, weather-indexed insurance, multi-annual contracts or publicly backed insurance schemes are not currently available. As a result, despite most farmers in Ireland having some form of private insurance, our particular interest was to examine farmer preferences for a publicly backed farm insurance scheme with features such as multi-annual coverage and weather-indexed insurance that currently does not exist in Ireland. This reflects the wider policy-interest more broadly as well as in Ireland in using insurance to manage financial risks in agriculture associated with climate change (IPCC, 2012; DAFM, 2018).

2. Methods and data

2.1. Modelling framework

Within a DCE, respondents are asked to make a series of choices between several hypothetical choice alternatives, with each alternative defined by its attributes and the levels of the attributes. The DCE framework assumes that respondents choose the alternative that provides the highest level of utility for them. The choices that respondents make indicate which attributes significantly influence their choices, their willingness to trade-off between the different attributes, and if price is included as an attribute, the willingness to pay for changes in each of the non-monetary attributes can be estimated (Hynes et al., 2013; Hanley et al., 2002).

The statistical analysis of DCE data is based on McFadden's random utility model (RUM) (McFadden, 1974). Within the RUM framework, Utility U_{ni} for individual n of alternative i consists of an observable component V_{ni} which is determined by the attributes of the alternatives in a DCE and respondent characteristics, and a random component ε_{ni}, which represents unobservable influences on individual choices. Different discrete choice models can be estimated depending on the assumptions regarding the distribution of the error term. The basic DCE model is the conditional logit (CL) model, which provides a useful starting point for the analysis. However, the CL model is associated with a number of restrictive assumptions that can bias policy implications in terms of the optimal implementation of results from a DCE (Train, 2009). Thus, other models such as the random parameters logit (RPL) model and the latent class model have been developed to relax some of the restrictive assumptions of the CL model.

One variant of the RPL model that is popular within the literature is the mixed logit model, estimated in willingness to pay (WTP) space (Train and Weeks, 2005; Scarpa et al., 2008). In the WTP space model, the ratio of the non-cost to cost coefficient is computed in the model giving direct WTP estimates, unlike the traditional preference space model, where utility coefficients are first estimated in the model and WTP is subsequently calculated extraneously. As such, the WTP space model represents a re-parameterisation of the preference space model by giving direct estimates of WTP.

2.2. Description of the discrete choice experiment

The attributes and levels chosen for inclusion in the DCE were the result of several stages. Following a review of the literature, 50 farmers were surveyed at a national farm event in July 2018, to ascertain whether/how extreme weather events were having an impact on their farming activities. To help determine the correct attributes and levels to include within the DCE, a further 18 in-depth face-to-face interviews were conducted to elicit farmers' attitudes towards insurance against extreme weather events. A draft survey based on the attributes of the DCE was then piloted with farmers to ensure that (a) the survey was understandable and (b) relevant attributes were not excluded from the DCE.

Three attributes were chosen for inclusion in the DCE as reported in Table 1.

The first attribute was the *duration of insurance contract*. As mentioned, several studies have discussed the benefits of multi-annual insurance contracts to protect against damages caused by weather-related events (e.g. Kunreuther et al., 2009; Kunreuther; Michel--Kerjan, 2011; Chen and Goodwin, 2015), A number of the farmers in the individual interviews indicated a preference for multi-annual insurance rather than yearly renewal, due to concerns that they would be exposed to higher premiums in the aftermath of an extreme weather event. This issue has also been noted in several reports in Ireland, particularly in the context of flood insurance (e.g. Surminski., 2017; Houses of the Oireachtas, 2019). This attribute gives farmers the security of being 'locked-in' to an insurance contract at a given price for a given duration, regardless of whether their farm has been affected by an extreme weather event. Respondent farmers in the DCE were instructed that the premium would have to be paid in every year of the contract.

Studies have identified a number of problems related to traditional indemnity insurance that could negatively affect farmers' willingness to engage in climate change adaptation (e.g. Conradt et al., 2015; Castells-Quintana, 2018; Surminski, 2016). As a result of this, we were interested in determining farmers' preferences for how damages were assessed. Therefore, we developed an attribute called *Method of Damage Assessment* with two levels. The first level was based on a traditional inspection, whereby loss-adjustors would assess damages during an on-site inspection. The second level was described as a 'weather-based index insurance' where payment would be triggered by weather (e.g. rainfall being below a certain level that would induce drought) as measured by an external source. This level reflected the interest in the wider literature and among policy-makers in this type of insurance for extreme weather events.

The third attribute is the *annual cost of the insurance,* which was identified as the most important attribute by farmers in the early interview stages of the research. The levels of this attribute were developed based on responses from farmers in the design phase of the study. Farmers were asked open-ended questions regarding how much they would be willing to pay for this type of insurance. The levels of this

Table 1
Attributes and levels.

Attribute Name and Description	Levels
Duration of insurance contract:	1, 2, 5, 10 years
Method of Assessment: (described as how damages would be assessed)	On-Farm Inspection or Weather-Indexed Insurance
Insurance Premium per year:	€50, €100, €200, €400, €600, €800

attribute were subsequently tested in interviews with farmers to ensure that they reflected a realistic range. A number of different ways to present the cost attribute were considered, such as using a percentage of the insured value or cost per hectare but the farmers indicated that they found using an annual cost the easiest to interpret.

Prior to completing the DCE choice cards, information was provided to respondent farmers in relation to the nature of the insurance. The insurance was described as an EU-backed insurance scheme that would pay for the loss of agricultural output associated with damages to livestock, crops, fodder, milk output or other damages to output caused by extreme weather events. It was made clear that this insurance was additional to any existing farm insurance and would only cover the farm for damages caused by extreme weather events (and not damages caused by other factors). These extreme weather events included damages to farms from severe drought, flooding, storms (hail and wind damage) and wildfires, as these events were deemed most important by farmers during the short-survey that we conducted during the preliminary farmer survey in 2018.

Based on the attributes and levels, the choice cards were generated using Ngene software based on a sequential Bayesian efficient experimental design (Rose and Bliemer, 2009). Each choice card contained two insurance options and an 'opt-out' alternative. The non-cost attributes were coded as dummy variables and the cost attribute was included as a continuous variable. For each of 12 choice cards, farmers were asked to choose their preferred alternative. The opt-out alternative was described as *no insurance*, while alternatives one and two describe two potential insurance options differentiated by the attribute levels. The inclusion of an opt-out alternative ensures that respondents are not forced to choose between two potentially unappealing alternatives, which would not be chosen in practice (Lancsar and Louviere, 2008). It also provides an indication of the share of farmers who would not be willing to buy this type of insurance.

Based on pilot surveys, changes were made to the survey wording and the experimental design for the DCE was updated using conditional logit estimates from the pilot data. Fig. 1 shows an example choice card used in the study.

2.3. Survey description and data collection

In addition to the DCE section, the survey included: (i) questions on the profile of the farm, (ii) statements querying attitudes towards extreme weather events, (iii) a contingent valuation section in relation to the maximum amount farmers would be willing to pay for insurance protecting against extreme weather events, (iv) questions about the demographic profile of the farmers and the farmers' level of financial literacy and financial risk preferences. The survey also included a section querying farmers' willingness to undertake adaptation measures. First, farmers were asked whether they grow a range of fodder crops, as crop diversification is essentially a severe weather adaptation but also a risk-aversion measure. Secondly, farmers were asked if they would consider applying flood restriction measures to rivers near their farms to protect downstream lands from flooding.[1] This is a measure that is increasingly raised in the context of reducing the loss of sediment to water as part of flood risk management plans for extreme weather events under the European Floods Directive (Nones, 2019). The Behaviour and Attitudes Survey Company collected the data from 270 farmers between April and August 2019, using a quota-based sample.

2.4. Empirical approach

A number of models are estimated on the DCE data for the farmers who chose at least one of the insurance options, to determine the willingness to pay for elements of insurance for those farmers who would be willing to buy insurance. A conditional logit model is estimated that includes interactions with the duration of insurance contract and method of damage assessment attributes to examine several hypotheses. First, we examine whether there are differences in preferences for the attributes, based on whether a farmer currently has farm insurance covering any type of damage. Farmers who already have insurance may be more risk averse or have greater experience with insurance products (Santeramo, 2018) than farmers who do not have insurance and this might influence their preferences for insurance duration and the method of damage assessment.

Second, models are estimated to examine whether farmers' stated concerns regarding extreme weather events or previous impacts of extreme weather have any effect on preferences for these attributes, as previous studies have shown that climate risk is related to willingness to buy insurance (e.g. Finger and Lehmann, 2012; DiFalco et al., 2014). Farmers who are more concerned or who have previously been affected, may prefer longer contracts to ensure that their farm has continual coverage even if affected by extreme weather events. They may also perceive that weather-indexed insurance is more efficient in terms of pay-out. Alternatively if they perceive that their farm is at high risk, they may prefer on-site inspection if they think it might more accurately assess damages.

Third, models are estimated to examine whether there is any relationship between farmers' risk attitudes and preferences for these attributes. It could be the case that farmers who are more risk averse prefer longer contracts and they may prefer on-site inspections with potentially more accurate assessment of damages. Finally, we examine whether there are differences in preferences for the attributes across farm characteristics related to farm size and type of farm, as these have been found to influence preferences for insurance in previous studies (e.g. Sherrick et al., 2004; Enjolras and Sentis, 2011).

To accommodate potential differences in unobserved preferences and scale heterogeneity, a mixed logit model estimated in WTP-Space is also presented. For this model, the coefficients on the non-cost attributes are random and are specified to follow a Normal distribution $\sim N(\mu, \sigma)$. The cost coefficient is specified to be Log-normally distributed and multiplied by minus one to ensure the estimated cost coefficient is strictly negative. The WTP-space models are estimated with the user-written *mixlogitwtp* packages in Stata 16 with 500 Halton draws (Hole 2007, 2016).

As a separate analysis, the probability that a farmer would serially choose the 'no insurance' option throughout the DCE is estimated using a logistic regression model and odds ratios are presented for this model. In this case, the dependent variable takes a value of one if the farmer chooses never to purchase insurance in the DCE and zero otherwise. The probability that a farmer chooses the no insurance option is modelled as a multivariate function of the farm and farmer characteristics. Several farm variables (size, location, type) may influence preferences for insurance. Farm size in particular has been shown to be a determinant of insurance decisions (e.g. Enjolras and Sentis, 2011; Finger and Lehmann 2012; Singerman et al., 2012).

Current farm insurance is also included as a covariate in the model as this may indicate that farmers with potentially higher risks or more experience, may be more risk averse or may be positively predisposed to insurance (e.g. Enjolras and Sentis, 2011; Santeramo, 2018). Farmer characteristics such as age, education, years farming, whether the farmer has an identified farm successor and whether the farmer has an

[1] This specific survey question was: "*It is possible to reduce the risk of flooding to downstream communities by placing flow restrictors on rivers near your farm. Flow restrictors reduce the volume of water travelling down the river. However flow restrictors would increase the chances of flooding on your farmland during the summer months. If you were offered a scheme that could lead to flooding on up to 1 ha or 2.5 acres of your farmland to protect downstream communities from flooding, would you be willing to participate in such a scheme? As part of the scheme you would be compensated for the value of the lost agricultural output associated with the flooding? This was included within the survey as it was also of interest for the RiskAquaSoil project of which this study is a component.*

	Insurance Product A	Insurance Product B	No Insurance
Duration of Contract	10 years	1 year	
Method of Damage Assessment	On-Farm inspection	Index-Based	
Insurance Premium	€200 per year	€100 per year	€0
I would Choose	☐	☐	☐

Fig. 1. Example choice card.

off-farm income are also included. A number of these variables have been found to influence preferences for insurance or wider farm adaptation measures in previous studies (e.g. Sherrick et al., 2004; Enjolras and Sentis, 2011; Finger and Lehmann 2012; Liesivaara, and Myyrä, 2014; Li et al., 2017; Tzemi and Breen, 2019).

Indicator variables for whether a farmer is concerned about extreme weather events or whether they have previously been affected by extreme weather events are also included as explanatory variables in the model. Previous studies have shown that climate-related risks can impact farmers' insurance decisions (e.g. Finger and Lehmann, 2012; DiFalco et al., 2014; Sherrick et al., 2004). While we do not have independent climatic risk information to include within the model, we use farmers' views on whether they are concerned about extreme weather events or whether their farm has been previously affected by extreme weather events as a proxy. Additional indicators reflecting whether they currently are or have ever been in an agri-environment scheme and whether they would be willing to place flood restrictors on rivers near their land to reduce downstream flooding to local communities are also included, as these indicators could reflect an underlying willingness to engage in broader adaptation measures. Moreover, for farmers who are members of agri-environment schemes, given that a percentage of their income is coming from the scheme(s) they may be less reliant financially than other farms on market income, which might influence their willingness to buy insurance (Sherrick et al., 2004; Finger and Lehman, 2012).

3. Results

Table 2 presents the descriptive statistics from the sample based on the demographic profile of the farmer and farm characteristics. In this table we assess the representativeness of our sample against the 2016 Farm Structure Survey (FSS) conducted by the Central Statistics Office (CSO, 2018) by comparing variables that were available in both surveys.

As shown in Table 2, the majority of farmers in our sample are male and older. Almost 60% of farmers are older than 55 years old, with roughly half of that figure (29% of the full sample) over 65 years old. The average number of years that the farmers have been farming in their own right is 31 years (with a standard deviation of 16 years) and approximately 50% of farmers have identified a farm successor. In terms of the educational profile, approximately 43% of farmers have a primary level education only or some secondary education, while 10% have a university degree or higher. Approximately 40% of farms have an off-farm job or income source. In terms of farm characteristics, nearly half of farmers surveyed have between 21 and 50 ha of farmland and are predominantly drystock/dairying farms. The majority of farmers in the survey have some form of private farm insurance. In terms of mainly cattle systems, this includes both 'Cattle Rearing' farmers (36%) and 'Cattle Other' (17%) farms.[2] Comparing our sample against national averages for farmers in Ireland (2016 FSS), it is evident that our sample is broadly representative of the wider farm population based on the

Table 2
Descriptive statistics of the sample.

Descriptive Characteristics	Percentage for categorical variables or mean and standard deviation for continuous variables (n = 270)	Farm Structure Survey (2016) (n = 137,500)
Gender: Male	84%	88%
Age Categories:		
Under 35 Years	8%	5%
35–44 Years	13%	16%
45–54 Years	21%	24%
55–64 Years	30%	25%
65 years or older	29%	30%
Married	76%	
Has Children	69%	
Average number of years farming	31 years (Std Deviation:16 years)	
Education Level		
Primary/Some Secondary	43%	
Complete Secondary	33%	
Professional Qualification	14%	
College/University Degree Level	10%	
Identified a farm successor	50%	
Has an Off-Farm Job	40%	
Farm Size		
Up to 10 ha	5%	
10–20 ha	21%	
21–30 ha	22%	32.4 ha
31–50 ha	26%	(average farm size)
51–100 ha	26%	
Farm System		
Mainly Dairying	23%	12%
Mainly Cattle	53%	57%
Mainly Sheep	13%	11%
Mainly Tillage	5%	9%
Mainly Mixed Livestock/other	6%	11%
Regional location		
Border, Midlands and West	53%	53%
Mideast and Midwest	21%	19%
South	26%	28%
Currently has some form of farm insurance	89%	

[2] *The 'cattle rearing' system refers to farms that mainly have suckler cows for rearing calves which may be sold as weanling or as stores (around 1 years old). The 'cattle other' system refers to cattle finishers who buy store cattle from cattle rearing farmers and finish the cattle for processing.*

available characteristics on gender, age and regional location. However, there is a higher proportion of dairy farmers and a lower proportion of tillage farmers in our sample compared to the FSS.

3.1. Empirical results: DCE analysis

In the DCE section, 69% of farmers indicated a willingness to buy insurance to protect their farm against extreme weather events, while 31% of farmers serially chose the 'no-insurance option' in all the choice cards. Table 3 presents the results of a CL model including interactions with observed farm characteristics. Only the variables with significant interactions (related to whether the farm is currently covered by insurance, whether the farmer keeps a variety of fodder (included as a measure of their risk preference and willingness to adapt) and whether a farmer stated they are concerned about extreme weather events) are presented in Table 3.

The results of the CL model including interactions shows that farmers who currently have farm insurance prefer longer insurance contracts. These farmers are willing to pay approximately €22.5 for each additional year of insurance. The main coefficient on the duration attribute becomes negative when the interaction is included, suggesting that those farmers who do not currently have insurance significantly dislike longer insurance contracts and are willing to pay €19.25 to avoid each additional year of an insurance contract. There was a positive and significant interaction, at the 10% level only, between preferences for longer contracts and whether the farmer keeps a variety of fodder when interacted with the duration attribute. With respect to the method of damage assessment, there was a significant and positive interaction for farmers who indicated that they are concerned about extreme weather events and preferences for weather-indexed insurance. These farmers are willing to pay approximately €74 for weather-indexed insurance relative to on-farm inspection. The main coefficient on the indexed-insurance attribute does not retain significance when the interaction is included, indicating that preferences for indexed-insurance over traditional indemnity insurance are driven by farmers who are concerned about extreme weather. Other interactions between the farm and farmer characteristics and the attributes are not significant and therefore these results are not presented.

We conducted a Hausman Test to determine whether the independence of irrelevant alternatives (IIA) assumption of the CL model is appropriate for our data. The results from the Hausman test reject the assumption of IIA (Chi-Square = 12.33, P = 0.015), therefore, a mixed logit model in WTP-space was estimated, with results presented in Table 4. This model presents the willingness to pay estimates for the non-cost coefficients. Interactions are not included in this model as the model would not converge when the interactions were included.

Table 3
Results from the CL model with interactions.

Variables	CL Model with Interactions
Duration of Insurance Contract	−0.077(0.034)**
Duration of Insurance Contract* Currently has farm insurance	0.089(0.035)***
Duration of Insurance Contract* Variety of Fodder	0.027 (0.014)*
Method of Damage Assessment	
On-Farm Inspection	
Indexed-Insurance	0.083(0.086)
Indexed-Insurance*Concern about extreme weather	0.297 (0.097)***
Cost per year	−0.004 (0.0001)***
Status Quo Constant	−1.54*** (0.133)
No. of individuals	186
No. of observations	2232
Log-likelihood	−1933.635
AIC	3881.265
BIC	3929.005

Note: Standard errors are shown in parentheses. * denotes significant at 10% level, ** denotes significant at 5% level, *** denotes significant at 1% level.

Table 4
Results from the mixed logit model estimated in WTP-space.

Variable	Mixed logit model in WTP space (€)
Random parameters: Mean	
Duration of Insurance Contract	€25.26 (3.29)***
Method of Damage Assessment	
On-Farm Inspection	*Reference level*
Indexed-based Insurance	€141.61 (28.20)***
Cost Per Year	−0.020 (0.008)***
Non-random parameters	
ASC – Status Quo	€-222.82 (29.75)***
Standard Deviation of random parameters	
Duration of Insurance Contract	€32.88 (1.56)***
Indexed-based Insurance	€199.62 (13.72)***
Cost Per Year	0.0601 (0.046)
No. of individuals	186
No. of observations	2232
Log-likelihood	−1722.89
AIC	3459.781
BIC	3507.446

Note: Standard errors are shown in parentheses. * denotes significant at 10% level, ** denotes significant at 5% level, *** denotes significant at 1% level. Cost variable is the coefficient value.

The results indicate that *ceteris paribus*, farmers are willing to pay on average €25.26 per year for each additional year of insurance coverage. With respect to the method of damage assessment, farmers have a price premium of €141 per year for indexed insurance relative to traditional indemnity-based insurance. Farmers have a premium of €222 to avoid the no insurance option. The estimated standard deviations are statistically significant and large, relative to the mean for the duration and indexed insurance attributes, which indicates that there is also sizable unobserved heterogeneity in farmers' preferences for these attributes. To account for this heterogeneity, Fig. 2 plots the distribution to willingness to pay for both the duration and indexed-based insurance attributes. It is evident that there is a large degree of heterogeneity in willingness to pay for the indexed-based insurance attribute. There is a considerable proportion of farmers who have negative willingness to pay for indexed-insurance, suggesting that they prefer a traditional on-site inspection of damages.

3.2. Empirical analysis of farmers who are not willing to buy weather insurance

As indicated, 31% of farmers (n = 84) stated that they would not be willing to buy insurance. The main reasons indicated in the survey for why farmers serially chose the no-insurance option was because they felt that they had adequate insurance already and did not need additional EU backed insurance (38%) or because they did not believe that extreme weather events would affect their farms (37%). .

Table 5 presents the odds ratios from a logistic analysis exploring the characteristics associated with farmers who indicated that they preferred not to buy insurance. A significant positive odds ratio of greater than one implies that the characteristic is associated with a farmer having a lower likelihood of buying insurance, with a greater likelihood associated with a significant positive odds ratio of less than one. Given the relatively small sample, all respondents who serially chose the 'no insurance' option were pooled together, regardless of their stated reasons.

Table 5 shows the significant associations between farmers who indicated they would not buy insurance and their farm and farmer characteristics. The results show no significant differences in the willingness to buy insurance across farm types, relative to dairy farmers, indicating that farmers from all farm types (e.g. dairy, cattle, sheep, mixed or tillage) were equally likely to buy insurance, however this may reflect the small sample size and this result should be interpreted with caution. Farm size is not a statistically significant predictor, suggesting

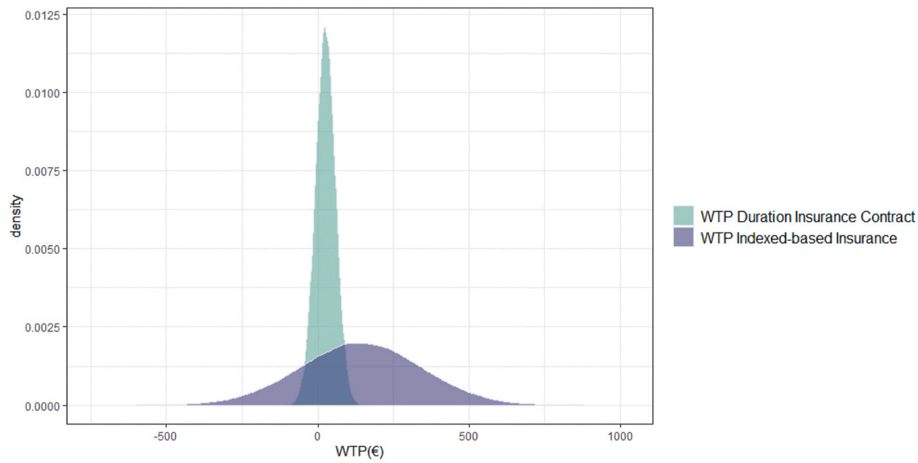

Fig. 2. Empirical distribution of willingness to pay for duration and indexed-based insurance.

Table 5
Empirical analysis examining factors associated with farmers not buying insurance.

Variable	Logistic Regression: Odds Ratio
Farm Characteristics	
Farm system	
Mainly Dairy	*Reference level*
Mainly Cattle Rearing	1.08 (0.442)
Mainly Cattle Other	1.57 (0.823)
Mainly Sheep	0.78 (0.444)
Mixed Livestock	0.79 (0.617)
Mainly Tillage	3.11 (2.61)
Farm Size	
Less than 50 ha	*Reference level*
50 ha or more	0.578 (0.223)
Has farm insurance	0.378 (0.186)**
Regional Location	
South	*Reference level*
Mideast and Midwest	0.542 (0.250)
Border, Midlands, West	0.469 (0.182)**
Farmer Characteristics	
Male	1.44 (0.692)
Age	1.61 (0.236)***
Years Farming	0.974(0.013)*
Education	
Lower than degree	*Reference level*
Degree or higher	1.35 (0.91)
Identified farm successor (Yes)	0.716 (0.245)
Off-Farm Job/Income (Yes)	0.594 (0.211)
Concerned about extreme weather (Yes)	0.778 (0.272)
Previously affected by extreme weather (Yes)	0.369 (0.125)***
Willingness to participate in flood scheme	0.366 (0.119)***
Participate in AES scheme	1.035 (0.326)
Number of Individuals	270
Log-likelihood	−136.51
AIC	312.324
BIC	384.292

Note: Standard errors are shown in parentheses. * denotes significant at 10% level, ** denotes significant at 5% level, *** denotes significant at 1% level.

either that both large farmers (with over 50 ha) and those with smaller holdings (less than 50 ha) were equally likely to buy insurance. Farmers who currently have some form of private farm insurance are also more willing to buy this additional publicly backed insurance for protection against extreme weather events. Farms located in the Border, Midlands and West of Ireland (where the largest proportion of farms are located) were significantly more likely to choose insurance compared to farmers located in the South of Ireland. We also observe that younger farmers are significantly more likely to buy insurance compared to older farmers. There are no significant differences in the likelihood of choosing the no insurance option based on a farmer's gender, educational profile, having an identified farm successor and having an off-farm job.

Participation in agri-environment schemes is not a significant predictor of farmers' willingness to buy insurance. Farmers who indicated a willingness to place flood restrictors on rivers near their land to reduce flooding to downstream communities are more likely to buy insurance, which could indicate greater willingness to engage in adaptation generally or a greater concern about extreme weather events. Farmers' concerns about extreme weather events are also not significantly related to their willingness to buy insurance, but farmers who were previously affected by extreme weather are more willing to buy insurance.

4. Discussion and conclusions

The main response to disaster events in many countries has been on post-disaster aid relief, which can be inefficient (ADB, 2019). Well-designed publicly-secured insurance contracts on the other hand, offer the opportunity to provide anticipatory planning for weather events through financial protection for farmers (IPCC, 2012). It is critical however, to design insurance schemes that do not dis-incentivise wider farm adaptation measures or lead to more risk-taking by farmers. This is of particular relevance in the context of climate change and the likely increase in the frequency and/or severity of extreme weather events into the future. Thus new evidence on farmer preferences and intended behaviours is important to inform policy in this area.

This paper provided insights for policy-makers on how to help farmers manage risks associated with extreme weather events through determining farmer's preferences for climatic related insurance. The IPCC (2012) highlighted the need for innovative public-private partnerships to develop insurance products that could respond to disaster risk and extreme weather events (IPCC, 2012). As a result, this study focuses on eliciting preferences for a publicly-backed insurance scheme, which is not currently available in Ireland. Our results show that 69% of farmers are willing to buy insurance against extreme weather events.

Farmers who are older, who currently do not have any insurance, who have not been previously affected by extreme weather events and who are from the South of Ireland are less likely to buy insurance. Findings with respect to experience of previous adverse weather events are similar to previous studies (e.g. Enjolras and Sentis, 2011). Our findings with respect to age are similar to those of Liesivaara and Myyrä (2014) who found that younger farmers favour insurance for extreme weather, however other studies found that older farmers were more likely to buy insurance (e.g. Sherrick et al., 2004). While other studies found that education, off-farm income, farm size and having an identified farm successor were significantly associated with buying insurance or wider farm adaptation behaviour (e.g. Sherrick et al., 2004; Enjolras and Sentis, 2011; Finger and Lehmann, 2012; Li et al., 2017), this was not evident in our study on willingness to purchase insurance.

We found that on average, farmers would be willing to pay approximately €222 per year to avoid the 'no insurance' option. To contextualise this figure, the median spend on farm insurance is €1600 per year (covering various categories of damages and causes) based on data collected for this study. This indicates that as a percentage of insurance costs, farmers would value additional EU-backed insurance from extreme weather events at approximately 14% of the current median cost of farm insurance. It could be the case that if there were no current private insurance system in Ireland, the results on the willingness to pay for this type of publicly backed insurance scheme may have been different.

Within a DCE framework, farmers' preferences for insurance duration, specifically the option of multi-annual insurance, method of damage assessment and cost were examined. The results showed that farmers had a statistically significant preference for longer insurance coverage. Yet the premium that farmers would be willing to pay for each additional year of guaranteed coverage was relatively small, and equated to approximately 10% of the value of total WTP for insurance for extreme weather events. Significant observed and large unobserved preference heterogeneity was also found for this attribute. With respect to observed heterogeneity, it is notable that farmers who currently have farm insurance significantly prefer longer insurance contracts, suggesting that these farmers may be more risk averse generally and as a result, prefer the duration and fixed price certainty associated with multi-annual insurance (Chen and Goodwin, 2015). Kleindorfer et al. (2012) investigated multi-year property insurance in the presence of weather risks and argue that both single- and multi-year policies should be provided as consumers have different degrees of risk aversion.

The results showed that farmers had a significant positive preference for weather-indexed insurance over traditional indemnity insurance, although with a large degree of heterogeneity in willingness to pay amongst farmers, with a significant proportion of farmers preferring on-farm inspections as illustrated in Fig. 2. These results contrast somewhat with Jørgensen et al. (2020) who found no significant differences in preferences for any particular type of insurance in a study of Danish farmers (although in their study they compared weather-indexed insurance to yield insurance). In their study of Finnish crop farmers, Liesivaara and Myyrä (2014) also found that farmers preferred indexed insurance over on-farm inspection, which they argued could be due to farmers' dislike of farm inspections. Farmers who indicated that they were concerned about extreme weather tended to favour indexed-insurance. The final attribute, cost, was the most important to farmers, highlighted during the individual interviews with farmers and by the statistical significance of the coefficient on this attribute.

From a policy perspective, these results suggest that there is scope to re-design farm insurance contracts, offering the multi-annual contracts with weather-indexed assessments, which is not currently available in Ireland or many other countries. The combination of continued insurance and this method of assessment may help overcome the well-known issues of moral hazard associated with traditional insurance, whereby once a farm has insurance, the incentive to reduce risks to the farm is smaller. One of the potential benefits of multi-annual insurance is that it could incentivise the insured farmer to invest in better resilience and adaptation measures knowing that they have guaranteed insurance for the length of the insurance contract (Maynard and Ranger, 2012).

Policy measures or insurance schemes offering lower premiums to encourage adaptation and improve farm resilience could be beneficial from the farmer perspective. This would have the dual-benefit of providing farmers with financial certainty against extreme weather damage, while also incentivising farmers to invest in farm resilience and adaptation (Beckie et al., 2019). One potential caveat though is that in the case of indexed insurance, adaptation and greater resilience benefit the farmer but not the insurance provider, since the insurance contract will pay out once the threshold weather conditions are reached, regardless of the actual damage incurred on the farm. While this might inhibit the incentive to offer a discount to farmers from the insurers' perspective, it could however be attractive for a public insurer (such as a government) who want to incentivise better farm adaptation to promote economic, environmental and social sustainability across the farming population. Given that cost was the most important attribute in the DCE and many farmers in the earlier individual interviews highlighted concerns around high insurance costs, this could be appealing to farmers. A similar idea was proposed by Jørgensen et al. (2020) who investigated farmers' willingness to engage in adaptation as a pre-condition to accessing farm insurance.

Before concluding, we must acknowledge some limitations of the study. First, the study focused on demand-side analysis based on farmer preferences and we did not investigate the practicalities of offering these types of insurance products from the supply-side, including the potential scheme costs. For example, we did not have information on individual farm risks to determine the actuarial fair price for insurance and therefore, the levels of the cost attributes were informed by average farm insurance costs in Ireland and the views of farmers collected during the qualitative interviews. Second, the insurance product presented was relatively simple, using three attributes only while in reality insurance products are complex. However, including too many attributes can affect respondents' ability to process all the information when making choices. In addition, in this study we were interested in examining preferences for attributes that might promote wider farm adaptation, while holding other important features of insurance constant across all choice cards. However, our study is limited in that we did not capture how farmers' risk preferences may affect their preferences for insurance. Moreover, as shown by previous studies, basis risk is an important determinant in explaining the low uptake of weather-indexed insurance in developing countries (Carter et al., 2014) and we did not investigate in our study how this would have impacted farmers' decisions to buy weather –indexed insurance. Therefore, it would have been more appropriate within the DCE to include an attribute capturing basis risk or uncertainty over outcomes within our analysis, similar to other studies (Glenk and Colombo, 2013; Larue et al., 2017). This would have enabled us to examine how farmers were willing to trade off between cost and basis risk and to determine whether farmers be willing to pay more for insurance for guaranteed pay out if they experienced a loss (i.e. when the basis risk is low). Excluding basis risk as an attribute is a limitation of this study. In addition, we attempted to include interactions within the WTP-Space model, however, the model would not converge when the interactions were included. Therefore, we only able to include interactions in the CL specification, which is associated with a number of restrictive assumptions, therefore the results should be interpreted with caution. A general potential limitation of stated preference methods is hypothetical bias, that is, whether the responses to hypothetical choice scenarios allow for predicting choices in real world settings. If hypothetical bias is present it can significantly affect the reliability of estimates for policy-making (Haghani et al., 2021). While we must acknowledge this as a potential limitation of this study, given that we asked hypothetical choice scenarios, we did ask farmers to make choices on a relatively well-known product (i.e. farm insurance). In addition, the WTP estimates were within the bounds of the amounts that farmers currently pay for insurance in Ireland. Finally and more generally, while insurance offers a number of benefits in dealing with extreme weather events, it is less suitable for dealing with other climate risks – such as with slow-onset events or changes in average conditions that could affect farms (Surminski, 2016). Moreover and more generally, maintaining insurance cover and affordable premiums for extreme weather events may become challenging if meaningful action on mitigation across all sectors of society is not undertaken.

In conclusion, our results suggest favourable preferences amongst Irish farmers to use insurance as a means to adapt to increasing risks posed by extreme weather events. Over two-thirds of respondents indicated a willingness to choose at least one extreme weather insurance alternative within the DCE. The results suggest there may be scope to redesign insurance schemes that could foster risk reduction measures while providing farms with assurance of financial protection from damages caused by extreme weather events.

All authors contributed to the development of the concept and design of the study. ED undertook the statistical analysis and prepared a first draft of the manuscript. SM, TMD, DN, MR, DOH contributed to the interpretation and writing the manuscript. All authors played a role in the review of the analysis, interpretation of the results and reviewing and recommending revisions to the final manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

ADB, 2019. Asian development bank. Asian development outlook 2019: strengthening disaster resilience. Available at: https://www.adb.org/sites/default/files/publication/492711/ado2019.pdf. (Accessed September 2020).
Akter, S., Krupnik, T.J., Rossi, F., Khanam, F., 2016. The influence of gender and product design on farmers' preferences for weather-indexed crop insurance. Global Environ. Change 38, 217–229.
Beckie, H.J., Smyth, S.J., Owen, M.D.K., Gleim, S., 2019. Rewarding best pest management practices via reduced crop insurance premiums. International Journal of Agronomy 2019, 11. https://doi.org/10.1155/2019/9390501. Article ID 9390501.
Blank, S.C., McDonald, J., 1996. Preferences for crop insurance when farmers are diversified. Agribusiness 12, 583–592.
Bucheli, J., Dalhaus, T., Finger, R., 2020. The optimal drought index for designing weather index insurance. Eur. Rev. Agric. Econ. 1–25. https://doi.org/10.1093/erae/jbaa014.
Budhathoki, N.K., Lassa, J.A., Pun, S., Zander, K.K., 2019. Farmers' interest and willingness-to-pay for index based crop insurance in the lowlands of Nepal. Land Use Pol. 85, 1–10.
Carter, M., De Janvry, A., Sadoulet, E., Sarris, A., 2014. Index-based weather insurance for developing countries: a review of evidence and a set of propositions for up-scaling. Development Policies working paper 111.
Cabas, J.H., Leiva, A.J., Weersink, A., 2008. Modeling exit and entry of farmers in a crop insurance program. Agric. Resour. Econ. Rev. 37, 92–105.
Castells-Quintana, D., del Pilar Lopez-Uribe, M., McDermott, K.J., 2018. Adaptation to climate change: a review through a development economics lens. World Dev. 104, 183–196.
Castellani, D., Viganò, L., Tamre, B., 2014. A discrete choice analysis of smallholder farmers' preferences and willingness to pay for weather derivatives: evidence from Ethiopia. J. Appl. Bus. Res. 30, 1671–1692.
Central statistics office (CSO), 2018. Farm structure survey 2016 [Available online. https://www.cso.ie/en/releasesandpublications/ep/p-fss/farmstructuresurvey2016/.
Chen, Y.-E., Goodwin, B.K., 2015. Policy design of multi-year crop insurance contracts with partial payments. PloS One 10, e0145384. https://doi.org/10.1371/journal.pone.0145384.
Clarke, D.J., 2016. A theory of rational demand for index insurance. Am. Econ. J. Microecon. 8, 283–306.
Clement, K.Y., Botzena, W.J., Brouwer, R., Aerts, J.C.J.H., 2018. A global review of the impact of basis risk on the functioning of and demand for index insurance. International Journal of Disaster Risk Reduction 28, 845–853.
Coble, K.H., Knight, T.O., Pope, R.D., Williams, J.R., 1996. Modeling farm-level crop insurance demand with panel data. Am. J. Agric. Econ. 78, 439–447.
Coletta, A., Giampietri, E., Santeramo, F.G., Severini, S., Trestini, S., 2019. A preliminary test on risk and ambiguity attitudes, and time preferences in decisions under uncertainty: towards a better explanation of participation in crop insurance schemes. Bio base Appl. Econ. 7, 265–277. https://doi.org/10.13128/bae-7679.
Conradt, S., Finger, R., Spörri, M., 2015. Flexible weather index-based insurance design. Climat Risk Management 10, 106–117.
DAFM, 2010. Risk insurance. Background papers, food harvest 2020. Available at: https://www.agriculture.gov.ie/foodwise2025/foodharvest2020/backgroundpapers/. (Accessed September 2020).
DAFM, 2018. Agriculture, forest and seafood climate change adaptation plan. available at:. Department of Agriculture, Food and the Marine, Ireland https://www.agriculture.gov.ie/ruralenvironmentsustainability/climatechangebioenergybiodiversity/agricultureforestandseafoodclimatechangesectoraladaptationplan/. (Accessed September 2020).
Di Falco, S., Adinolfi, F., Bozzola, M., Capitanio, F., 2014. Crop insurance as a strategy for adapting to climate change. J. Agric. Econ. 65, 485–504.
Du, X., Feng, H., Hennessy, D.A., 2017. Rationality of choices in subsidized crop insurance markets. Am. J. Agric. Econ. 99, 732–756.
Ellinger, P.N., Schnitkey, G.D., 2004. Factors influencing farmers' crop insurance decisions. Am. J. Agric. Econ. 86, 103–114.
European Environmental Agency, 2019. Agriculture and climate change. Available at: https://www.eea.europa.eu/signals/signals-2015/articles/agriculture-and-climate-change. (Accessed August 2020).
Enjolras, G., Sentis, P., 2011. Crop insurance policies and purchases in France. Agric. Econ. 42, 475–486.
Enjolras, G., Capitanio, F., Adinolfi, F., 2012. The demand for crop insurance. Combinedapproaches for France and Italy, Agricultural Economics Review 1, 5–15.
Fankhauser, S., McDermott, T.K., 2014. Understanding the adaptation deficit: why are poor countries more vulnerable to climate events than rich countries? Global Environ. Change 27, 9–18.
Finger, R., Lehmann, N., 2012. The influence of direct payments on farmers' hail insurance decisions. Agric. Econ. 43, 343–354.
Fleckenstein, A., Lythgo, A., Lu, J., Thompson, N., Doering, O., Harden, S., Getson, J.M., Prokopy, L., 2020. Crop insurance: a barrier to conservation adoption? J. Environ. Manag. 276, 111223 https://doi.org/10.1016/j.jenvman.2020.111223.
Fuchs, A., Wolff, H., 2011. Concept and unintended consequences of weather index insurance: the case of Mexico. Am. J. Agric. Econ. 93, 505–511.
Garrido, A., Zilberman, D., 2008. Revisiting the demand for agricultural insurances: the case of Spain. Agric. Finance Rev. 68, 43–66.
Glauber, J.W., 2004. Crop insurance reconsidered. Am. J. Agric. Econ. 86, 1179–1195.
Glenk, K., Colombo, S., 2013. Modelling outcome-related risk in choice experiments. Aust. J. Agric. Resour. Econ. 57 (4), 559–578.
Goss, R., O'Neill, D., 2010. Long-term Retail General Insurance: the Potential for Long-Term Home Insurance Contracts in the Context of Flood Risk. ABI Research Paper No. 21 (London).
Haghani, M., Bliemer, M.C.J., Rose, J.M., Oppewal, H., Lancsar, E., 2021. Hypothetical bias in stated choice experiments: Part I. Integrative synthesis of empirical evidence and conceptualisation of external validity. https://arxiv.org/ftp/arxiv/papers/2102/2102.02940.pdf.
Hanley, N., Wright, R., Koop, G., 2002. Modelling recreation demand using choice experiments: rock climbing in Scotland. Environ. Resour. Econ. 22, 449–466.
Hill, R.V., Hoddinott, J., Kumar, N., 2013. Adoption of weather index insurance, learning from willingness to pay among a panel of households in rural Ethiopia. Agric. Econ. 44, 385–398.
Hole, A.R., 2007. Fitting mixed logit models by using maximum simulated likelihood. STATA J. 7, 388–401.
Hole, A.R., 2016. MIXLOGITWTP: Stata module to estimate mixed logit models in WTP space. In: Statistical Software Components. Boston College Department of Economics.
Houses of the Oireachtas, 2019. Report on scrutiny of the flood insurance bill, 2016. Available at: https://data.oireachtas.ie/ie/oireachtas/committee/dail/32/joint_committee_on_finance_public_expenditure_and_reform_and_taoiseach/reports/2019/2019-06-18_report-on-scrutiny-of-the-flood-insurance-bill-2016_en.pdf. (Accessed August 2020).
Hynes, S., Tinch, D., Hanley, N., 2013. Valuing improvements to coastal waters using choice experiments: an application to revisions of the EU Bathing Waters Directive. Mar. Pol. 40, 137.
IPCC, 2012. Managing the risks of extreme events and disasters to advance climatechange adaptation. In: Barros, C.B.V., Stocker, T.F., Qin, D., Dokken, D.J., Ebi, K.L., Mastrandrea, M.D., Mach, K.J., Plattner, G.-K., Allen, S.K., Tignor, M., Midgley, P.M. (Eds.), A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field. Cambridge University Press, Cambridge, UK, and New York, NY, USA, p. 582.
Jørgensen, S.L., Termansen, M., Pascual, U., 2020. Natural insurance as condition for market insurance: climate change adaptation in agriculture. Ecol. Econ. 169 https://doi.org/10.1016/j.ecolecon.2019.106489.
Kleindorfer, P.R., Kunreuther, H., Ou-Yang, C., 2012. Single-year and multi-year insurance policies in a competitive market. J. Risk Uncertain. 45, 51–78.
Knight, T.O., Coble, K.H., 1997. Survey of US multiple crop insurance literature since 1980'. Rev. Agric. Econ. 19, 128–156.
Kunreuther, H.C., Michel-Kerjan, E.O., Doherty, N.A., Grace, M.F., Klein, R.W., Pauly, M. V., 2009. At War with the Weather: Managing Large-Scale Risks in a New Era of Catastrophes. MIT Press, Cambridge, MA.
Kunreuther, H.C., Michel-Kerjan, E.O., 2009. Managing Catastrophes through Insurance: Challenges and Opportunities for Reducing Future Risks. Risk Management and Decision Processes Center, The Wharton School of the University of Pennsylvania.
Larue, B., West, G.E., Singbo, A., Tamini, L.D., 2017. Risk aversion and willingness to pay for water quality: the case of non-farm rural residents. J. Environ. Manag. 197, 296–304.
Leppert, D., Dalhaus, T., Lagerkvist, C.J., 2021. Accounting for geographic basis risk in heat index insurance: how spatial interpolation can reduce the cost of risk. Weather, Climate, and Society. https://doi.org/10.1175/WCAS-D-20-0070.1.
Liesivaara, Petri, Myyrä, Sami, 2014. Willingness to pay for agricultural crop insurance in the Northern EU. Agric. Finance Rev. 74, 539–554. https://doi.org/10.1108/AFR-06-2014-0018.
Li, S., Juhász-Horváth, L., Harrison, P.A., Pintér, L., Rounsevell, M.D.A., 2017. Relating farmer's perceptions of climate change risk to adaptation behaviour in Hungary. J. Environ. Manag. 185, 21–30.

Maynard, T., Ranger, N., 2012. What role for "long-term insurance" in adaptation? An analysis of the prospects for and pricing of multi-year insurance contracts. Geneva Pap. Risk Insur. - Issues Pract. 37, 318–339.
McFadden, D., 1974. Conditional logit analysis of qualitative choice behaviour. In: Zarembka, P. (Ed.), Frontiers in Econometrics. Academic Press, New York, pp. 105–142.
Michel-Kerjan, E., Kunreuther, K., 2011. Redesigning flood insurance. Science 333, 408–409.
Meuwissen, M.P.M., de Mey, Y., van Asseldonk, M., 2018. Prospects for agricultural insurance in Europe. Agric. Finance Rev. 78, 174–182.
Munich, Re, 2017. Natural catastrophe losses at their highest for four years. Press release. Available from: https://www.munichre.com/en/media-relations/publications/press releases/2017/2017-01-04-press-release/index.html.
Nones, M., 2019. Dealing with sediment transport in flood risk management. Acta Geophys. 67, 677–685. https://doi.org/10.1007/s11600-019-00273-7.
OECD, 2009. Managing Risk in Agriculture: A Holistic Approach. OECD Reports.
Rose, J.M., Bliemer, M.C.J., 2009. Constructing efficient stated choice experimentaldesigns. Transport Rev.: A Transnational Transdisciplinary Journal 29, 587–617.
Santeramo, F.G., 2018. Imperfect information and participation in insurance markets: evidence from Italy. In: Agricultural Finance Review. https://doi.org/10.1108/AFR-06-2017-0053.
Scarpa, R., Thiene, M., Train, K., 2008. Utility in willingness to pay space: a tool to address confounding random scale effects in destination choice to the Alps. Am. J. Agric. Econ. 90, 994–1010.
Senapati, A.K., 2020. Insuring against climatic shocks: evidence on farm households' willingness to pay for rainfall insurance product in rural India. International Journal of Disaster Risk Reduction. https://doi.org/10.1016/j.ijdrr.2019.101351.
Sherrick, B.J., Barry, P.J., Ellinger, P.N., Schnitkey, G.D., 2004. Factors influencing farmers' crop insurance decisions. Am. J. Agric. Econ. 86, 103–114.
Surminski, S., 2016. Insurance instruments for climate-resilient development. In: Fankhauser, S., McDermott, T. (Eds.), Economics of Climate Resilient Development. Edward Elgar.
Surminski, S., 2017. Fit for the future? The reform of flood insurance in Ireland: resolving the data controversy and supporting climate change adaptation. Available at: http://www.lse.ac.uk/granthaminstitute/wp content/uploads/2017/05/Fit_for_the_Future_Surminski_May2017.pdf. (Accessed June 2020).
Train, K., 2009. Discrete Choice Models with Simulation, 2nd Edition. Cambridge University Press, Cambridge.
Train, K.E., Weeks, M., 2005. Discrete choice models in preference space andwillingness to-pay space. In: Scarpa, R., Alberini, A. (Eds.), Application of SimulationMethods in Environmental and Resource Economics. Springer, Dordrecht, pp. 1–16.
Tzemi, D., Breen, J., 2019. Climate change and the agricultural sector in Ireland: examining farmer awareness and willingness to adopt new advisory mitigation tools. Clim. Pol. 19, 611–622.
UNU, 2020. Munich Climate Insurance Initiative. United Nations University. https://unu.edu/projects/climate-insurance-projectmunich-climate-insurance-initiative.html#outline. (Accessed May 2020).
Vargas Hill, R., Robles, M., Ceballos, F., 2016. Demand for a simple weather insurance product in India: theory and evidence. Am. J. Agric. Econ. 98, 1250–1270.
Wreford, A., Topp, C.F., 2020. Impacts of climate change on livestock and possible adaptations: a case study of the United Kingdom. Agric. Syst. 178. https://www.sciencedirect.com/science/article/abs/pii/S0308521X18302555.