GERMAN FARMERS' PERCEPTION OF CLIMATE CHANGE EFFECTS AND DETERMINANTS INFLUENCING THEIR CLIMATE AWARENESS

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Abstract

This paper focuses on the attitude of German farmers towards climate change effects and aims to identify determinants affecting their perception of weather conditions. For this purpose, descriptive statistics and multiple linear regression approaches were applied. Data was collected using a questionnaire survey, which was conducted in spring 2013 among 173 German farmers in the two regions Swabian Alb and Kraichgau. The analyses revealed that four main factors influence the perception of weather variability. In particular, respondents' age, the region where the farm is located, the share of agricultural income and the farm profit are statistically significantly related with the degree of support for the respective weather statements. The findings further indicated age of farmer, location of the farm, method of production and farm size as significant predictors concerning the farm leader's perception of climate change consequences. As descriptive statistics revealed, the majority of farmers perceive for their location a change in weather conditions, an increase in weather variability as well as decreasing predictability of weather and expect consequences for their farming activities due to these developments.

Keywords

Perception of climate change effects, weather variability, demographic characteristics, attributes of farm and household, regional scale, German farmers

1   Introduction

Climate change is a global phenomenon. It naturally affects weather conditions on regional scale, since they are a spatial representation of the global situation. A potential increment of weather variability will influence agricultural activities and accordingly the productivity of agricultural ecosystems. This applies as well for our study region, which is located in Southwest Germany in the federal state of Baden-Wuerttemberg and includes the two study sites Swabian Alb and Kraichgau. A general definition of the word climate change is given by the Intergovernmental Panel on Climate Change (IPCC), which defines the term as *"[…] a change in the state of the climate that can be identified […] by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer"* (IPCC, 2013)*,* whereby climate describes the average weather, respectively the statistical description of the means of relevant quantities (e.g. temperature and precipitation) over a period of time (IPCC, 2013). In conclusion, variations in climate manifest in changes in the relevant variables. For the federal state of Baden-Wuerttemberg, the existence of climate change is documented by the German Meteorological Service, whose data reveals an unevenly distributed increase of annual mean temperature since the beginning of the 20th century (period 1914-2013). As indicated in Figure 1, from the 1980s onwards, the temperature in Baden-Wuerttemberg follows an increasing trend. In 2013, a mean value of 8.6 °C was observed. Compared to the climate normal period (1961-1990)[1], this value

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[1] The World Meteorological Organization (WMO) has set the current climate normal period from 1st January 1961 to 31th December 1990 (30-year period) in order to determine the statistical parameters of different climatological variables with satisfactory accuracy (WORLD METEOROLOGICAL ORGANIZATION (ED.), 2015).

represents a temperature deviation of +0.5 °C (DEUTSCHER WETTERDIENST, 2015b). However, the changes in climate are reflected furthermore in variations of the frequency of extreme weather events. While the number of ice days[2] (+1.6 days) and frost days (+5.0 days) only slightly increased between the period 1961-1990 and 2013, the quantity of summer days rose by 41.3 % (+12.8 days) (DEUTSCHER WETTERDIENST, 2015b). The frequency of observed days with temperatures $> 30\,°C$ (+12.8 days) and days with summer hailstorm events (+1.8 days) even doubled (DEUTSCHER WETTERDIENST, 2015b).

Figure 1: Mean annual temperature in Baden-Wuerttemberg from 1914 to 2013
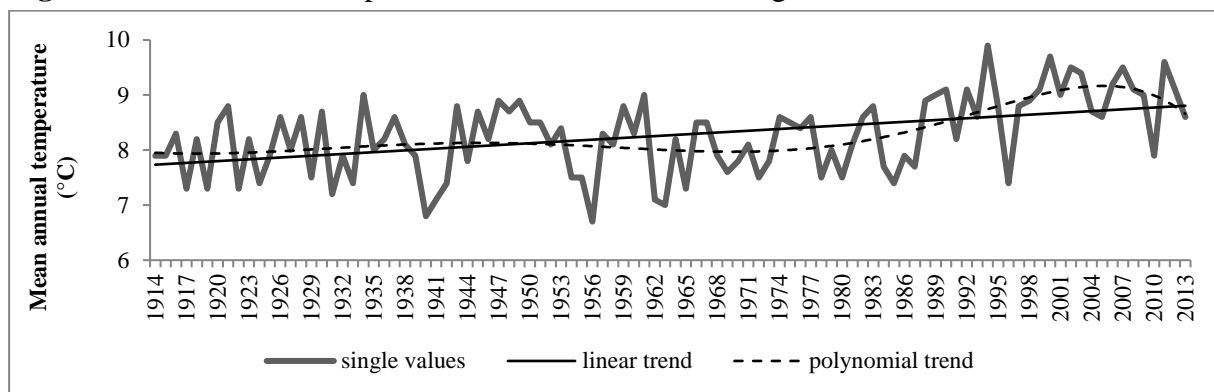
Source: Own illustration with German Meteorological Service data (DEUTSCHER WETTERDIENST, 2015a).

For the future, a study on potential climate development for the federal state of Baden-Wuerttemberg suggests an additional increment in annual mean temperature of +1.1 °C for the period 2021-2050 (WAGNER, 2013). In particular, this is projected to be accompanied by a decreasing number of frost days (-19.1 days) and ice days (-8.9 days) as well as an increasing quantity of heat days (+2.7 days) and summer days (+10.1 days) (WAGNER, 2013). Besides these changes in temperature, the regional climate projections also outline higher precipitation quantities for the hydrologic winter half year[3], while precipitation in the hydrologic summer half year might only slightly change (WAGNER, 2013). Beyond these consequences of global warming, an increment in extreme weather events has been projected. It is suspected to be due to a greater frequency of heavy precipitation and a prolongation of drought periods (WAGNER, 2013). Scientific research considers these consequences of global warming predominantly as negative, since they connote an important risk for agricultural systems and food supply. The changing of climate and coping with the consequences for agriculture initially requires the understanding of how farmers perceive the weather conditions. The perception of their variability is the basic precondition to guide future strategies for adaptation of agricultural activities to climate change. Hence, the major objective of the research paper is to investigate the awareness of German farmers towards the effects of changing climate and further to ascertain determinants influencing their perception of weather variability. For this purpose, the paper is structured as follows: Section 2 briefly presents the model approach and data used for analyses. Section 3 highlights the main estimation results, while outcomes of the descriptive statistics and regression analyses are discussed in Section 4. Finally, the research paper ends with a summary of the findings in Section 5.

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[2] Ice days are defined as days with a temperature maximum $< 0\,°C$, frost days have a temperature minimum $< 0\,°C$, heat days have a maximum in temperature $\geq 30°C$ and summer days have a temperature maximum of at least 25 °C (WAGNER, 2013).

[3] Hydrological winter half year covers maximum precipitation quantity for the months November-April in mm and hydrological summer half year includes precipitation quantity for the months May-October in mm (WAGNER, 2013).

2 Material and Method

2.1 Data

The data used for the analyses are taken from a study on perceptions and attitudes toward climate change, which was carried out as a part of the DFG Research Project "Agricultural Landscapes under Global Climate Change – Processes and Feedbacks on a Regional Scale". In spring 2013, questionnaires were mailed to 739 farm managers, whose farms are located in one of the study regions in the Southwest of German, the Swabian Alb and the Kraichgau. The survey contained 39 open and closed ended questions (BRYMAN, 2008), subdivided into nine major categories: basic farm characteristics, information on experience in farming, use of information sources for decision making and information on decision finding. Furthermore, questions on perception of climate change effects, adaptation measures, information on risk attitudes, income expectations and demographic attributes were also posed. In total, 173 of the postal questionnaires returned (82 from the Swabian Alb and 91 from the Kraichgau), resulting in a final response rate of 23.4 %. The representativity of the population of farmers in both regions in terms of demographic attributes is difficult to assess due to missing data. With respect to farm characteristics (particularly farm size and share of full-time/part-time managed farm businesses), the sample was not representative, as compared to agricultural statistics data provided by the State Office of Statistics Baden-Wuerttemberg (STATISTISCHES LANDESAMT BADEN-WÜRTTEMBERG, 2014).

2.2 Method and Model Specification

The regression analysis is a multivariate technique used in many fields of sciences to investigate the relationship between a continuous dependent variable and one or several independent variables (MONTGOMERY ET AL., 2012). For the purpose of our study, this analytic approach was adopted to investigate the influence of various predictors on German farmers' perception of climate change effects, measured as degree of support for several statements that concern local weather variability. The general empirical specification of the regression models was:

$$y = \beta_0 + \beta_1 age + \beta_2 region + \beta_3 profit + \beta_4 ing\_agr + \beta_5 mgm + \beta_6 area\_sum + u.$$

In the equation, y is the response variable that represents the agreement of the surveyed farmers with a certain statement. The terms β_1 to β_6 denote the parameters that describe the average change in the response variable per change of one unit in the corresponding predictor, ceteris paribus (MONTGOMERY ET AL., 2012). For the analysis of farmers' weather variability perception[4], the respondents were asked to state their level of agreement to a series of statements. The magnitude of agreement with these issues was retrieved on a seven-point Likert scale that ranged from 1-"completely agree" to 6-"do not agree at all", with an additional response option 7-"not possible to tell". For ease of interpretation of regression results, the Likert scale of the attitude variables was recoded before performing regression analyses[5]. Since higher scores are now associated with agreement, the scale reflection results

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[4] The authors' experiences from previous surveys indicate difficulties for farmers to understand and make statements if the word climate is used, most likely because it is a rather abstract scientific concept. Instead, a synonymous understanding and use of the term "weather" (meaning weather conditions typical for a certain time of the year) was found to be common among farmers. Due to this fact and the IPCC definition of climate as average weather, the authors decided for the application of questions concerning weather conditions in the survey.

[5] New Likert scale used for regression analyses: 1-"do not agree at all", 6-"completely agree". Scale category 7-"not possible to tell" was coded as missing value.

in a simplification of the regression coefficients' interpretation, particularly referring to their algebraic signs. The question on the weather statements was as followed: "If you look at the time you spent working at your farm, how strongly would you agree with the following statements with respect to how they apply to your location?" With the presented response items: 1) "The weather has changed over the years," 2) "With respect to the weather, there are more extreme years," 3) "The weather is changing to my farm's disadvantage" and 4) "The weather is changing, but it's neither to my farm's advantage nor disadvantage."[6]

The explanatory variables we expect to influence farmers' perception of weather conditions are based on empirical literature, previous studies and also on available data from the survey. As similar studies find, knowledge about climate change and its effects, experiences in farming as well as in forecasting of weather conditions are associated with a higher age, because older farmers have been exposed to past climate conditions for a longer life span (DERESSA ET AL., 2009; MADDISON, 2007). Therefore, we assume that the age of the farmers influences the observation of changes in weather conditions. Information on climate change is related to farm income, which can also be used as indicator for wealth, because monetary resources enable the access to information and knowledge acquisition (DERESSA ET AL., 2009). Furthermore, off-farm income represents the importance of farming for the respondent and mirrors the household's dependency on agricultural business (LI ET AL., 2013). Hence, we assume an influence of the income on the climate change perception. In total, two variables represent the farmers' income in the analyses: the expected annual farm profit[7] and the share of agricultural income in relation to total household income. With regards to the production management system, organic methods of agricultural production are associated with climate protection and environmental terms. In particular, pest control poses a great challenge under changing weather conditions for farm managers who practice organic farming. Therefore, we expect an effect of the production method on the perception of weather conditions. Based on the issue that the size of agricultural area managed by a farmer is associated with more capital, wealth and also a greater interest to dedicate resources to gather information on climate change (DERESSA ET AL., 2009), we also hypothesize an influence of the farm size on climate change perception. Another relevant aspect might be the regional location of the farm business. The study region includes the two study sites Swabian Alb and Kraichgau, which represent different agricultural conditions with specific climate and soil properties. The Swabian Alb is a large karst region, characterized by cold and harsh climate with an annual mean precipitation ranging from 800 to 1,000 mm. In contrast, the Kraichgau is a fertile hilly region with mild climate, a higher annual mean temperature and moderate precipitation (720-830 mm per annum). Due to these aspects of specific climate conditions, we hypothesize an effect of the farm location on farmers' perception of weather variability.

Table 1 provides a brief description of the predictors included in the analyses. The descriptive statistics of the data collected and the model estimations are performed using the statistical software Stata version 12.0 (STATACORP., 2011).

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[6] In the survey, the attributes were presented to the farmers in German language: "Wenn Sie auf die Zeit schauen, in der Sie auf Ihrem Betrieb wirtschaften, wie stark würden Sie folgenden Aussagen für Ihren Standort zustimmen?" Items: 1) "Das Wetter hat sich über die Jahre verändert", 2) "Bezüglich des Wetters gibt es immer mehr extreme Jahre", 3) "Das Wetter verändert sich zum Nachteil meines Betriebes" and 4) "Das Wetter verändert sich zwar, daraus ergeben sich aber weder Vor-, noch Nachteile für meinen Betrieb."

[7] The question on expected annual farm profit was: "What level of annual operating profit/net income before tax do you expect from your farming operation in a typical year?", with the corresponding question in German language: "Mit welchem Betriebsgewinn/Jahresüberschuss vor Steuern rechnen Sie aus Ihrem landwirtschaftlichen Betrieb in einem typischen Jahr?"

Table 1:   List of predictor variables included in the regression models

Variable label	Description	Measurement	Variable type
age	Age of respondent (in years)	Numeric value	Continuous
region	Region of farm	1-Kraichgau; 0-Swabian Alb	Dummy
profit	Annual farm profit (in 1,000 €)	Numeric value	Continuous
inc_agr	Share of agricultural income to total household income (in %)	Numeric value	Continuous
mgm	Production method	1-organic; 0-conventional	Dummy
area_sum	Cultivated agricultural area (in ha)	Numeric value	Continuous

Source: Own illustration

3   Empirical Results

3.1   Descriptive Statistics

Table 2 presents the descriptive statistics for the total sample. The results show a balanced distribution of participating farms in terms of their regional location. Given that females account for only 2 % of respondents, the farming in both regions is dominated by males. The farmers' average age is 51 years over all respondents, with an age span that ranges from 24 to 84 years. The mean farm profit among the participating farms amount to 46,400 € per year, whereas on average 63 % of the total household income is covered by agricultural activities. Farmers cultivate on average 97 hectares of agricultural area (including arable land, grassland, woodland and special crops). As the majority of all farmers manage the business in full-time, these farms are over-represented in the study sample. Conversely, the part-time farmers are under-represented, as compared to data of the State Office of Statistics Baden-Wuerttemberg (STATISTISCHES LANDESAMT BADEN-WÜRTTEMBERG, 2014). With respect to the production method applied, almost all respondents (92 %) practice conventional farming, while only a small share (8 %) implements organic production. Data further reveal that sampled farmers have on average 30 years of experience in the agricultural sector, indicating long-time professional agribusiness knowledge of the farmers.

Table 2:   Descriptive statistics of the survey

Characteristics	Respondents	Mean	Std. Dev.
Gender of respondent	170	0.98	---
Age of respondent (in years)	169	51.10	10.13
Practical experience in agriculture (in years)	167	30.22	10.99
Region of farm	173	0.53	---
Scope of farm business	173	0.61	---
Production method	173	0.08	---
Annual farm profit (in 1,000 €)	138	46.39	39.97
Share of agricultural income related to total household income (in %)	158	62.54	34.88
Area of agricultural land (in ha)	172	96.46	106.09

Note: Std. Dev. – Standard Deviation
Source: Own calculations with Stata version 12.0 (STATACORP., 2011)

3.2 Farmers' Perception of Climate Change Effects

A change in local weather conditions as a perceivable effect of climate change seems to be sensed by the majority of all respondents, as 73 % agree to the statement 1 "The weather has changed over the years" and 58 % reject the statement 2 "The weather is more or less as it always has been" (cf. Table 3). In particular, 71 % of the farmers perceive increasing frequency of extreme years (statement 4) and a slight majority (52 %) evaluates weather conditions for them as less predictable (statement 3) (cf. Table 3). Almost three-quarters of the surveyed respondents notice a change in weather, but only 35 % agree to the statement 7 "The weather is changing, but it's neither to my farm's advantage nor disadvantage" (cf. Table 3). Although the majority of respondents (59 %) do not consider the effects of weather changes positive (statement 5), there is an obvious disagreement among survey participants, concerning the statement 6 that the weather is changing to their farm's disadvantage, where almost as many farmers agree (42 %) as disagree (41 %) to this aspect (cf. Table 3).

Table 3:   Farmers' perception of weather variability

Statements variables	Sample (% of n=173)		
	Disagree	Agree	"not possible to tell" or no statement
Statement 1: "The weather has changed over the years."	21.97	72.83	5.20
Statement 2: "The weather is more or less as it always has been."	57.80	32.95	9.25
Statement 3: "The weather is more difficult to judge."	35.26	51.45	13.29
Statement 4: "With respect to the weather, there are more extreme years."	23.12	71.10	5.78
Statement 5: "The weather is changing to my farm's advantage."	58.96	23.70	17.34
Statement 6: "The weather is changing to my farm's disadvantage."	40.46	41.61	17.92
Statement 7: "The weather is changing, but it's neither to my farm's advantage nor disadvantage."	46.24	34.68	19.08

Note: Likert scale ranges 1 to 3 (1-"do not agree at all"; 2-"disagree"; 3-"somewhat disagree") are summarized as "Disagree" and ranges 4 to 6 (4-"somewhat agree"; 5-"agree"; 6-"completely agree") as "Agree".
Source: Own calculations with Stata version 12.0 (STATACORP., 2011)

3.3 Determinants influencing Farmers' Perception of Climate Change

Table 4 depicts the econometric results of the multiple regression models. In the study, the response variables are farmers' rate of agreement to four different statements on local weather conditions. Demographic characteristics and other factors (as discussed in Section 2.2) serve as predictors, which hypothetically affect the response variables.

Using the Shapiro-Wilk normality test (SHAPIRO & WILK, 1965; ROYSTON, 1982), the linear model assumption of normally distributed residuals is rejected for the regression models 1 and 2. Based on the central limit theorem, WOOLDRIDGE (2013) concludes that on one hand, the larger the sample size, the closer a distribution is to normality ($n \geq 30$; GHASEMI & ZAHEDIASL, 2012; BACKHAUS ET AL., 2011). On the other hand, the fulfillment of all the further classical linear model assumptions results in an approximate normal distribution. Hence, no problems should appear for the analyses due to the violation of this assumption. Furthermore, the regression models were checked for multicollinearity, using test methods such as variance inflation factor (VIF) and its reciprocal term, the tolerance (1/VIF) (ACOCK,

2010; WEIBER & MÜHLHAUS, 2010; BACKHAUS ET AL., 2011). Small VIFs[8] with values < 10, tolerance values[9] > 0.1 and low correlations among predictors (values < 0.8) indicate no cause for concern in terms of multicollinearity. The application of White's test (WHITE, 1980) for constant variances confirms the assumption of homoscedasticity for the four models. In addition, the Ramsey regression equation specification-error test (RESET) (RAMSEY, 1969) for omitted variables and the link test for specification errors (PREGIBON, 1980) were conducted and show no evidence for misspecified models. In terms of sample size, the number of observations differs between the models from 114 to 133 cases, as result of missing data in the four response variables of weather statements and the predictors.

Table 4: **Results of the multiple linear regression models on climate perception, extreme events and consequences for farm management**

Dependent variables	Model 1		Model 2		Model 3		Model 4	
	Statement: "The weather has changed over the years."		Statement: "With respect to the weather, there are more extreme years."		Statement: "The weather is changing to my farm's disadvantage.		Statement: "The weather changes, but it's neither to my farm's advantage nor disadvantage."	
age	-0.156	**	-0.0188		-0.0285	**	0.0463	***
sq_age	0.00139	*	------		------		------	
region[(a)]	0.685	***	0.427	*	0.607	**	-0.773	**
inc_agr	0.0151	***	0.0112	**	0.000316		-0.00766	
profit	-0.0266	**	-0.0288	***	-0.0155		------	
sq_profit	0.000167	***	0.000197	***	0.000111		------	
mgm[(b)]	0.606		0.922	**	0.00547		-0.967	**
area_sum	-0.00390		-0.00469		-0.00342		0.00758	**
hprofit	------		------		------		-0.000000257	
_cons	8.100	****	5.273	****	5.162	****	1.184	
N	**130**		**133**		**117**		**114**	
R²	**0.200**	****	**0.164**	***	**0.119**	**	**0.180**	***

Note: (a) 1-Kraichgau, 0-Swabian Alb; (b) 1-organic farming, 0-conventional farming; the variables *sq_age, sq_profit* and *hprofit* were used to model a nonlinear relationship; *sq_age* and *sq_profit* refer to the square terms of the variables age and profit; *h_profit* refers to the hyperbolic term of the variable profit; scaling of response variables: 1-"do not agree at all" to 6-"completely agree"; level of significance: * $p \leq 0.10$, ** $p \leq 0.05$, *** $p \leq 0.01$, **** $p \leq 0.001$
Source: Own calculations with Stata version 12.0 (STATACORP., 2011)

Model 1: "The weather has changed over the years."

The first regression model examines farmers' perception of changing weather conditions over the years (cf. Table 4). In Total, 20 % (R^2 of 0.200) of the variance in the agreement scores towards the weather statement can be explained by the four statistically significant predictors.

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[8] FREUND ET AL. (2006) suggest that a VIF exceeding a value of 10 is an indicator of the existence of multicollinearity. This cut-off value is also proposed by ACOCK (2010). WEIBER & MÜHLHAUS (2010) recommend a more conservative cut-off value of > 3. In these multiple linear regression analyses VIF for all predictor variables were < 10 (1.03-2.74). Naturally, only the variables *age* and *sq_age* in the multiple regression model 1 and the variables *profit* and *sq_profit* in the regression models 1, 2 and 3 showed magnitudes > 10, because one variable is the square term of the other.

[9] Conversely to the cut-off value of VIF < 10, ACOCK (2010) states that a tolerance value > 0.1 causes no problems of multicollinearity.

Regression findings reveal a negative relationship of the variables concerning the farmers' age as well as the annual farm profit (for both $p \leq 0.05$) and the perception of climate change effects. Furthermore, the region where the farm is located and the share of agricultural income influence the awareness of changing weather conditions positively at a 1 % error probability level. A statistically significant relationship between the agreement to the statement "The weather has changed over the years" and the remaining predictors (production method and farm size) is not found.

Model 2: "With respect to the weather, there are more extreme years."

The regression model 2 focuses on the identification of factors influencing the agreement to the issue of more frequent occurrence of years with extreme weather conditions. According to the F-test, there is a relationship between agreement to the statement and the set of predictors. The moderate goodness of fit (R^2 of 0.164) implies that the independent variables explain approximately 16 % of the variance in the response variable. Table 4 summarizes the results of the regression analysis. In total, four statistically significant predictors are found to affect the agreement scores for the statement "With respect to the weather, there are more extreme years." The regional location of the farm ($p \leq 0.10$), the share of agricultural income ($p \leq 0.05$) and the method of production ($p \leq 0.05$) are positively associated with the perception of an increasing occurrence of extreme years. The annual farm profit shows as well an effect on the respondents' agreement to this statement, but it is negatively related (significant at a 1 % level). A statistically significant influence of the remaining predictors, which capture farmers' age and farm size, is not established.

Model 3: "The weather is changing to my farm's disadvantage."

The third regression model establishes the respondents' agreement to the statement of emerging disadvantages for the farm business due to changes in weather conditions (cf. Table 4). In total, two variables explain about 12 % of the variance in the perception of negative consequences of weather variability (R^2 of 0.119). A positive effect, at a 5 % level of significance, is found for the region allocation of the farm. The results in Table 4 further show a significant negative influence of the farmers' age ($p \leq 0.05$) for stating agreement to the statement "The weather is changing to my farm's disadvantage." For the remaining predictor variables, which cover the share of agricultural income, the annual farm profit, the production method and the farm size, the findings show no statistically significant effects on the dependent variable.

Model 4: "The weather changes, but it's neither to my farm's advantage nor disadvantage."

The fourth regression model examines the agreement of farmers to the statement that neither advantages nor disadvantages arise for their farms due to changes in weather conditions. Overall, approximately 18 % (R^2 of 0.180) of the variation in the agreement to the response variable can be explained by using the set of predictors. The model findings (cf. Table 4) indicate that the farmers' age ($p \leq 0.01$) and the farm size ($p \leq 0.05$) are positively correlated with the response variable reflecting agreement to this statement. A statistically significant influence on the agreement to the issue is also found for the region and the agricultural production method. These variables are negatively related with the response variable, both at a 5 % error probability level. The remaining predictors concerning the income (share of agricultural income as well as farm profit) have no statistically significant effect on the awareness of either positive or negative consequences that result from weather variability.

4   Discussion

The general finding that farmers perceive changes in climate is in line with outcomes of several other studies, which were conducted in Africa (NDAMBIRI ET AL., 2013; OKONYA ET AL., 2013), North America (VAN HADEN ET AL., 2012; ARBUCKLE ET AL., 2013) and China (LI ET AL., 2013). The results of our regression analyses imply a negative correlation between the statements concerning the perception of changing weather conditions as well as the more frequent occurrence of years with extreme weather events and the age of respondents.[10] Interestingly, these outcomes contradict the conclusions of other surveys, where the awareness of changes in weather conditions and the age of the respondent are positively related (NDAMBIRI ET AL., 2013; OFUOKU, 2011; OKONYA ET AL., 2013). As possible explanation for this finding, it is conceivable that older farmers might attribute less importance to years with extreme weather events when assessing climate conditions due to their longer reference period, and hence might consider these years (e.g. drought of the year 2003) as natural weather variability and not as a trend in climate conditions. In contrary, younger farmers might be more concerned about the long-term weather variability and therefore more sensible when assessing weather conditions, because they will be managing their farm businesses until further in the future. Another aspect could be information collection patterns: younger farmers are often more familiar with the use of new information technologies than older ones. Hence, they might gather easily information to follow the scientific discussion on climate change.

Based on our results, the regional allocation of the farm also influences the perception of climate change. Respondents of the Kraichgau show a more distinct awareness of changes in weather conditions and increasing frequency of extreme years, as compared to their colleagues from the Swabian Alb. They also state to be aware of a generally negative trend of consequences emerging for their farms due to the perceived change in weather conditions. The perception of weather variability and the pessimistic attitudes of Kraichgau farmers towards climate change effects might be explained by their operating focus on the cultivation of crops. About 83 % of the agricultural land in the region is used for the production of cash crops and also special crops. The effects of climate change might be more damaging for Kraichgau farmers, because the region is one of the warmest in Germany and changes in weather conditions, for instance an increase in temperature, might negatively affect the production and could quickly lead to crop failures.

OKONYA ET AL. (2013) unveil that farmers with off-farm income sources perceive climate change more strongly. This statement is contradicted by the findings of our study, as the farmers' awareness of changes in weather conditions increased with the share of agricultural income from total household income. A possible explanation might be that no additional income source besides farming increases the dependency of farmers on agriculture (LI ET AL., 2013). Furthermore, off-farm activities might compete with the production on farm, what might result in a shifting focus on non-agricultural activities and an altered perception of climate change (NDAMBIRI ET AL., 2013). The authors SEMENZA ET AL. (2008) reveal in their survey that high-income groups are more likely to be aware of climate change than low-income groups. In contrast, NDAMBIRI ET AL. (2013) find a negative (albeit not significant) relationship for farm income and perception of climate change. Our results support the finding of NDAMBIRI ET AL. (2013) as we find a decreasing perception of changes in climate with

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[10] The "Peak Age" can be calculated using a modification of the formula of WEBER (2008): $1 * -\beta_{age} / (2 * \beta_{sq\_age})$. For the model 1, the following formula applies: $1 * -(-0.156) / (2 * 0.00139) = 56.115$. The result indicates an increase of agreement from the age of 56.1 years due to the positive algebraic sign of the regression coefficient of the variable *sq_age*.

increasing farm profit[11]. This reversal of the impact for the case of respondents might be explained by the fact that farmers typically share common characteristics, such as dependence of production and farm profits from the variability of nature. Thereby, dependence and sensitivity might be less for more wealthy farmers, e.g. due to a greater range of opportunities to buffer climate related risks, for instance by technological means (e.g. the use of powerful machines) or via financial means (e.g. insurances).

According to the production method, farmers who apply organic production system show a more distinct agreement to the statement "With respect to the weather, there are more extreme years" than their colleagues who manage the farm conventionally. The positive correlation between the corresponding statement and organic production supports our hypothesis that the production method farmers apply influences the agreement to the statement of more frequent occurrence of extreme years. In addition to this outcome, respondents with organic farming believe that changes in climate will affect their farm activities, contrary to farmers practicing conventional methods. The explanation for the finding might be that farmer with organic production are more vulnerable for damages referring to changing weather conditions, because they depend on the use of non-chemical-synthetic plant protection products for pest control, for example.

GRAMIG ET AL. (2013) establish in their study a negative relationship between farm size and the belief that climate change will not affect the farm management. Conversely to that statement, the results of our analysis suggest that respondents owning enterprises with large area tend to asses consequences of climate change effects as neither positive nor negative, compared to farmers who run farms of a smaller scale. Hence, a higher agreement that no effects on how farmers operate their farms emerge due to weather variability is associated with increasing farm size. Maybe, the direct dependence of farmers on climate raises especially the awareness of the less profitable farm owners with regard to climate change; an effect which is not visible in the general public. The finding might also be elucidated by the relationship of farm size and wealth. Because farmers owning enterprises with large area commonly generate more profit, they have as well greater monetary resources to implement appropriate adaptation strategies for addressing their farm activities on climate risks and are therefore less concerned about the climate change effects.

In general, the moderate multiple coefficients of determination and model findings suggest that besides the analyzed determinates other relevant factors may exist, which explain a large share of the variation in the perception of changing weather conditions over the years. Some studies reveal a relation between gender and the perception of climate change (FALAKI ET AL., 2013; NDAMBIRI ET AL., 2013). However, due to the fact that there are only four female respondents in the sample of 173 survey participants, the analysis of the gender effect on awareness of climate variability is not possible. Initially, the level of education and the farms' main production activities were expected to have an effect on the agreement to the climate change perception. Nevertheless, no significant relationship could be found in the analyses and the related variables have been removed from the models. The finding is particularly surprising for the education level, because several studies reveal a higher probability of more educated farmers to be aware of changes in climate than of less educated farmers (OFUOKU, 2011; NDAMBIRI ET AL., 2013). Hence, these preliminary findings indicate that a need for additional research on this topic remains in order to investigate and to understand the primary drivers of climate change perception among farmers in Germany.

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[11] The "Peak Profit" can also be calculated using a modification of the formula of WEBER (2008). Regarding the positive algebraic sign of the regression coefficient of the variable *sq_profit* in the models 1 and 2, the agreement increases with the value of 79,640 €(Model 1) and the value of 73,096 €(Model 2).

5   Summary

In this research paper, a sample of 173 German farmers from the regions Swabian Alb and Kraichgau has been analyzed with regards to their perception of climate change effects, in order to identify the influence of demographic attributes, aspects of the farm household as well as farm characteristics. For investigating the determinants on their agreement to certain weather statements, four multiple linear regression analyses were employed. The findings reveal a statistically significant effect of all predictor variables on the perception of changes in weather conditions and the assessment of consequences for farm management. However, not all predictor variables could be related to the estimated regression models. In detail, the model outputs imply that respondents' age, the regional allocation of the farm, the share of agricultural income and the farm profit are relevant determinants of the perception of changes in weather conditions. In terms of consequences for farm businesses as a result of climate variability, the estimated models establish the age of farmer, regional of allocation of the farm, the production method as well as the farms size as statistically significant predictors of agreement to the respective statements. According to the results of the descriptive statistics, we conclude that farmers perceive changes in weather conditions, a more frequent occurrence of extreme weather events and increasing difficulties in handling weather conditions. In addition to climate change awareness, future research on regional scale should explore appropriate adaptation strategies that enable farm business managers to reduce potential negative effects of ongoing climate change for their businesses.

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