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GERMAN FARMERS' PERCEPTION OF CLIMATE CHANGE EFFECTS AND DETERMINANTS INFLUENCING THEIR CLIMATE AWARENESS[1]

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Abstract

This paper focuses on the attitude of German farmers toward climate change effects and aims to identify determinants affecting their perception of weather conditions. For this purpose, descriptive statistics and multiple linear regression analyses were applied. Data was collected by means of a questionnaire based survey, which was conducted in May 2013 among German farmers in two study sites in Southwest Germany, the Central Swabian Alb and the Kraichgau. Analyses reveal that four main factors influence the perception of changes in local weather conditions and expectations about the effects. In particular, respondents' age, location of the farm, share of agricultural income and farm profit are statistically significantly related with the degree of support for the respective weather statements. The findings further indicate 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 reveal, the majority of farmers perceive a change in weather conditions for their location, an increase in weather variability as well as decreasing predictability of weather conditions 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 to our study sites, which are located in Southwest Germany in the federal state of Baden-Wuerttemberg and approximately cover the natural areas Central Swabian Alb and Kraichgau. A general definition of the word climate change is given by the Intergovernmental Panel on Climate Change (IPCC). The organization 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 meteorological variables.

At a regional scale, the meteorological time series data gathered and evaluated by the German Meteorological Service (DWD) support the existence of ongoing climate change for the federal state of Baden-Wuerttemberg. Since the beginning of the 20th century (period 1914-

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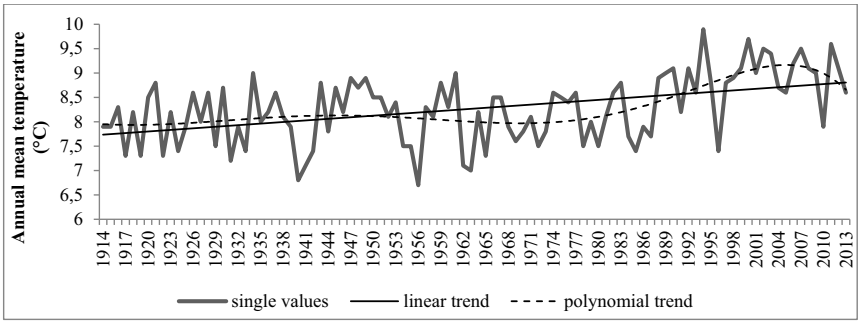
2013), the data show an increasing trend of annual mean temperature, especially from the 1980s onwards (cf. Figure 1). In 2013 a mean value of 8.6 °C was observed. Compared to the climate normal period (1961-1990)[3], this value represents a temperature deviation of +0.5 °C (DEUTSCHER WETTERDIENST, 2015b). In addition to mean temperature changes, the effects of global climate change are also reflected in variations of the frequency of extreme weather events at the regional scale. While the number of ice days[4] (+1.6 days) and frost days (+5.0 days) only slightly increased between the period 1961-1990 and the year 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 in the period considered (DEUTSCHER WETTERDIENST, 2015b).

Figure 3: Annual mean temperature in Baden-Wuerttemberg from 1914 to 2013



Source: Own illustration with German Meteorological Service data (DEUTSCHER WETTERDIENST, 2015a).

The recent climate change trend will most likely continue in the future (WAGNER, 2013). In order to assess the consequences associated with changing climate conditions, the Ministry of the Environment, Climate Protection and the Energy Sector Baden-Wuerttemberg commissioned a study on potential climate development. The evaluation of different regional climate projections conducted in the study suggests an additional increment in annual mean temperature of +1.1 °C for the period of 2021-2050 (WAGNER, 2013). This is projected to be accompanied by a decreasing frequency of frost days (-19.1 days) and ice days (-8.9 days) in particular, as well as an increasing occurrence of heat days (+2.7 days) and summer days (+10.1 days) (WAGNER, 2013). Besides these variations in temperature, the regional climate projections also outline changes in precipitation (e.g. higher precipitation quantities for the hydrologic winter half year[5]) and an increment in extreme weather events (e.g. a prolongation of drought periods) (WAGNER, 2013). Scientific research considers the changes of global climate conditions predominantly as negative, since they connote an important risk for agricultural ecosystems and food supply.

[3] 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, 2015).

[4] 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 ≥ 30 °C and summer days have a temperature maximum of at least 25 °C (WAGNER, 2013).

[5] Hydrological winter half year covers 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).

Nevertheless, evaluation of the predicted impacts requires a differentiated consideration at the regional scale. Depending on the location of farm businesses, climate change will affect agricultural practices in various directions. For that reason, understanding farmers' perception of changes in typical weather conditions is important, especially as it is the basic precondition to guide future strategies for adapting agricultural activities to climate change at the farm level. Hence, the major objective of this research paper is to investigate farmers' perception of changing weather conditions and potential effects for their businesses as well as to ascertain determinants influencing their attitude toward climate change. For this purpose, the paper is structured as follows: Section 2 briefly presents the econometric model and data used for analyses. Section 3 highlights the main estimation results. Finally, the research paper ends with a discussion of the outcomes and conclusions in Section 4.

2 Material and Method

2.1 Data

The data used in our analyses are taken from a study on perceptions and attitudes toward climate change. In May 2013, questionnaires were mailed to 739 farm managers in the study sites. The survey contained 39 open-ended and closed-ended questions (BRYMAN, 2008), subdivided into nine major categories: basic farm characteristics, 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 posed.

Questions related to the perception of climate change effects were set up as series of statements on changes in local weather conditions[6]. The question that preceded the weather statements was: "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 response items: 1) "The weather has changed over the years," 2) "With respect to weather there are more and 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."[7] Respondents were asked to indicate their level of agreement 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".

In total, 173 of the mailed out questionnaires returned (82 from Central Swabian Alb and 91 from Kraichgau), resulting in a final response rate of 23.4 %. The representativity of the sample of respondents with regards to the population in the study sites 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 compared to agricultural statistics data provided by the State Office of Statistics Baden-Wuerttemberg (STATISTISCHES LANDESAMT BADEN-WÜRTTEMBERG, 2014).

[6] 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, the authors decided for the application of questions referring to weather conditions in the survey.

[7] The question and related items were presented in German language in the survey: "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."

2.2 Method and Model Specification

Regression analysis is a multivariate technique used 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 is adopted to investigate the influence of various predictors on farmers' perception of climate change. The general empirical specification of the regression models is:

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

In this equation the response variable y represents the level of agreement of the farmers with each respective 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 ease of interpretation, the scale of the attitude variables was recoded before performing regression analyses so that higher scores are now associated with a higher level of agreement[8]. This scale reflection results in a simplification of the regression coefficients' interpretation in particular with regard to the direction of the effect.

Perception of weather conditions may be driven by various factors. We based the analyses of potential explanatory variables on empirical literature, previous studies and also on available data from the survey. One relevant aspect in terms of climate change perception might be the location of the farm business in one of the study sites, Central Swabian Alb and Kraichgau. The study sites were selected so as to represent different agricultural conditions with specific climate and soil properties. The Central Swabian Alb is a large karst region, characterized by cold and harsh climate with an annual precipitation ranging from 800-1,000 mm. In contrast, the Kraichgau is a fertile hilly region with mild climate, a higher annual mean temperature and moderate precipitation (720-830 mm p. a.). Due to these specific climatic conditions, we hypothesize an effect of the farm business location on farmers' perception of weather conditions. As similar studies find, accumulated knowledge about climate change and its effects, experience in farming as well as success in evaluating weather 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). Due to this aspect, we assume an influence of farmers' age on perception of changes in weather conditions and consequences for farm management. Farm income can be used as indicator for wealth (DERESSA ET AL., 2009). Sufficient monetary resources are required for adapting costly agricultural practices or financially challenging investments, for example to hedge against increased climate risks (KNOWLER AND BRADSHAW, 2007), and more wealthy farmers might therefore be less concerned about climate change. 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 income on climate change perception and on the awareness of effects for the farm business. In total, two variables represent the farmers' income structure in the analyses: the expected annual farm profit[9] and the share of agricultural income from total household income. The size of a farm is related with more wealth (DERESSA ET AL., 2009) and a greater capacity to mobilize resources with regard to climate adaptation (FRANZEL, 1999). To investigate whether there is a relationship between farm size and the perception of changes in local weather conditions, we included the variable in the regression model as well. Organic farming is associated with increased environmental awareness. At the risk management side,

[8] 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.

[9] The question on expected annual farm profit was: "What level of annual operating profit/annual surplus 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?"

pest control poses a great challenge under changing weather conditions for farm managers who practice organic farming. For that reason, we expect an effect of the production method for the perception of weather conditions and of potential consequences for the farm business.

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).

Table 8: List of predictor variables included in the regression models

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

Source: Own illustration

3 Empirical Results

3.1 Descriptive Statistics

Table 2 presents descriptive statistics for the total sample. The results show a balanced distribution of participating farms in terms of their regional allocation. Given that females account for only 2 % of respondents, the farming in both study sites 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 of the participating farmers/farm managers amounts to 46,400 € per year, whereas on average 63 % of the total household income is covered by agricultural activities. Farmers cultivate 97 hectares of agricultural area (including arable land, grassland, woodland and special crops), on average. As the majority of farmers manage the business in full-time, this type of farms is over-represented in the sample 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. Data further reveal that sampled farmers have on average 30 years of experience in the agricultural sector, indicating long-time professional agribusiness knowledge of most of the responding farmers.

Table 2: Descriptive statistics of the survey

Characteristics	Respondents	Mean	Standard deviation
Gender of respondent	170	0.98	---
Practical experience in agriculture (in years)	167	30.22	10.99
Scope of farm business	173	0.61	---
Age of respondent (in years)	169	51.10	10.13
Region of farm	173	0.53	---
Production method	173	0.08	---
Mean 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

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 respondents, as 73 % agree to statement 1 "The weather has changed over the years" and 58 % reject statement 2 "The weather is more or less as it always has been" (cf. Table 3). In particular, 71 % of the farmers perceive an 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 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 statement 6 that weather conditions are 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 changes in weather

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: "It gets more and more difficult to predict the weather."	35.26	51.45	13.29
Statement 4: "With respect to weather there are more and 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 Effects

Table 4 depicts the results of the econometric multiple regression models for four of the statements on local weather conditions (statements 1, 4, 6 and 7). Demographic characteristics and other factors (as discussed in Section 2.2) serve as predictors, which hypothetically affect the response variables' level of agreement to the respective statements.

Using the Shapiro-Wilk normality test (SHAPIRO and 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 and 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

and MÜHLHAUS, 2010; BACKHAUS ET AL., 2011). Small VIFs[10] with values < 10, tolerance values[11] > 0.1 and low correlations among predictors (values < 0.8) indicate no cause for concern in terms of multicollinearity for all of the models presented here. The number of observations differs between the models from 114 to 133 cases, as result of missing data on either the response variables or the predictors.

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

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

Regression model 2 focuses on the identification of factors influencing the level of agreement to the issue of more frequent occurrence of years with extreme weather conditions. 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 weather there are more and more extreme years." The 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 level to this statement, but it is negatively related (significance is at a 1 % level). A statistically significant influence of the remaining predictors, which capture farmers' age and farm size, has to be rejected, based on our model.

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

The third regression model establishes the respondents' degree of 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 changes in weather conditions (R^2 of 0.119). A positive effect, at a 5 % level of significance, is found for the location of the farm. The results in Table 4 further show a significant negative influence of farmers' age ($p \leq 0.05$) on level of agreement to the statement "The weather is changing to my farm's disadvantage." For the remaining predictor variables, which cover share of agricultural income, annual farm profit, production method and farm size, the analysis shows no statistically significant effects.

[10] 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 and MÜHLHAUS (2010) recommand 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.

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

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

The fourth regression model examines the agreement scores 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 level of agreement to the response variable can be explained by using the set of predictors. The model findings (cf. Table 4) indicate that farmers' age ($p \leq 0.01$) and farm size ($p \leq 0.05$) are positively correlated with the response variable reflecting the level of agreement to this statement. A statistically significant influence on the degree of 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 income (share of agricultural income and annual farm profit) have no statistically significant effect on the awareness of either positive or negative consequences that result from changes in weather.

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

Note: (a) 1-Kraichgau, 0-Central Swabian Alb; (b) 1-organic farming, 0-conventional farming; the variables *sq_age, sq_profit* and *h_profit* 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 (cube) 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)

4 Discussion and Conclusions

In this research paper, a sample of 173 German farmers from the regions Central 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 farm household as well as farm characteristics. For investigating the determinants on their attitude to certain weather statements, four multiple linear regression analyses were employed. 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).

Based on our results, the location of the farm in either one of our two research regions influences the perception of climate change effects. Respondents of the Kraichgau show a more

distinct perception of changes in weather conditions and increasing frequency of extreme years, as compared to their colleagues from the Central Swabian Alb. They also state to be aware of a generally negative trend of consequences occurring for their farms due to a change in weather conditions. The perception of changes in weather conditions and the pessimistic attitudes of Kraichgau farmers toward climate change effects might be attributed to the focus of their farm businesses, which typically is 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. Furthermore, it is conceivable that global climate change showed a stronger manifestation in the region Kraichgau in the past due to its climatic characteristics (higher annual mean temperature and moderate precipitation) and therefore the farmers have a more distinct awareness of changes in weather.

The results of our regression analyses imply a negative correlation between level of agreement to the statements of changing weather conditions as well as the more frequent occurrence of years with extreme weather events and the age of respondents.[12] Interestingly, these outcomes contradict the conclusions of other surveys, where the perception of changes in climate 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. the drought of the year 2003) not as a trend in climate conditions. The older farmers are conceivably more conservative and traditional in terms of their attitude toward farming and might explain the extreme weather events with natural climate variability (EGGERS ET AL., 2015; MCRAE-WILLIAMS, 2009). In contrary, younger farmers might be more concerned about the long-term climatic conditions at their location 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 (STRICKER ET AL., 2001). Hence, they might more easily gather information to follow the scientific discussion on climate change.

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) establish with their survey of U.S. American households 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 between farm income and perception of climate change. Our results support the finding of NDAMBIRI ET AL. (2013), as we find a decreasing

[12] The "Peak Age" can be calculated using a modification of the formula of WEBER (2008: 186): $1 * -\beta_{age} / (2 * \beta_{sq\_age})$. For the model 1, the following formula applies: 1 * -(-0.156) / (2 * 0.00139) = 56.115. The result indicates an increase of the level of agreement from the age of 56.1 years due to the positive algebraic sign of the regression coefficient of the variable *sq_age*.

perception of changes in climate with increasing farm profit[13]. This reversal of the impact for the case of respondents might be driven 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 more powerful machines) or via financial means (e.g. insurances).

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 level of agreement that no effects on how farmers operate their farms emerge due to changes in weather 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 adjusting their farm activities to reduce climate risks and are therefore less concerned about climate change effects.

Farmers who follow organic production schemes show a more distinct level of agreement to the statement "With respect to weather there are more and more extreme years" than their colleagues who manage their farms conventionally. The positive correlation between the corresponding statement and organic production supports our hypothesis that the production method farmers apply influences the degree of agreement to the statement of more frequent occurrence of extreme years. In addition to this outcome, respondents who practiced organic farming more often believed that changes in climate will affect their farm activities, contrary to farmers practicing conventional methods. The explanation for the finding might be that farmers 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.

In general, the moderate coefficients of determination (R^2) and model findings suggest that besides the analyzed determinates other relevant factors exist, which explain a large share of the variation in the perception of changing weather conditions. 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 changes in climate is not possible. Initially, the level of education and the farms' main production activities were expected to have an effect on the magnitude of agreement to the perception of climate change effects. 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 education level because several studies reveal a higher probability of more educated farmers to be aware of changes in climate than of less educated ones (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 high-income countries, e.g. in Germany. Due to the discovery that the overall level of awareness of changing weather conditions among farmers of the two study sites Central Swabian Alb and Kraichgau is high, future research on regional scale

[13] The "Peak Profit" can also be calculated using a modification of the formula of WEBER (2008: 186). Regarding the positive algebraic sign of the regression coefficient of the variable *sq_profit* in the models 1 and 2, the level of agreement increases with the value of 79,640 € (Model 1) and the value of 73,096 € (Model 2).

should focus and explore the potential of appropriate adaptation strategies that enable farm business managers to reduce potential negative effects of ongoing climate change for their businesses.

The sample is not representative for the population of agricultural businesses in the regions Central Swabian Alb and Kraichgau due to the composition of the survey participants in terms of farm size and farm business structure. Particularly, the study represents the weather perception of successfully operating farmers with large farm businesses mainly managed in full-time. We assume that these farmers will quite likely continue farming in the nearer future. An important aspect with respect to the research topic is the low availability of studies investigating the climate change perception of farmers in Europe (EGGERS ET AL., 2015; BARNES and TOMA, 2012; KARRER, 2012). In regard of that the findings of this study contribute to the understanding of perceptions of climate change and expectations toward it's effects as well as it serves as basis for further research, even though they cannot be generalized.

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