Weather, Values, Capacity and Concern: Toward a Social-Cognitive Model of Specialty Crop Farmers' Perceptions of Climate Change Risk

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Abstract

As specialty crop production has become increasingly important to U.S. agriculture, public and private stakeholders have called for research and outreach efforts centered on risks posed by climate change. Drawing on a survey of specialty crop farmers, this study explores farmers' perceptions of climate change risks. Underlying cognitive, experiential, and socio-cultural factors hypothesized to influence farmers' climate change risk perceptions are tested using structural equation modeling techniques. Results show that specialty crop farmers exhibit an overall moderate concern about climatic risks. The more capable and prepared farmers feel themselves to be, the less concerned they are about climate change. Farmers who have recently experienced more extreme weather events perceive climate change to present greater risks. In addition, farmers' risk perceptions are also shaped by attitudes toward human exemptionalism and productivism values. Based on these findings, we provide recommendations for outreach and future research.

Keywords: climate change, risk perception, mental models, specialty crop farmers, SEM

Specialty crops, including fruits and vegetables, tree nuts, and horticulture and nursery crops, are a cornerstone of American agriculture and food systems. With a market value of nearly $80 billion in 2017 (National Agricultural Statistics Service [NASS], 2019a) and accounting for 60% of the U.S. agricultural workforce (Bureau of Labor Statistics, 2020), specialty crops are seen as central to meeting domestic demand for healthy food (Produce for Better Health Foundation, 2015; Yeh et al., 2016). Concurrently, climate change is impacting all areas of agriculture (Hatfield et al., 2018) and has become a major threat to specialty crop production (U.S. Global Change Research Program, 2018; Kistner et al., 2018). In the U.S., warming trends since the mid-1980s have contributed to more frequent extreme weather events, including heatwaves, droughts, floods, severe storms and wildfires (IPCC, 2014). Warmer temperatures and—in the Midwest and Northeast—wetter conditions have led to soil erosion, higher incidence of plant disease, more favorable conditions for pests, and reduced time for field operations (U.S. Global Change Research Program, 2018; Morton et al., 2015). Specialty crops are particularly sensitive to climatic variability because of shallow root systems and preferences for lighter soils with specific moisture and temperature ranges (Singh, 2013; Kistner et al., 2018). By disturbing flowering and pollination processes (Houston et al., 2018), climate change has negatively affected both the yield and quality of specialty crops. Indeed, climatic conditions have contributed to the degradation of crop properties that are central to consumer appeal, including nutritional content, taste, aroma and texture (Ahmed & Stepp, 2016; Kistner et al., 2018).

Public and private stakeholders have called for more research and outreach centered on helping specialty crop farmers to understand the risks of climate change and incorporate these risks into agricultural decision-making (Jasperse & Pairis, 2020; Johnson & Morton, 2015). Farmers' personal judgments about climate change-related threats to cropping systems—which we term “risk perceptions of climate change” (Slovic, 2010; van der Linden, 2015, 2017)—are a key antecedent of adaptation behavior and, for educators and scientists, an important ingredient in efforts to develop adaptation strategies that better reflect farmers’ needs (Arbuckle et al., 2013, 2015). It is therefore notable, given the economic importance and climate vulnerability of specialty crops, that few if any studies have examined what might cause specialty crop farmers, in particular, to perceive the risks of climate change in different ways. Moreover, findings about climate change risk perception based on studies of field crop growers (e.g. Arbuckle et al., 2015; Carlton et al., 2016; Mase et al., 2017) cannot simply be applied to specialty crop growers, because specialty crops and field crops respond differently to changing weather and climatic conditions. Compared with field crops like corn and soybeans, specialty crop systems require very different temperature and moisture regimes, and are characterized by specific sensitivities to winter and early-season low temperatures, heat and sunlight, and natural moisture (Singh, 2013; Walthall et al., 2013; Kistner et al., 2018). With the distinctive requirements of specialty crops in mind, the current gap in knowledge about how specialty crop farmers form climate change risk perceptions can only be directly addressed by studies involving this particular population.

In this study, we address the question: what are the underlying cognitive, experiential, and socio-cultural factors that influence climate change risk perceptions among specialty crop farmers? We proceed in the following way. First, we summarize the state of specialty crop agriculture and highlight specific problems posed by climate change. Second, based on a review of the environmental risk perception literature, we develop a social-cognitive model of farmers’ climate change risk perceptions and propose hypotheses regarding how these perceptions might be shaped by experience of extreme weather, views about climate-related threats, subjective self-efficacy, and other attitudinal factors. Third, we report the results of data analysis conducted using original 2017 survey data from specialty crop farmers in Michigan and Ohio (Han et al., 2018). We conclude by discussing the implications of our findings for farmer outreach, and limitations to our study that point to the need for future research.

Agricultural Adaptation to Climate Change

As the consequences of climate change have become increasingly visible, adaptation—defined as "adjustment in social-ecological systems in response to actual, perceived, or expected environmental changes and their impacts" (Janssen & Ostrom, 2006, p. 237)—has come to be seen as a primary response strategy (Deressa et al., 2009; Dietz & Bidwell, 2011; Watson, 2011). In the agricultural sector as a whole, new technologies, government programs, and farm production practices can all play a role in responses to the negative effects of climate change (Smit & Skinner, 2002). At the level of individual farms, climate change adaptation practices include adopting drought/wet-tolerant crop varieties, building irrigation/drainage facilities, increasing biodiversity, integrating crop and livestock systems, reducing tillage, improving soil organic matter, and adjusting planting dates (Deressa et al., 2009; Walthall et al., 2013).

A wide range of possible agricultural adaptation strategies for climate change exist (Janowiak et al., 2016); however, it is largely up to individual farmers whether to rethink their management approach and employ adaptation practices on their own farms (Howden et al., 2007; Smit & Skinner, 2002). With the importance of farmer decision-making in mind, many social scientists have sought to identify determinants of farmers' adaptation behaviors (Abid et al., 2016; Arbuckle et al., 2015; Bryant et al., 2000; Howden et al., 2007; Sanderson & Curtis, 2016; Smit & Skinner, 2002; Mase et al., 2017; Mitter et al., 2019; Morton et al., 2015; Walthall et al., 2013). This body of work has produced substantial evidence that farmers' willingness to perform climate change adaptation behaviors is centrally driven by what they believe about how climate change might impact their own operations. As summarized by Gardezi and Arbuckle, "farmers who perceive climate change to be a threat to their farm enterprises are more likely to … anticipate or react to changing conditions that may place the farm enterprise at risk" (2018, p. 4).

Farmer perception of risks associated with climate change has emerged as key to understanding adaptation behaviors. Researchers have devoted much less effort, however, to theorizing or examining how "risk perceptions of climate change" might themselves be shaped by cognitive, socio-cultural, and experiential factors other than pre-existing beliefs about the seriousness of climate change (Arbuckle et al., 2015; Mitter et al., 2019; Sanderson & Curtis, 2016). Moreover, among recent studies that have explicitly looked at determinants of risk perception (Eitzinger et al., 2018; Hitayezu et al., 2017; Schattman et al., 2016), only one was conducted in the U.S. (Schattman et al., 2016), and none has specifically examined the attitudes, values and experiences of specialty crop farmers. As noted above, specialty crop systems face different—and in many cases particularly concerning—threats from variability in weather and long-term shifts in climate, and therefore the climate change perceptions of specialty crop farmers are of clear interest to researchers (e.g. Singh, 2013; Kistner et al., 2018). Yet to date, existing studies of how farmers form views about adverse impacts from climate change have not looked specifically at specialty crop growers.

In sum, theoretical frameworks for how specialty crop farmers might form perceptions of climate change risks remain underdeveloped in the literature. Gaps in research such as this have implications not only for empirical knowledge about how farmers understand the world and make decisions, but also for policy and practice, including potential failures of intervention and low effectiveness of outreach programs (Eitzinger et al., 2018; Weber & Stern, 2011).

Risk and Risk Perception

Risk has been conceptualized as "a situation or event in which something of human value … has been put at stake and where the outcome is uncertain" (Skinns et al., 2011, p. 17). This definition reveals the three characteristics of a risk: possibility, uncertainty, and having a stake in outcomes. In the realm of social science, there are arguably two main approaches to the study of risk perception: psychological (or psychometric) and sociological (Arnoldi, 2009; Renn & Swaton, 1984). The psychological approach focuses on personal rationality and reasoning within a decision-making process (Renn & Swaton, 1984). The sociological approach studies risk with a focus on social values, institutions, and reference groups (Renn & Swaton, 1984). Arnoldi (2009) argues that the perception of risk is both personal and social, which is consistent with Garland's (2003) claim that "risk is subjective and socially constructed" (p. 49). In this paper, drawing in particular on the work of Renn and Swaton (1984), we use the term "climate change risk perception" to mean the process through which a farmer mentally represents and assimilates the likelihood of adverse effects caused by climate change to his or her farm operation. We adopt a social-psychological approach to the study of risk perception because we are interested in how personal values and beliefs, social cultures, and cognitive factors combine to influence farmers' risk perceptions with respect to climate change.

The concept of risk perception is central to this paper. Prior studies on how farmers perceive and respond to climate change have generally emphasized behavioral models. Niles et al. (2016) employed a theory of planned behavior to examine how farmers' climate change mitigation and adaptation practices might be explained by beliefs and risk perceptions of climate change. Drawing on a value-belief-norm framework, Arbuckle et al. (2015) also used risk perception to predict farmers' attitudes towards adaptation behaviors. Similarly, Frank et al.

(2011) conceptualized a model of private proactive adaptation to climate change to examine the relationship between farmers' risk perception and adaptation. These behavioral models implicitly treat risk perception as a causal factor of adaptation behaviors rather than as an endogenous concept whose origins might be of independent interest. Hence, to increase the understanding of risk perception, we adapt an integrated theory—called the "Climate Change Risk Perception Model" (CCRPM)—as the fundamental conceptual framework in this study.

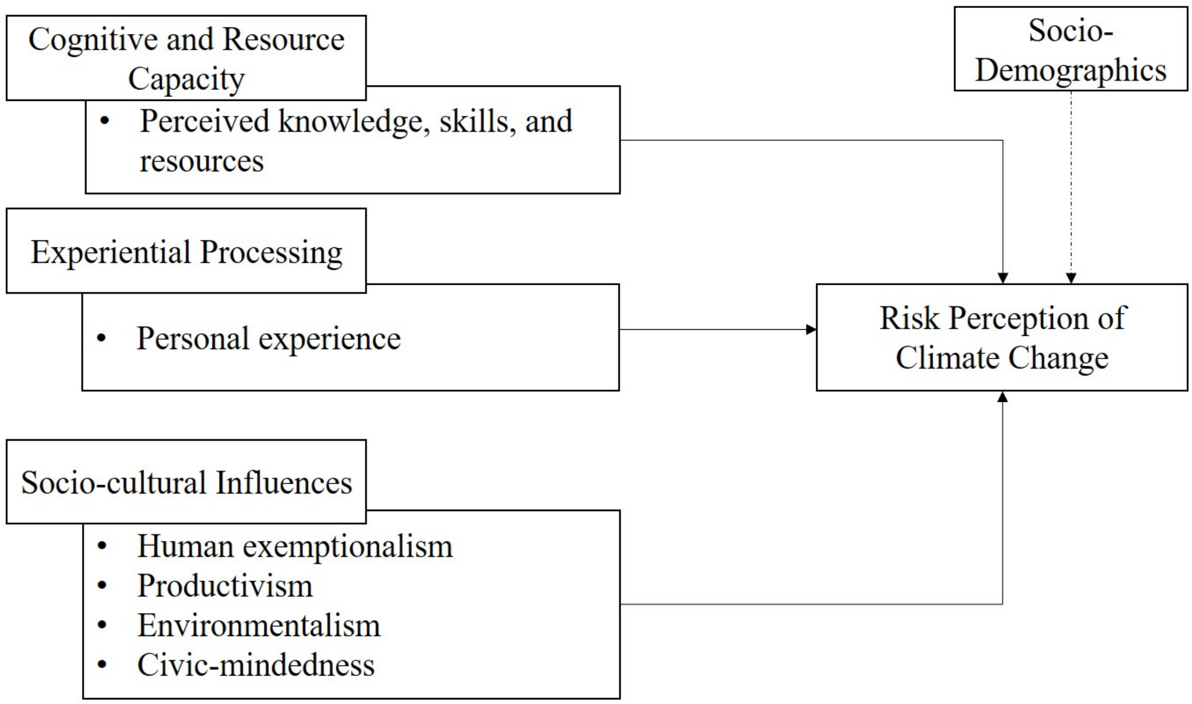
Conceptual Framework and Hypotheses

Climate Change Risk Perception Model (CCRPM)

In this research, we propose and test a risk perception model to address the question: what are the underlying cognitive, experiential, and socio-cultural factors that influence climate change risk perceptions among specialty crop farmers? The original CCRPM, developed by van der Linden (2015, 2017), integrated multiple theoretical perspectives on climate change risk perception. Consistent with other risk theorists (Arnoldi, 2009; Garland, 2003; Renn & Swaton, 1984; Slovic, 2010), van der Linden grounded CCRPM in the fundamental argument that climate change risk perception is driven by both psychological and sociological factors. We have modified a version of van der Linden's CCRPM (Figure 1) to illustrate how specialty crop farmers' climate change risk perceptions are theorized to be determined by: 1) perceived cognitive capacity of one's own knowledge, skills, and resources; 2) experiential process, and 3) socio-cultural influences, in particular values concerning the proper role of the farmer and one's relationship to community and the natural world. In the rest of this section, we describe in detail the modified CCRPM framework and related research on climate change risk perception by farmers. We then propose a series of testable hypotheses motivated both by this framework and by the findings of existing studies.

Figure 1

Climate Change Risk Perception Model



Note. This model is based on a model first proposed by van der Linden (2015).

Self-efficacy: Perceived Cognitive, Technical and Resource Capacity

Cognitive effort is required to make sound judgments about risks related to climate change (Sundblad et al., 2007; Weber, 2010; Weber & Stern, 2011). Based on previous studies, van der Linden (2015) argued that knowledge related to climate change (including causal knowledge, impact knowledge, and response knowledge) reflects the cognitive aspects of risk perception, and that knowledge is a prerequisite to perceiving risks related to climate change. Recent studies have shown that knowledge is an important predictor of perceptions of climatic risks. For instance, Mitter et al. (2019) found that farmers' knowledge about climate change significantly predicts how farmers perceive adverse effects due to abnormally warm and wet weather conditions. Ansari et al. (2018) found that farmers' perceptions of the risks associated with climate change are shaped by their knowledge about climate processes.

Research conducted by van der Linden (2015, 2017) employed objective knowledge to manifest the cognitive factors affecting climate change risk perception. But according to Bandura's (1982, 1989, 1995) social cognitive theory, the concept of self-efficacy—confidence in one's own abilities to execute a preferred course of action—may provide an equally important manifestation of cognitive factors. In the context of climate change social science, the concept of perceived adaptive capacity—whether people feel prepared to take particular actions in response to new situations (Seara et al., 2016)—maps closely onto the idea of self-efficacy (Gardezi & Arbuckle, 2018; Grothmann & Patt, 2005). Perceived adaptive capacity regarding climate change includes not only how well people perceive their knowledge related to climate change, but also perceived access to resources such as time, money, and social support (Abid et al., 2016; Grothmann & Patt, 2005). Indeed, several scholars (Arbuckle et al., 2015; Eitzinger et al., 2018; Grothmann & Patt, 2005; Morton et al., 2015) have posited or found that perceived adaptive capacity can positively affect adaptation behaviors.

In contrast to recent work on adaptation behaviors, the potentially significant role of perceived adaptive capacity has not been adequately examined in the empirical literature on farmers' climate change risk perceptions. From a theoretical perspective, it seems reasonable to think that farmers who perceive themselves to possess or have access to sufficient knowledge, skills, and economic resources, would be less concerned about risks associated with climate change for their farm operation (Fellmann, 2012; Smit & Wandel, 2006). Therefore, we propose *Hypothesis 1 (H1): Specialty crop farmers' perceived cognitive and resource capacity to deal* *with climate change will be negatively associated with farmers' risk perceptions of climate change.*

Experiencing Climate Change Impacts

Broadly speaking, whether and how people have personally experienced adverse events can shape how they perceive precipitating conditions to which these events are understood to be related. In CCRPM, the experiential process relevant to climate change risk perception includes personal experience with extreme weather events (van der Linden, 2015, 2017), as well as the concept of affectivity (Slovic et al., 2007), which is not included in our model due to considerations which we discuss later in this paper. Technically speaking, climate change is a phenomenon that requires the long-term accumulation of measurement, observations, and tests (Weber, 2010; Weber & Stern, 2011). This also means that it can be difficult to detect climate change in daily life, and long-term trends in certain aspects of weather (like more frequent extreme rains) may resonate louder in lay experience than others (like minute increases in average temperature) (Marlon et al., 2019). Farming, however, is unlike most modern professions, in that it benefits from close attention to both immediate weather conditions and long-term climatic trends. Extreme weather events, such as flooding, drought, and heatwaves, can be indicative of climate change and may create a vivid image in farmers' minds in cases where non-farmers would not necessarily be affected (Gardezi & Arbuckle, 2019; Mase et al., 2017; Walthall et al., 2013). Morton et al. (2017) also find that farmers' experience with extreme weather events is a significant predictor of sensing climate change as an uncertainty. Therefore, we propose *Hypothesis 2 (H2): Specialty crop farmers' experience with extreme weather events will be positively associated with risk perceptions of climate change.*

Socio-Cultural Influences on Risk Perception

CCRPM, which owes a theoretical debt to social representations theory (Moscovici, 1988) and the social amplification of risk (Kasperson et al., 1988), recognizes that risk is socially constructed. Social representations theory posits that collective social paradigms influence individuals' cognition and reaction behaviors towards relevant phenomena—including environmental phenomena such as climate change (Moscovici, 1973). Similarly, the social amplification of risk framework emphasizes that public perceptions of risk can be amplified or reduced by social interactions and ideologically-informed beliefs about, as well as personal experiences with, new technologies (Kasperson et al., 1988; Mase et al., 2015). Drawing on these paradigms, CCRPM holds that people's risk perceptions will be shaped by social representations related to the corresponding risk. Indeed, in the broadest sense, personal values have consistently been found to impact the formation of attitudes toward climate change (e.g. Arbuckle et al., 2015; Leiserowitz, 2006; Morton et al., 2017; Sanderson & Curtis, 2016; Weber & Stern, 2011).

Social science researchers have conceptualized a wide range of "social representations" relevant to climate change risk perception. Four stand out as particularly significant, given the contours of CCRPM and the topic of this study. First, the Human Exemptionalism Paradigm (HEP) (Brulle & Dunlap, 2015; Catton & Dunlap, 1978) holds that humans are unique creatures because of our capacity to learn, consciously evolve, and solve complex problems. Seen through the lens of HEP—still a powerful ideology in industrialized societies (Gardezi & Arbuckle, 2018; Vaillancourt, 2010)—human culture will provide technological solutions to even the most daunting environmental challenges, obviating the need to preemptively reduce resource consumption. In the context of climate change, the HEP would suggest that climate change does not present a true risk to civilization, because humans will develop solutions such as geoengineering and resilient infrastructure (Arbuckle et al., 2013). Therefore, we propose *Hypothesis 3 (H3): Specialty crop farmers' inclination to human exemptionalism will be negatively associated with risk perceptions of climate change.*

In addition to the HEP, researchers have identified a number of "values systems" or "farming philosophies" where possible connections to climate change risk perceptions clearly merit consideration. As originally conceptualized, CCRPM examined three dimensions of personal values: egoistic, biospheric, and altruistic (Stern, 2000; Stern et al., 1999). According to van der Linden, egoistic values prioritize "maximizing individual outcomes"; biospheric values prioritize "caring for non-human nature and biosphere"; and altruistic values prioritize "caring about others" (2015, p. 116). In several studies looking at farmers' value systems, three roughly analogous dimensions can be discerned: productivism; environmentalism; and civic-mindedness (Brodt et al., 2006; McGuire et al., 2013; Schoolman et al., 2021). Productivist values lead farmers to prioritize yield, efficiency and profitability through the use of modern equipment and agricultural technologies; environmentalist values lead farmers to prioritize natural ecological systems and minimal disturbance to these systems in farm operations; and civic-mindedness values lead farmers to prioritize community leadership and civic engagement (McGuire et al., 2013, 2015; Schoolman, 2020). These three value systems are distinct but not mutually exclusive; individuals can subscribe to more than one but prioritize which dominates in the context of specific situations (McGuire et al., 2015).

Existing studies present somewhat contradictory indications as to how productivism, environmentalism, and civic-mindedness might be related to climate change risk perception. According to van der Linden "the specific role of values in risk perception has not been explored sufficiently," and consistent relationships have not been discovered between value orientations and climate change risk perception (2015, p.116). Hyland et al. (2016), however, find that both productivism and environmentalism are negatively associated, for farmers, with concern about adverse impacts from climate change. Productivist farmers, according to this study (ibid.), are generally not well aware of climate change and so they do not believe that climate change poses risks for their agricultural enterprises. Many environmentalist farmers, on the other hand, can be characterized as early adopters of risk-offsetting adaptation practices. Moreover, while altruistic values were not found to be a significant predictor of risk perception in van der Linden's study (2015), Corner et al. (2014) argue that altruistic values do in fact motivate elevated concern about the risks and consequences of climate change.

Inconsistent findings regarding relationships between value orientations and risk perceptions of climate change raise difficulties for researchers seeking to propose compelling directional hypotheses. But vigorous debates in the literature also demonstrate the importance of continuing to examine these relationships with empirical data. In this study, we take our strongest cues from value-belief-norm theory, which fundamentally holds that risk perceptions are tied to belief in the likelihood of adverse consequences (Arbuckle et al., 2015). In one influential study using this framework, egoistic values were found to be negatively associated with awareness of consequences from environmental problems, while both biospheric and altruistic values were positively associated (De Groot & Steg, 2008). Therefore, we propose *Hypothesis 4 (H4): Productivist values of specialty crop farmers will be negatively associated with risk perceptions of climate change; Hypothesis 5 (H5): Environmentalist values of specialty crop farmers will be positively associated with risk perceptions of climate change; and Hypothesis 6 (H6): Civic-mindedness values of specialty crop farmers will be positively associated with risk perceptions of climate change.*

Methods

Data Collection

Data for this study are from a 2017 survey of specialty crop growers in Michigan and Ohio. Basic response tabulations for items on this survey have been reported in formats aimed at university-based cooperative extension and other applied or technical offices (Han et al., 2018). These two states were ideal sites for survey research related to specialty crops and climate change. Among Midwestern states, Michigan and Ohio have successfully incorporated specialty crop production into their agricultural economies. From 2012 to 2017, the production value of specialty crops in Michigan increased from $1.48 billion (17.03% of Michigan's total agricultural production value) to $1.74 billion (21.22%) (NASS, 2018a, 2019b). A similar trend was found in Ohio, where the production value of specialty crops increased from $602 million (5.99%) to $680 million (7.32%) during the same period (NASS, 2018b, 2019c). The "Great Lakes region" that includes Michigan and Ohio has exhibited climate trends that largely track those of the upper Midwest. The area around the Great Lakes has become warmer and wetter over the past three decades, with attendant production challenges for farmers (Anderson, 2011).

The USDA National Agricultural Statistics Service (NASS) was contracted to administer the survey and manage data collection. Only farms that harvested at least 1 acre of vegetable and/or fruit crops in 2016 were included in the sampling frame (8,383 farms). Once stratified by operation size and dominant crop type, 3,000 farms were drawn from the sampling frame and surveyed from January to March 2017. Farmers selected for the survey received the questionnaire twice by mail over the course of three weeks, followed by phone calls from survey enumerators. These two contact methods (mail and phone) potentially have unique biases; for instance, telephone interviews, relative to mail, may pose a higher risk of giving what are perceived to be socially desirable responses (Marlar, 2018). However, NASS uses both methods when conducting the census and other surveys, and has not, to the best of our knowledge, determined that the mode of collection affects data in a statistically significant way.

A total of 1,401 valid survey reports were returned to investigators, resulting in a response rate of 46.7%. Reports were considered non-usable if respondents were either no longer farming or no longer farming specialty crops. There were 881 survey reports returned that were both valid and usable, and these became the final sample used for this study. As a percentage of returned reports, our final sample of usable reports (881=63.9% of 1,401) was slightly higher than that of another recent study that used data collected by NASS, where 40.8% of returned reports were non-usable (Matts et al., 2016). NASS updates its farm lists after every census of agriculture, but farmer attrition and cropping decisions can result in substantial change in between census years. We discuss possible implications of this NASS sampling issue later in this paper.

Within the dataset of outcome and predictor variables used in this study, the amount of missing data was relatively small (5.6%). Multiple imputation was employed to address the issue of missing data (Allison, 2010; Lang & Little, 2018). Specially, we used the Monte Carlo Markov Chain (MCMC) method with 10 imputations following the process outlined by Schumacker and Lomax (2010).

Sample Characteristics

The average age of survey respondents was 57 years old; 87% of respondents were male; and more than half of respondents (56.8%) had at least a 2-year college degree. Based on a comparison with the 2012 Census of Agriculture, the survey sample was demographically representative of the intended population of specialty crop growers in Michigan and Ohio.

According to census reports for state agricultural sectors in 2012 (similar breakdowns have not yet been released for the 2017 census), principal operators growing specialty crops in Michigan were on average 56.8 years old in 2012 and 87.3% were male; in Ohio the average age of specialty crop principal operators was 55.4 years old and 86.4% were male (NASS, 2015). In terms of farm characteristics, the majority (77%) of respondents' farm operations fell into USDA's small farm category of less than $350,000 annual gross farm income (Economic Research Service, 2019). The average operation size was 266 acres—close to the national average for specialty crop farms (NASS, 2015)—and the majority (75%) of respondents operated 200 acres or less.

Outcome Variable

The outcome variable of this study is a latent variable designed to capture specialty crop farmers' perceptions of risks commonly associated with climate change. Survey respondents were asked: "How concerned are you about the following problems for your farm operation?", and then presented with a list of climate change-related threats adapted from Arbuckle et al. (2013) and Mase et al. (2017). Respondents were directed to answer on a scale of 1 (not concerned) to 4 (very concerned). Table 1 shows the specific items on which the outcome variable is based.

Table 1

Variables and Indicators

Outcome variable	Indicator label	Indicator item statement	Scale
Risk perceptions (latent)	Dry	Longer dry periods and drought	4-point
	Rain	More frequent extreme rains	4-point
	Temperature	Fluctuations in spring temperatures	4-point
	Heat	Increased heat stress on crops	4-point
Predictor variable	**Indicator label**	**Indicator item statement**	**Scale**
Perceived cognitive and resource capacity (latent)	Knowledge	I have the knowledge and technical skills to deal with most weather-related threats to my farm operation	3-point agreement scale

	Resources	I have the financial resources to deal with most weather-related threats to my farm operation	3-point agreement scale
Personal experience	Experience	Over the past five years, if you have experienced… a. Significant drought on your farm b. Saturated soils or ponding on your farm. c. Significant flooding on your farm.	Index from 0 to 3
Human exemptionalism	HEP	Climate change is not a big issue because human ingenuity will enable us to adapt to changes	3-point agreement scale
Productivism (latent)	Yield	Have the highest yields per acre	4-point importance scale
	Profit	Have the highest profit per acre	4-point importance scale
	Equipment	Have the most up-to-date equipment	4-point importance scale
Environmentalism (latent)	Water	Consider the health of streams on/near your land to be your responsibility	4-point importance scale
	Soil	Minimize soil erosion	4-point importance scale
	Nutrient	Minimize nutrient runoff into waterways	4-point importance scale
Civic-mindedness (latent)	Leader	Be a leader in your community	4-point importance scale
	Organization	Be active in farm organizations	4-point importance scale
	Community	Be active in your community	4-point importance scale

Predictor Variables

Predictor variables and measurement items were developed based on our conceptual framework and proposed hypotheses. Table 1 also presents all predictor variables, item statements, and measurement scales.

The first predictor is a latent variable that reflects and integrates two dimensions of farmers' perceived cognitive and resource capacity to thrive in the face of climate change challenges. Two items were included to manifest this latent variable: the first item measured farmers' perceived knowledge and technical skills to deal with weather-related threats to their farm operation; the second item measured farmers' perceived access to resources necessary to deal with weather-related threats. Both items were measured on 3-point agree-disagree scale (1=Disagree, 2=Uncertain, 3=Agree). Conceptually speaking, a 3-point Likert-type scale captures less information than a 5-point or 7-point scale, and so the latter type is more common. However, items with fewer response options are generally easier for respondents to answer (Dolnicar et al., 2011); survey time-to-completion is of particular concern when participants are extremely time-constrained, as is often the case with farmers, and when subject incentives are not being used. In the case of this survey, the relatively large number of items dealing with climate change led us to prioritize a scale that would not strain the capacities of respondents and lead to a lower response rate, particularly as many respondents were projected to complete the survey by phone.

Personal experience with extreme weather is the second predictor variable. Three distinct items asked farmers to recall if they have experienced a specific kind of extreme weather event (drought, ponding, and flooding) in the past five years. This variable was indexed by summing up the three responses to the extreme weather events. The index ranges from 0 (did not experience any of the extreme weather events) to 3 (experienced all three types of extreme weather events).

Four predictor variables were included to model the hypothesized role of socio-cultural influences. One item was developed to measure farmers' inclination towards human exemptionalism (HEP) on a 3-point Likert scale (1=Disagree, 2=Uncertain, 3=Agree). Three latent variables intended to capture personal value orientations (productivism, environmentalism, and civic-mindedness) serve as the last three predictors. Farmers were asked to rate the importance level (1=Not important, 2=Slightly important, 3=Important, 4=Very important) of a series of criteria for how they make decisions for their farm operation. The productivism latent variable consists of three items related to maximizing yield and profit and having up-to-date equipment; the environmentalism latent variable consists of three items related to minimizing soil erosion and pollution from agricultural chemicals; and the civic-mindedness latent variable consists of three items related to community leadership and civic engagement.

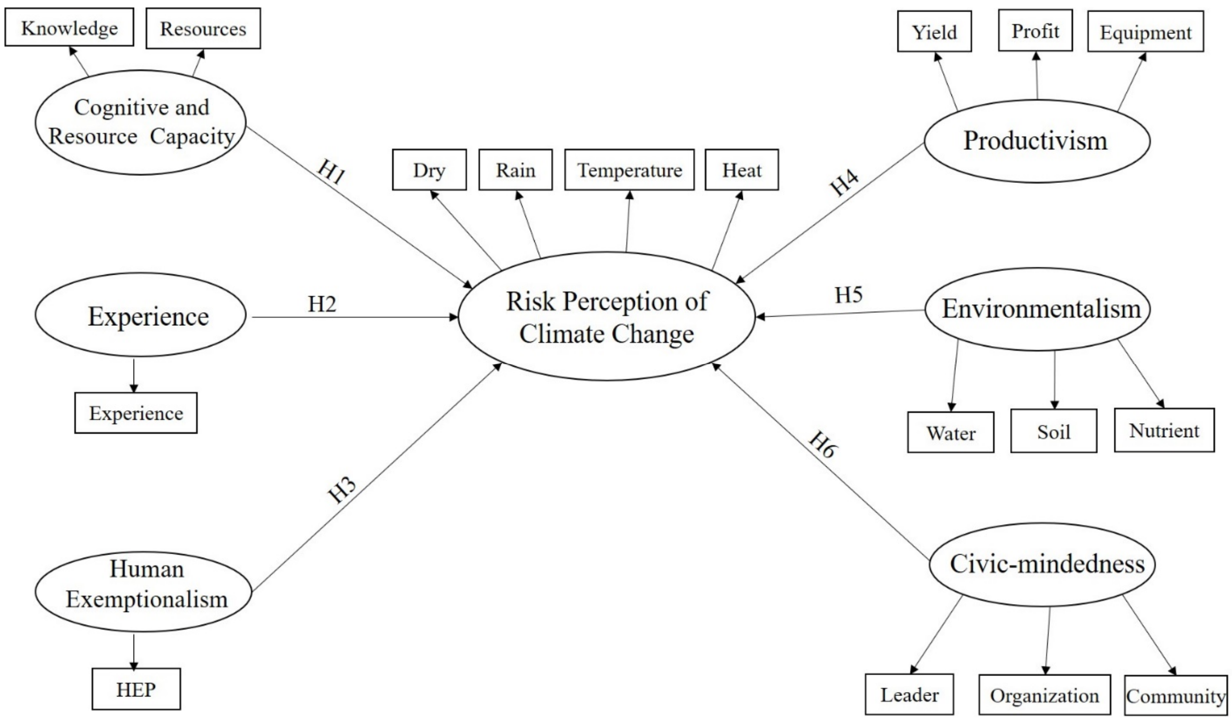
Analytical Approach and Model Specification

Given that risk perception and many of its determinants are latent constructs, structural equation modeling (SEM) was employed to test hypotheses regarding relationships between latent variables. Figure 2 shows the hypothesized model. We employed a two-step SEM approach where we first test the measurement model using confirmatory factor analysis (CFA) and thereafter we identify, estimate, and test the structural model. SEM was conducted using the Mplus 7.0 package; we used Maximum Likelihood Robust (MLR) estimation as it is robust to non-normality and non-independence of observations (Muthén & Muthén, 2012).

Subsequent to running the model shown in Figure 2, which includes all cognitive, experiential, and socio-cultural factors, we also experimented with running the model again with additional control variables for gender, age, education, and acres of operation. These sociodemographic variables have frequently been included as controls in studies of attitudes and behaviors related to climate change (e.g. Arbuckle et al., 2015; Gardezi & Arbuckle, 2019; Hitayezu et al., 2017; Leiserowitz, 2006; Mase et al., 2017); in these studies, however, results have not always pointed to significant and consistent effects. In our analyses, adding sociodemographic controls did not result in a converged model, which may be caused by model misspecification (Schumacker & Lomax, 2010). For this reason, in the next section we report results from the model composed of the primary variables directly related to our hypotheses without adding additional controls.

Figure 2

Hypothesized Structural Model of Climate Change Risk Perception among Midwest Specialty Crop Farmers



Results

Descriptive Statistics and Measurement Model

Table 2 presents descriptive statistics for each indicator variable as well as the results of the measurement model (CFA). All of the indicators loaded significantly on the associated constructs ($p<0.01$). The measurement model displayed an overall good fit (CFI close to 0.90 or 0.95; TLI close to 0.90 or 0.95; RMSEA≤0.06; SRMR≤0.08) (Hu and Bentler, 1999; Schumacker & Lomax, 2010), which allowed us to proceed to the full structural model to examine the hypotheses. Below, we first describe the details of each construct measurement.

Table 2

Descriptive Statistics of Measurement Model

Construct	Indicator	Scale				*M*	*SD*	Standardized Loadings (λ)	Composite Reliability	Cronbach's alpha	AVE
		Not Concerned	Slightly Concerned	Concerned	Very Concerned						
Risk perceptions	Dry	22.9%	30.1%	32.0%	15.0%	2.39	1.00	0.69**	0.82	0.83	0.53
	Rain	30.4%	30.3%	27.5%	11.9%	2.21	1.00	0.70**			
	Temperature	15.3%	24.9%	31.3%	28.5%	2.73	1.03	0.70**			
	Heat	20.2%	29.2%	34.5%	16.0%	2.46	0.99	0.82**			
Construct	Indicator	Scale				*M*	*SD*	Standardized Loadings (λ)	Composite Reliability	Cronbach's alpha	AVE
		Disagree	Uncertain		Agree						
Cognitive and resource capacity	Knowledge	9.6%	33.5%		56.8%	2.47	0.67	0.70**	0.61	0.61	0.44
	Resources	24.6%	35.3%		40.1%	2.16	0.79	0.62**			
Construct	Indicator	Scale				*M*	*SD*	Standardized Loadings (λ)	Composite Reliability	Cronbach's alpha	AVE
		None	One event	Two events	Three events						
Personal experience	Experience	40.5%	32.3%	16.9%	10.2%	0.96	0.99	-	-	-	-
Construct	Indicator	Scale				*M*	*SD*	Standardized Loadings (λ)	Composite Reliability	Cronbach's alpha	AVE
		Disagree	Uncertain		Agree						
Human exemptionalism	HEP	31.3%	39.5%		29.2%	1.98	0.78	-	-	-	-
Construct	Indicator	Scale				*M*	*SD*	Standardized Loadings (λ)	Composite Reliability	Cronbach's alpha	AVE
		Not Important	Slightly Important	Moderate Important	Very Important						
Productivism	Yield	9.2%	23.6%	38.5%	28.7%	2.87	0.93	0.78**	0.74	0.75	0.50
	Profit	9.8%	20.6%	36.9%	32.7%	2.92	0.96	0.79**			
	Equipment	24.2%	38.5%	26.8%	10.5%	2.23	0.94	0.50**			
Environmentalism	Water	7.6%	12.8%	40.3%	39.2%	3.11	0.90	0.61**	0.72	0.75	0.47
	Soil	5.6%	11.6%	41.4%	41.4%	3.18	0.85	0.72**			
	Nutrient	14.7%	11.3%	37.6%	36.4%	2.95	1.03	0.71**			
Civic-mindedness	Leader	27.0%	30.0%	29.5%	13.5%	2.30	1.00	0.79**	0.75	0.80	0.51
	Organization	25.5%	35.3%	27.2%	12.0%	2.26	0.97	0.65**			
	Community	11.7%	27.1%	36.9%	24.4%	2.74	0.96	0.69**			

Note. N=881. ** $p < 0.01$. Model fit: X^2 (102, N = 881) = 396.88, $p < 0.01$; RMSEA = 0.057; CFI = 0.914; TLI = 0.885; SRMR = 0.080. AVE: Average variance extracted.

Specialty crop farmers presented as generally moderately concerned about climatic risks. Among the four types of climatic risks, fluctuation in spring temperatures was the problem of most concern, followed by heat stress on crops, more frequent extreme rains, and longer dry periods and drought. The composite reliability (CR=0.82) showed good construct reliability. The average variance extracted (AVE) is a summary measure of convergent validity that was first proposed by Fornell and Larcker (1981). With the value of AVE=0.53, the climate change risk perceptions construct presented good convergent validity (Hair et al., 2014).

Specialty crop farmers also exhibited an overall moderate perceived cognitive and resource capacity to deal with climate change. Specifically, more than half of all farmers agreed that they have the knowledge and skills to deal with climate change, but nearly 60% of farmers did not think the same about their resources. Both the reliability and validity of this construct are slightly below common thresholds (CR=0.61 < 0.7; AVE=0.44 < 0.5) (Fornell & Larcker, 1981; Hair et al., 2014). Following Hair et al. (2014) and Hair et al. (2017), we still retained the indicators due to the overall good fit of the measurement model and their impact on further model results.

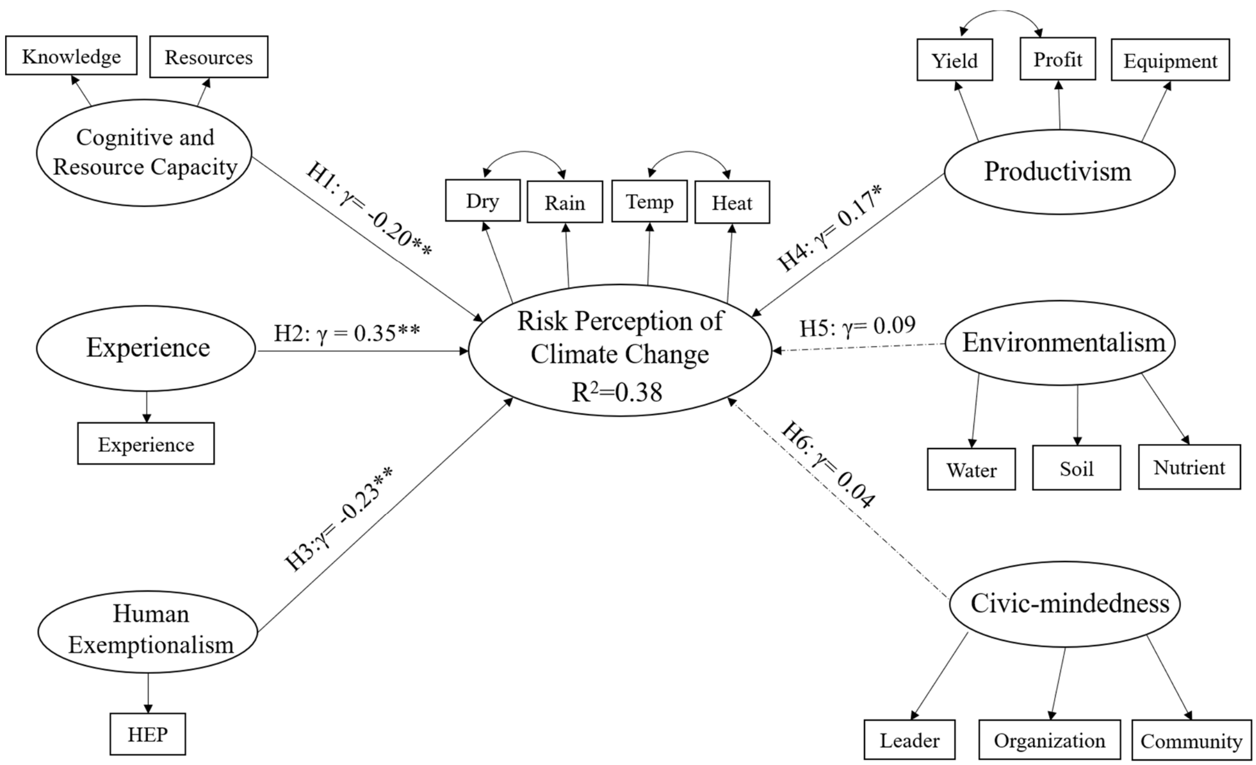
A majority of specialty crop farmers (60%) had experienced at least one type of extreme weather event in the past five years, and farmers exhibited a range of attitudes toward climate change and environmental and civic goals. For the human exemptionalism construct, farmers showed an overall uncertainty regarding abstract human capacity to adapt agriculture to climate change (*HEP*); only 30% of farmers agreed that “human ingenuity” meant that climate change was not a “big issue.” Because both the personal experience construct and the human exemptionalism construct have only one indicator each, we fixed the indicators’ loading at 1 and made them correlated with other constructs in the CFA model. Farmers exhibited the strongest orientation toward environmentalism values, followed by productivism and civic-mindedness. All three values constructs showed good construct reliability (CR>0.7) and acceptable construct validity (AVE=0.5 or close to 0.5).

Structural Model and Hypothesis Tests

We first specified the hypothesized model, as illustrated in Figure 2. Though the initial model fit was in the acceptable range (X^2 (102, N = 881) = 396.88, $p < 0.01$; RMSEA=0.057; CFI=0.914; TLI=0.886; SRMR=0.080), model modification indices provided by Mplus (Muthén & Muthén, 2012) suggested that model fit could be improved by adding three pairs of residual covariance: *Dry* and *Rain* (r=0.48; $p < 0.01$); *Temperature* and *Heat* (r=0.64; $p < 0.01$); and *Yield* and *Profit* (r=0.68; $p < 0.01$). The variables of each pair are conceptually and statistically related to each other, and so it seemed reasonable to expect that their unexplained variance would be related, as well. For hypothesis tests, we preferred this more robust model, which had a smaller value for Akaike's information criterion and the Bayesian information criterion than the initial model (Lin et al., 2017).

Figure 3

Final Structural Model with Hypothesis Tests and Residual Covariances Included



Note. Model Fit: X^2 (99, N = 881) = 299.90, $p < 0.01$; RMSEA = 0.048; CFI = 0.941; TLI = 0.920; SRMR = 0.077. *$p < 0.05$; **$p < 0.01$.

Figure 3 presents the final structural model of relationships between climate change risk perception and theoretically important cognitive, experiential, and socio-cultural factors. The final model (including the three sets of residual correlations) resulted in a robust model fit (X^2 (99, N = 881) = 299.90, $p < 0.01$; RMSEA=0.048; CFI = 0.941; TLI = 0.920; SRMR = 0.077). The model explained 38% of the total variance of specialty crop farmers' climate change risk perceptions (R^2=0.38). We conducted post-hoc power analysis based on the RMSEA value of the final SEM model (Moshagen and Erdfelder, 2016) and using the semPower R package

(Moshagen, 2020). Post-hoc power analysis revealed that on the basis of sample size (n=881), the power to detect the obtained effect (RMSEA=0.048) at a 0.05 significance level was more than 99% likely for the overall SEM model.

Table 3

Hypotheses Tests in the SEM Model

Hypothesis	Path	γ (Standardized coefficient)	Standard error	t-Statistic	*p*
H1	Perceived cognitive & resource capacity --> Risk Perception	-0.20	0.05	-4. 05	<0.001
H2	Experience--> Risk Perception	0.35	0.03	11.08	<0.001
H3	Human exemptionalism (HEP) --> Risk Perception	-0.23	0.05	-5.03	<0.001
H4	Productivism--> Risk Perception	0.17	0.07	2.48	0.013
H5	Environmentalism --> Risk Perception	0.09	0.06	1.66	0.096
H6	Civic-mindedness--> Risk Perception	0.04	0.05	0.72	0.474

Note. N=881; Model fit: X^2 (99, N = 881) = 299.90, $p < 0.01$; RMSEA = 0.048; CFI = 0.941; TLI = 0.920; SRMR = 0.077

Table 3 reports the results of hypothesis tests. Path coefficients offer insight into the magnitude of each path related to their contribution to the SEM model. Consistent with the proposed H1, farmers' perceived cognitive and resource capacity to deal with climate change is negatively associated with their risk perception of climate change (γ = -0.20, $p < 0.001$). In other words, the more capable and prepared farmers feel themselves to be, the less concern they feel about climate change. For each additional standardized unit of farmers' perceived cognitive and resource capacity, risk perception of climate change decreases by 0.20 standardized units.

Consistent with H2, specialty crop farmers' experience with extreme weather events is positively associated with their risk perception of climate change (γ = 0.35, $p < 0.001$); in fact, the experience-risk perception path is highly significant and represents the strongest effect, relative to the other paths. The more personal experience that farmers have with extreme weather, the more concerned they are about what climate change might mean for the future of their farm operation. For each additional standardized unit of farmers' experience with extreme weather events, risk perception of climate change increases by 0.35 standardized units. The magnitude of the experience-risk perception path coefficient can be interpreted to mean that experience with climate hazards has the strongest influence on risk perceptions among the predictor variables included in the model.

Consistent with H3, inclination to human exemptionalism is negatively associated with farmers' risk perception of climate change ($\gamma = -0.23$, $p < 0.001$). Farmers with a high degree of confidence in humans' ability to think and engineer their way out of problems are in general less worried about how climate change might impact their farm operations. For each additional standardized unit of agreement with human exemptionalism, risk perception of climate change decreases by 0.23 standardized units. This effect, though smaller than that for experience of climate hazards, was substantively greater than those for perceived capacity or any of the values variables.

Results did not support H4, however. Contrary to expectations, productivist values were found to be positively associated with climate change risk perceptions ($\gamma = 0.17$, $p = 0.013$). For each additional standardized unit of productivist values, the climate change risk perception score is 0.17 standardized units higher.

For the last two hypotheses (H5 and H6), we did not find statistically significant results. Neither the environmentalist values nor the civic-mindedness of specialty crop farmers were significantly associated with climate change risk perceptions. In summary, model results support H1, H2, and H3; we found a significant positive effect for productivist values on risk perception, rather than the negative effect anticipated by H4; and we did not find significant effects for environmental and civic values, leading us to reject H5 and H6.

Discussion and Implications

Stronger Perceived Capacity Leads to Lower Climate Change Risk Perceptions

Weber (2010) argues that simply having knowledge about climate change does not mean that people will take motivated action, because people need to perceive risks prior to engaging in behaviors aimed at mitigating or adapting to human-induced climate change. The fact that risk perception may play a crucial mediating role in climate adaptation behavior means that it is imperative to explore factors that may shape climate risk perception itself. Yet as we highlight in the first half of this paper, climate risk perception among specialty crop farmers—a vital population at the heart of American agricultural and food systems—has rarely been treated as a social fact in need of explanation.

Our findings suggest that farmers' perceptions of potential negative impacts due to climate change are indeed malleable, and contingent on such factors as perceived cognitive and resource capacity, personal experience of extreme weather, and certain values systems. For instance, according to our findings, farmers who see themselves as highly capable of weathering the worst effects of climate change tend to think of climate change as posing less risk for their farm operations. One logical consequence of these findings suggests something of a paradox. Conventional wisdom holds that increasing farmers' knowledge about climate change and adaptation possibilities will lead farmers to proactively protect their farm, to the extent possible, from such climate change-related threats as early-season temperature swings, extreme heat and bouts of intense precipitation. But if farmers understand themselves to have sufficient capacity to deal with climate change, then they may overlook risks and threats with which they may not actually be prepared to deal. Indeed, van der Linden (2015, 2017) warns that people tend to overrate their own cognition abilities related to climate change. It is useful to keep in mind this potential for unintended consequences of efforts to increase farmer knowledge and perceived self-efficacy. Future policy and research efforts, for instance, might find it beneficial to emphasize helping farmers to develop realistic judgments about their personal climate change adaptation capacity. A checklist or assessment tool could help farmers and their crop advisors to better assess farm-level vulnerabilities and capacities—and to avoid the trap of reduced risk perception based on an inflated sense of preparedness.

Personal Experience with Climate Impacts Leads to Stronger Perception of Risks

Experience of climate hazards had the strongest effect on how farmers perceive the seriousness of climate change threats. One implication of this finding is that future outreach programs focused on improving farmers' actual capacity, in terms of knowledge and technical skills, in the face of the climate crisis, may benefit from utilizing farmers' own concrete experiences to enhance learning, identify resource needs and motivate adaptation strategies. Put another way, program development based on experiential learning activities could be a more effective approach than a top-down technology transfer model that links researchers to extension agents to farmers in a linear fashion. For instance, cooperative extension could encourage farmers to use a variety of gauges (e.g. temperature, humidity and precipitation) to measure and track climate change over time, as well as hold field days on farms that have suffered from flooding or severe drought.

As just noted, the relationship between farmers' experience of climate-related extreme weather and their risk perceptions of climate change is the strongest in the model. However, the magnitude of this connection may be at least partially due to the fact that the items on which both latent variables are based are not unrelated, conceptually speaking. For instance, both the experience and risk perception latent variables involve items that directly mention drought and precipitation or problems related to precipitation. If more general items, such as measures of the perceived overall harmful or beneficial impacts of climate change, had been used, the causal relationship between the risk perception outcome and the experience predictor might have been weaker, and other relationships might have been stronger. As our paper is one of the first to take climate change risk perception among farmers as an object of endogenous interest, future efforts to continue in this vein, especially but not only where specialty crop farmers are concerned, would benefit from experimenting with alternative measures and variable constructions.

Higher Human Exemptionalism, Lower Climate Change Risk Perception

It is not surprising that specialty crop farmers with a strong sense of human exemptionalism had lower perceptions of climate change risk. Studies of field crop farmers by Arbuckle et al. (2013, 2015), Gardezi and Arbuckle (2018), and Mase et al. (2017) have all reported similar findings. In our sample of specialty crop farmers, about 30% of respondents agreed that human ingenuity will enable farmers to successfully adapt to climate change. As the U.S. becomes an increasingly post-industrial, urbanized society where environmentalist sentiments are widespread, the HEP may command less support than was once the case. Yet, there continues to be a sizable group of farmers with this viewpoint. Also noteworthy is the large proportion (40%) of specialty crop farmers who were uncertain about whether human ingenuity would enable them to adapt to changes brought on by climate change. This proportion is nearly the same in Gardezi and Arbuckle's (2018) analysis of data from 5,000 Midwestern grain farmers. The question of how to discuss or promote adaptive action with farmers who adhere to or are uncertain about the HEP may prove to be an important component of future outreach, given the negative relationship between HEP attitudes and climate change risk perceptions. Indeed, findings for HEP attitudes take on added significance in light of what the model reveals about the similarly negative effect of perceived cognitive and resource capacity. In a sense, HEP is perceived individual capacity writ large: confidence in the ability of humanity as a whole to manipulate nature and transcend environmental limits, rather than confidence simply in one's own ability to manage successfully in the face of a changing environment. No matter what the scale or agent in question, confidence that environmental problems can be surmounted appears to attenuate farmers' willingness to acknowledge climate risks. Finding messages that resonate with farmers who hold these attitudes may well be one of the most important tasks for agricultural climate communicators who use new social learning to encourage climate adaptations.

Productivism and Risk Perceptions

Among the three personal values systems captured by this study, only productivism was significantly associated with the climate change risk perceptions of specialty crop farmers. The relationship between these two constructs, however, ran in the opposite direction than we had hypothesized, and our findings here were also contrary to those of Hyland et al.'s (2016) research with British cattle and sheep farmers.

In considering how this finding might be explained, we return to an earlier point: specialty crop farming is an agricultural enterprise that is highly sensitive to climate change—arguably to an even greater extent, for instance, than farming field crops like corn and soybeans. For specialty crop farmers who prioritize productivist criteria like maximizing yields and profitability, it is necessary to work to constantly control temperature, moisture, and light conditions. Farmers may accomplish—or try to accomplish—productivist goals through the use of a wide range of in-field technologies and climate-controlled environments, including sophisticated irrigation equipment, temperature enhancement systems, greenhouses, high tunnels and low tunnels, and drainage systems (Singh, 2013). To the extent that climate change is associated with greater environmental unpredictability, productivist farmers whose operations are finely tuned machines for producing particular crops might find the growing importance of this variable to be especially worrisome.

The findings regarding productivism may also have implications for outreach and climate adaptation programs. Specialty crop farmers with a productivist mindset appear to be especially sensitive to climate change risks. Consequently, this group may derive significant benefit from customized strategic planning initiatives and programs that, by facilitating social learning, improve situation assessments and build new knowledge about climate change adaptation options (Morton, 2020).

The loading coefficient of environmentalism on the risk perception path is positive, but not significant. Eighty percent of farmers self-reported moderate to high levels of environmentalist values. This suggests a strong environmental ethic in this group, but also a possible ceiling effect in the sample that influenced the non-significance of this variable. The civic-mindedness value orientation is positive but does not appear to be a significant predictor for farmers' climate risk perceptions. Notably, the social-altruistic value was also not a significant predictor in van der Linden's (2015) study. Nevertheless, the theoretical rationale for a link between environmental and civic values and perceiving climate change as personally threatening remains compelling, even if empirical evidence for this link is so far underwhelming. Future research should continue to explore the role that environmental and civic or altruistic values may play in the climate change risk perceptions of fruit and vegetable farmers, and in how these values might indirectly influence adaptive management decisions.

Conclusion and Limitations

This study represents a step toward a better understanding of how American specialty crop farmers form views about the underlying risks to agriculture posed by climate change. We conclude, first, that Ohio and Michigan specialty crop farmers display an overall moderate concern about climatic risks, and second, that risk perceptions are driven by both psychological and social factors. More specifically, determinants include farmers' perceived cognitive and resource capacity to deal with climate change, prior experience with extreme weather events, inclination to human exemptionalism, and a productivist value orientation. Further, it is clear that both social and cognitive aspects of farmers' mental models influence their risk perceptions of climate change and likely the kind of adaption they undertake in response. Our climate change risk perception model, which explains 38% of the total variance and reveals support for three out of six hypotheses (while contradicting a fourth), is a broad stroke that offers qualified affirmation for certain core findings of prior studies, while also advancing knowledge about climate change attitudes within an important but understudied population of farmers.

The climate change risk perception model that we employ and test in this study would benefit from additional development and exploration. At least three shortcomings deserve attention. First, the variable for perceived cognitive and resource capacity exhibited measurement reliability and construct validity that were slightly lower than is normally considered ideal. Moreover, while the latent variable for perceived capacity is based on items that measure "response knowledge" of climate change, other cognitive characteristics of individuals, including "cause knowledge" and "impact knowledge" (van der Linden, 2017), are not represented. The fact that the latent variable used does not speak to all dimensions of the motivating concept may help to account for the relative weakness of the relationship of the cognitive and resource capacity variable to the risk perception outcome. Subsequent research might find it productive to experiment with alternative measures for perceived cognitive and resource capacity, with an eye toward improving reliability, validity and explanatory power both by refining individual items and by expanding the conceptual dimensions addressed.

Second, compared with the original CCRPM, our model does not incorporate "affectivity" as an additional covariate of the experiential process. This omission was deliberate and based on a lack of access to accurate measurements of farmers' "affect heuristic"—i.e. imagery and discrete sentiments associated with climate changes (Slovic, 2010; van der Linden, 2014). It seems likely that more could be done both to theoretically refine the concept of affectivity around climate change, and to improve the operationalization of its measurement through one or more standardized survey items in an agricultural context.

Third, the values variables—for productivism, environmentalism, and civic-mindedness—do not map exactly onto the egoistic, biospheric and altruistic values systems conceptualized for the original CCRPM. In particular, researchers have often understood "altruistic values" to mean prioritizing social justice, equality, and peace, broadly speaking (De Groot & Steg, 2008). By contrast, the civic-mindedness items for this study measure the strength of one's commitment to the wellbeing of one's more restricted, local community. The absence of a significant result for the civic-mindedness variable suggests that commitment to, and engagement with, one's community, is not associated either positive or negatively with greater concern for the impacts of climate change on one's farm. But this finding—failing to reject the null hypothesis—should not be interpreted to mean that altruistic values as originally considered for the CCRPM also are not related to climate change risk perception. Questions about altruistic values specifically, and their relationship to risk perception, await further examination using survey items or other research methods tailored for this purpose.

At least two issues might be raised with the nature of our study population and sampling strategy. First, this study focuses on specialty crop farmers in Michigan and Ohio, and findings therefore cannot, strictly speaking, be generalized beyond this population. We have argued from the beginning that specialty crop farmers make decisions with particular environmental conditions and needs in mind, and that how these farmers think about climate and risk cannot be separated from local agricultural context. Now, having arrived at some conclusions regarding determinants of risk perception among specialty crop farmers, we urge the same note of caution regarding applying these findings either to farmers who do not grow primarily specialty crops (e.g. fruits and vegetables), or to farmers whose operations are located in other regions. Put another way, although environmental impacts of climate change—such as temperature, precipitation patterns and extreme variability—are often treated as phenomena that pose generic challenges to farmers, it is critical to remember that for different cropping systems, crop response to these phenomena is not generic but specific. Thus, risk perceptions related to specific conditions are likely to be specific rather than generic.

It is a strength of our study that the sample used for data analysis, which emerged from NASS's population frame of farm operations, appears highly representative of the target population of Midwestern specialty crop farmers. However, it must also be remembered—as a second qualifier stemming from the nature of the sample—that there was a high proportion of valid survey responses that were deemed non-usable, because they were returned by respondents who were no longer farming or no longer farming specialty crops. The existence of "non-usable" survey reports would be relevant to survey findings under certain circumstances. For instance, these respondents may have made decisions that took them out of the sampling frame precisely because of acute experience with, or acute awareness of risks posed by, climate change. Even if this were the case, however, it is not clear that study findings would change if these non-usable respondents could somehow be included. After all, hypothesis tests revealed that risk perceptions of climate change are positively associated with negative, personal experiences, and negatively associated with perceived cognitive and resource capacity. Theoretically speaking, it certainly seems plausible that these descriptions would also be found to apply to farmers whose perceptions of climate change risks forced major changes in how they farmed. Without definite information on respondents behind non-usable surveys, however, we can only speculate on what these farmers might be like. If possible, future studies could address this problem by attempting to collect data on a small but representative number of non-respondents and respondents whose non-usable surveys indicated a major change in farming status.

Finally, the descriptive statistics on model variables in Table 2 reveal several intriguing trends related to specialty crop farmers that would benefit from additional analysis in subsequent studies. For instance, compared with earlier studies on field crop growers' risk perceptions of climate change (Arbuckle et al., 2013 and Mase et al., 2017), specialty crop farmers in our sample appear to be slightly less concerned by the climatic risks of longer dry periods, more frequent extreme rains, and increased heat stress on crops. Rather, specialty crop farmers are most concerned about the risks of fluctuations in spring temperatures. This is a perhaps a proxy for concern over early frost damage and the risk of premature leaf, bud, and bloom emergence with early warming spells and risk of harm to yields when the temperature drops below a certain threshold. As Kistner et al. (2018) explain, "false springs" in the Midwest from 2007 to 2012 created enormous problems for specialty crops. This specific situation is endemic to specialty crop production and normally does not present high risk to corn or soybean cropping systems, because corn and soy are not planted until the soil becomes relatively warm. These differences between cropping systems and their different sensitivities to environmental changes matter not just to academic theory-building, but also to efforts to transfer modeling findings to real-life advice on whether and how to adapt and which strategies might be most effective.

Future examinations of knowledge, attitudes and behaviors among field crop growers and specialty crop growers should continue to refine understanding of how different kinds of farmers are perceiving and adapting to climate change. In this discussion, we have speculated as to what some of these differences might be and might mean, based on studies that were largely conducted with farmers growing field crops outside of Michigan and Ohio, and prior to when our study was conducted. In future work, it would be useful to develop social-cognitive models for specialty crop farmers in parallel with corn-soybean farmers, in order to isolate convergence and distinct differences in the significance and strength of conceptual variables. Further, even within the specialty crop sector, optimal plant-growing conditions vary by annual or perennial type and plant species, and thus risk perceptions could also vary accordingly and merit further exploration. The answers to these questions, among others, may have significant implications for how farmers move forward in the face of ongoing climate change.

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