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Experimental measurement of mechanisms of expectation formation in the context of climate change

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Context/Theoretical background/Research question

Climate change already is – and is expected to become even more – one of the most challenging factors for agricultural production around the world. The way how economic agents (i.e. farmers) form their expectations about climate change effects and related risks influences their perceived need for adaptation, decisions on adaptation strategies and with that, the speed and magnitude of adaptation of the whole agricultural sector. Economic (simulation) models typically rely on the assumption of rational expectation formation when used to reproduce and analyze economic decision making (Tesfatsion, 2006). Nevertheless, research in the field of behavioral economics has revealed a number of systematic violations of common standard assumptions of economic models (Harrison & Rutström, 2008). In addition, empirical research delivered evidence that for the case of climate change perception and adaptation behavior, learning from own experience likely has a stronger impact than scientific information and that therefore biases may have a strong effect (Marx et al., 2007, Weber, 2010). For this reason, assuming a purely rational expectation mechanism may be even less appropriate for the problem of climate change adaptation modeling.

To prove this assumption we developed a computer-based lab experiment in order to test models of expectation formation against observed behavior in the context of agricultural production and climate change. The experiment incorporates i) uncertainty about the direction of climate change effects (positive/negative) in the short- to medium-term, and ii) a sequential reduction of this uncertainty due to experiential learning about climate change effects on production outcomes (i.e. the profitability of choice options).

Methodology

Participants were placed in a decision situation that is a simplification of farmers' year-to-year arable production decision. They were asked to make a production decision for five plots by choosing from four crops, whose gross margins differed depending on the weather condition of the production year. The crops were named neutrally to avoid framing effects due to associations with individual real world conditions. Associated gross margins were € 16000, 12000, 8000 and 5000 respectively in a year with "good" weather conditions, and € -4000, -3000, 1000 and 4200 respectively in a year with "bad" weather conditions.

The binary distribution that represented climate and from which weather outcomes were randomly determined in each round of the experiment (i.e. in each subsequent production year), was known to participants to entail equal probabilities for good and bad weather outcomes during a first phase of the experiment. In a second phase, climate was uncertain. During this phase, the participants observed 15 weather outcomes resulting from random drawing from one of two possible and equally likely distributions. One involved an increased probability of good weather outcomes (60%), the other an increased probability of bad weather outcomes (60%), compared to the initial situation. In addition to the cropping decision participants took in each round, they were asked for a statement on which of the two possible distributions they believed the observed weather outcomes were being drawn from, as well as for a statement on the weather outcome they expect to occur next.

Subsequent to the random determination of the weather condition in each production year total gross margins participants had earned from their decisions were automatically calculated and added to the total credit that resulted from the previous production years. The total amount earned during the 20 rounds of the experiment was then monetarily rewarded after the experiment had finished.

Results

The experiment was conducted with i) experienced farmers ii) farmer school students (from *Meister*- and *Technikerschulen*), and iii) University students of agricultural sciences (n=95). From each participant we retrieved a sequence of statements on weather and climate expectations. Together with the information about the actual composition of the distribution in effect and the stage of the experiment (i.e. the amount of information about the distribution available at any time), we calculated Bayesian probabilities for either climate and for each round of the experiment. Based on this objective measure of evidence for either climate regime, we designed several models of expectation formation that incorporate frequently cited biases and heuristics and compared them to the sequences of stated expectations we received from participants, based on their goodness-of-fit. The models we tested represent i) unbiased rational expectation formation based on Bayesian probability updating, ii) rational decision making with different levels of risk aversion, iii) a bias due to a preset expectation of either climate, iv) short-sightedness in expectation formation, v) an anchoring and adjustment heuristic, as well as vi) a naïve mechanism of expectation formation.

Our preliminary results indicate that the expectation formation of participants is strongly influenced by the strength and clarity of the climate signal, i.e. the composition and the order of weather outcomes that resulted from the random draws. Myopic patterns of expectation formation increased when evidence for the possible climate regimes was ambiguous, i.e. if the sequences of weather outcomes were more balanced and contained only short subsequences of either good or bad weather outcomes in a row. Rational expectation formation with Bayesian probability updating turned out to be more common among student participants than among the other groups of participants, whereas experienced farmers' expectation formation processes were frequently biased by a preset expectation of either of the two climate regimes, even though the randomness of the climate selection process was clearly demonstrated. We further find a significant relationship between the risk level of crop choices and the stated expectations for most of the participants. Stated short-term expectations (i.e. the stated expectation about next year's weather outcome) seemed to matter more for the cropping decisions of most of the participants than their stated long-term expectation (i.e. the stated expectation about the climate in effect). Hereby, the frequently cited *gambler's fallacy* seems to play a role, surprisingly most frequently in the group of participants who showed a rational mechanism of expectation formation with regard to climate expectations.

Conclusion

Our results indicate that a purely rational model of expectation formation is not suitable to describe all our participants' expectation formation properly. Model fit und thus quality of predictions could be improved for a large share of participants as heuristics and biases were included. This was especially true for random sequences of weather outcomes in which the signal for either of the possible climates was less clear. How this heterogeneity in mechanisms of expectation formation links to patterns of decision making in the experiment and personal characteristics will be subject to further analysis. We conclude for economic models applied in the context of climate change, that before considering a large variety of expectation formation processes one should make sure to consider a variety of climate signals as well.

References

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