Climate Risk Management xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Climate Risk Management

journal homepage: www.elsevier.com/locate/crm

Induce or reduce? The crowding-in effects of farmers' perceptions of climate risk on chemical use in China

Liqun Tang[a,b], Jiehong Zhou[a,*], Ihtiyor Bobojonov[b], Yanjie Zhang[b], Thomas Glauben[b]

[a] Center for Agricultural and Rural Development, Zhejiang University, Hangzhou 310058, PR China
[b] Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Halle 06120, Germany

ARTICLE INFO

Keywords:
Perception of climate risk
Chemical use
Rice farmer
Endogenous switching regression model
China

ABSTRACT

Farmers' perceptions of climate risk reflect their subjective probability weighting bias, which are the prerequisite for their adaptation decisions and thus shape their actions. As an adaptation strategy, farmers prioritized the technological measures of chemical input as the most simple and convenient for climate risks. However, this is little evidence of empirical work on the mechanism between farmers' perceptions and chemical use behavior. Based on 1080 households' survey data from 4 leading rice provinces in China, this study develops a theoretical framework that considers adaptation decisions of heterogonous farmers within a perception-decision- action (PDA) analytical framework, and further estimates the effects of farmers' perceptions on chemical use behavior by utilizing endogenous switching regression model. The results indicate that under *ceteris paribus*, the key variables "perception of climate risk" of farmers have significant effect on their claim of increase in the quantity of chemical use. Farmers who perceived *very obvious* climate risk increased by about 13% in the quantity of chemical use, while farmers who perceived *obvious* climate risk increased by 8%. We find evidence of crowding-in of farmers' perceptions on chemical use. The paper concludes by offering some policy implications for the presented results.

1. Introduction

Accumulating evidence have revealed significant climate warming trends in recent decades (IPCC, 2014; Shrestha and Nepal, 2016). Climate change, characterized by increasing temperature, uncertain rainfall and changing weather patterns, poses a major threat to agricultural systems (Rosenzweig and Parry, 1994; Parry et al., 1999; Zhou et al., 2018). For China, the economic losses due to natural disaster reached 13.6 billion dollars in 2015, which suffered most serious from natural disaster globally (UNISDR, 2016), and the annual average crop area suffering from drought has more than doubled since the 1950s, followed by flood events (MWR, 2014). Ju et al. (2007) report that the direct economic losses caused by meteorological disaster account for an estimated 3–6% of GDP each year, among of which drought is the most severe extreme events faced by China's rice producers. Rice is the main staple food in China, which produces nearly 30% of the world's total rice output (FAOSTAT, 2014), but it is particularly vulnerable to climate extremes. Hence we especially shed light on rice production in this study.

A large body of literature have examined the impact of climate change on crop yield (e.g. Rosenzweig et al., 2001; Ju et al., 2007; Chen, 2015; Huang et al., 2015; Bobojonov et al., 2016; Zhou et al., 2018), but climate change, especially extremely high temperatures during the ripening period can lead to high risk of milky white grains, immature grains, cracked grains (Kawasaki and

* Corresponding author.
E-mail addresses: luckytlq@zju.edu.cn (L. Tang), runzhou@zju.edu.cn (J. Zhou), bobojonov@iamo.de (I. Bobojonov), zhang@iamo.de (Y. Zhang), glauben@iamo.de (T. Glauben).

https://doi.org/10.1016/j.crm.2018.02.001
Received 18 July 2017; Received in revised form 7 January 2018; Accepted 2 February 2018

Uchida, 2016) and accelerate the evaporation rate of chemical use (Ahmed and Stepp, 2016; Zhou et al., 2017). This in fact may bring about a decline in the effectiveness of chemical use and an expanding range of pests and diseases outbreaks (Chen and McCarl, 2001; Miraglia et al., 2009; Sun et al., 2012; Chen, 2015; Zhou et al., 2017). As an adaptation strategy, farmers then adjust their chemical use quantity to new emerged conditions in order to mitigate potential yield loss. In China, the chemical fertilizers consumption rises from 25.90 million tons in 1990 to 59.12 million tons in 2013 (NBSC, 2014). However, the chemical fertilizer use efficiency is only around 33% (MOA, 2015), indicating that around two thirds of the agricultural chemicals utilized go into the environment. So China's agricultural expansion has been at the expense of environment and of sustainable development (Ali et al., 2017). Despite their positive contribution to agricultural productivity, excessive chemical use can lead to contamination of surface and groundwater, soil, and a higher risk of chemical residues via agricultural products (e.g. Rosenzweig et al., 2001; Chen and McCarl, 2001; Hall et al., 2002; Zhou et al., 2017). There is substantial evidence that Chinese farmers apply too much chemical fertilizers (e.g. Li and Zhang, 2013;Zhang et al., 2015; Zhou et al., 2017). As the principal microeconomic entity of agriculture production, individual and small-scale production by farmers in China is identified as the main factor affecting the agriculture environment and food quality (Gong et al., 2010; Tian et al., 2015; Zhou et al., 2017). Farmers' proper use of chemical input is an original and key link to ensure the safety of food quality, because it will be reflected in all the downward links of supply chain and sequentially affect consumers' health and safety (Henson et al., 2005; Koureas et al., 2012; Thongprakaisang et al., 2013; Zhou et al., 2017). Especially along with increasing society's concerns for sustainability and global climate warming, to reduce pesticide and fertilizer use is becoming one of the most challenging environmental policy objectives. But farmers in China are most poorly educated, 40.3% of whom are primary school level or less, 48.1% are middle school level and only 11.6% are highly educated[1]. The low-level education of farmers poses more challenges to the proper use of chemical input. Thus seeking to reduce pesticide and fertilizer use has therefore become a policy priority in China (MOA, 2015).

However, climate change as objective phenomenon, farmers may observe the change on climate, but they do not necessarily perceive its change. Only farmers who have perceived climate risk can possibly form adaptation decision and then take adaptation behavior (Deressa et al., 2011; Banerjee, 2015; Hou et al., 2015, 2017). The existing literature has stated that farmers' perceptions are an essential first step in the adaptation process (Gbetibouo, 2009; Moser and Ekstrom, 2010; Hou et al., 2015; Devkota et al., 2016). Farmers' perceptions of climate risk are prerequisite for farmer's adaptation, and farmers' adaptation behaviors can be regarded as the process of how their perceptions are be translated into decision-making in agriculture production (Below et al., 2012; Banerjee, 2015). Only farmer who is aware of climate risk, he or she will form a decision or motivation to take actions (Gbetibouo, 2009; Hou et al., 2017). But farmers who decided to do not really mean that they would translate into actions, thus it is essential to distinguish farmers' adaptation decisions from actual adaptation behaviors. Generally, farmers' adaptation behaviors exhibited a three steps of engagement pattern: observation, risk perception and action, and each of these steps occurred in sequence, whereby taking each step depended on the step that precede it (Bohensky and Brewer, 2013). Thus we select the key variable of "perception of climate risk" focused on in the study as the indicator, rather than objective meteorological data, to measure the effects of climate change on farmers' rice production behaviors. However, the potential endogeneity of perceived risk may be endogenous to adaptation decisions, which might induce estimation bias (Whitehead, 2006). Very few studies have so far examined the impact of farmers' perceptions of climate risk on adaptation behavior by jointly addressing the importance of psychological factors in the process of forming adaptation decisions and thus on adaptation behaviors. In this study, we argue that perception of climate risk have to be treated as endogenous to adaptation decisions in order to accurately evaluate farmers' adaption behaviors. To the extent that farmers self-select into increasing or not increasing chemical use, we use endogenous switching regression model to account for potential endogeneity and selectivity bias.

To address the gap in current literature, based on 1080 households' survey data from four leading rice producing provinces in China, by taking into account the endogeneity of perceptions on adaptation decision, we developed a Perception-Decision-Action (PDA) analytical framework and adopted an endogenous switching regression model to estimate the effects of farmers' perceptions of climate risk on their chemical use behavior, which taking farmer's psychological steps into consideration when they make adaptation decisions. Specifically, we attempt to answer the following questions: what are the perceptions of farmers on the local climate and their effects on rice, especially changes in drought and flood? How do farmers' perceptions affect their adaptation decisions, particularly with respect to chemical use? To what extent are farmers' chemical use behavior affected by their perceptions?

Rest of the paper is organized as follows. Section 2 illustrates climate risk and rice farmers' responses in study areas. Section 3 explains the empirical strategy used to evaluate farmers' perceptions of climate risk and their effects on chemical use. Section 4 introduces the data and sampling method used in this study. Then Section 5 provides econometric estimation results. The final section concludes with policy implications.

2. Climate risk and rice farmers' responses: A PDA analytical framework

2.1. Drought and flood trends in study areas

The areas affected by drought and flood respectively account for 17.6% and 8.1% of the total grain acreage, while the proportions for each province respectively vary from 5–19% and 2–10% in China (Ju et al., 2007). Considering that drought and flood are the most severe weather events faced by Chinese rice farmers, so the scope of this study is limited to drought and flood events. According

[1] Data source: according to the survey results of *Sixth Population Census* conducted by National Bureau of Statistics of the People's Republic of China in 2010.