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A Reconsideration of Crop Insurance as Climate Change Adaptation Approach

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Abstract
Adaptation to the adverse effects of climate change is an urgent issue and a critical part of the development agenda, especially in countries where the agricultural sector accounts for a large part of the industrial structure. Although insurance has attracted attention in the context of adaptation to losses caused by climate change, many studies of climate change adaptation in developing countries have overlooked the existing literature on crop insurance in the fields of agronomics and development economics. Therefore, this study aims to link the accumulated discussion on crop insurance with that on climate change adaptation. Several theoretical studies on indemnity crop insurance have already been undertaken in developed countries. Recently, a new approach—index-based insurance—has attracted particular attention as an adaptation measure for climate change. In the first part of this paper, I marshal the research on both types of crop insurance and aim to bring unrevealed issues to light. Economists have studied crop insurance, but most have devoted their efforts to increasing the uptake rate, especially in developing countries; few studies have discussed insurance in association with climate change adaptation. Even though some articles related to climate change adaptation have proposed that insurance could contribute to the improvement of people's adaptation capacity, the effect of insurance has been insufficiently validated in the context of climate change adaptation. The next crucial step in figuring out the effectiveness of insurance as climate change adaptation is to understand the effect of insurance on the individual decision-making process that leads to adaptation behavior. In fact, several studies have already revealed that insurance affects farmers' decision-making processes and behaviors, which might be the key to understanding how insurance has an effect on farmers' climate change adaptation capacities. In the latter sections of this paper, I review this research and suggest further empirical research topics.
Keywords: Climate Change Adaptation, Crop Insurance

1. Introduction

1.1 Climate Change and Agriculture

Weather risk is typically highly correlated with agricultural production losses. Agricultural activities, which depend on climate conditions, are considerably affected by climate change and increasing extreme weather events such as droughts, floods, and storms (Nelson et al., 2009). Unexpected and unpredictable climate change causes farming failure, which exposes farmers to income fluctuation. Low-income farmers in developing countries are particularly vulnerable to climate change because the economy is largely dependent on the agricultural sector, and because of the lack of a social safety net and infrastructure. (Hallegatte et al., 2015) Therefore, some farmers in developing countries are forced to change their traditional farming methods or, in the worst case, to abandon agriculture. Moreover, climate change creates an unprecedented situation for farmers. According to Faisal et al. (2014), who studied farmers' perceptions of drought in rural northeast Thailand, the majority of farmers define drought as irregular rainfall distribution such as deficiency of rainfall, delayed rainy season, and early cessation of rainfall. Though farmers usually cultivate their land based on a crop calendar, erratic distribution of rainfall or meteorological disaster might derail the seasonal cropping cycle. A decrease in agricultural incomes due to climate change will exacerbate poverty and reduce the ability of farmers to invest in a better future (Stern, 2007).

1.2 Climate Change Adaptation in the Agricultural Sector

To deal with this serious situation, many researchers have argued that climate change adaptation should be accelerated, particularly in lower income countries (Nordhause, 1991; Reilly et al., 1996; Mendelsohn & Dinar, 1999; Howden et al., 2007). Nelson et al. (2007) defines adaptation as:

> the decision-making process and the set of actions undertaken to maintain the capacity to deal with future change or perturbations to a social-ecological system without undergoing significant changes in function, structural identity, or feedbacks of that system while maintaining the option to develop. (p. 397)

Generally, people use various means to adapt to climate change (McCarthy, 2001). Adaptation strategies related to farming include crop choice and changing the farming system or cropping pattern. Some farmers shift their crops to new varieties or other crops that provide a higher yield and are tolerant to high temperatures, heavy rain, and drought. For example, some farmers who are suffering from drought change their land use patterns and

transform their rice farms to produce drought-tolerant crops such as sugarcane and cassava, whereas those who are affected by flooding may try to shift traditional rice varieties to new rice varieties that can be cultivated earlier (Kawasaki & Herath, 2011; Polthanee & Promkhambut, 2014). Changing the crop calendar is an alternative way to adapt to climate change, but adjusting to irregular rainfall distribution is extremely difficult (Deressa et al., 2009). Thus, the introduction of new farming systems (e.g., applying chemical fertilizers, soil fertility management, the practice of crop rotation, and introducing agricultural machinery) is a commonly used adaptation strategy. In addition, farmers who engage in rain-fed agriculture and are exposed to serious drought risk cope with water shortages by introducing irrigation systems, or by digging ponds or reservoirs to store rain water (Smit & Skinner, 2002). On the other hand, some farmers diversify their livelihood by increasing non-agricultural income (Ellis, 2000).

1.3 Crop Insurance as Climate Change Adaptation

Even though most adaptation activities mentioned above have been reactive approaches to climate shocks, proactive adaptation approaches—including risk-management strategies—are necessary to adapt to climate risk (Zilberman et al., 2012). Therefore, insurance as a risk transfer mechanism is also an important adaptation strategy to climate change for farmers (Mills, 2005; Hallegatte, 2009). Crop insurance, one of the traditional risk management tools, enables farmers to deal with various risks such as market risks, production risks, and asset risks. For many years, farmers have used insurance schemes to avoid the risk of an unexpected decrease in a crop harvest. Mendelsohn (2006) suggested that crop insurance is a good climate change adaptation measure for farmers to avoid the risks associated with increased weather variability due to climate change. On the other hand, many attempts have been made to discuss crop insurance in relation to developing countries, which can be applied to discussion on climate change adaptation for vulnerable people. (Hazell et al., 1986; Hazell, 1992; Alderman & Paxson, 1994).

In the first part of this paper, I review the existing literature and explore what has mainly been discussed, including some hints for climate change adaptation and dividing crop insurance into two categories: indemnity insurance and index-based insurance. The second part of the paper focuses on why crop insurance is effective as a climate change adaptation strategy. To understand the effect of insurance on farmers' decision-making processes and on behavioral change is a critical step in the assessment of crop insurance as a tool for building climate change adaptation capacity.

2. Literature Review

2.1 Indemnity Crop Insurance

Typical crop insurance is indemnity-type, which provides compensation for actual economic losses caused by a specific disastrous event. The payout is determined by assessment and is up to the limiting amount of the insurance policy. A large number of studies on the use of indemnity crop insurance by farmers for risk management have been published since the 1990s. The interest in this topic was initiated by the discussion on the U.S. Federal Crop Insurance Improvement Act in 1980 (Goodwin, 1993; Goodwin, 1994; Smith & Baquer, 1996; Knight & Coble, 1997). These studies sought for evidence of and solutions for the potential problems with crop insurance such as moral hazard, adverse selection, and systemic risk (Miranda & Glauber, 1997; Just et al., 1999; Goodwin, 2001). Miranda & Glauber (1997) revealed that reinsurance scheme allow insurers to cover their systemic risk by using empirical model of the United States crop insurance.

In 2004, Glauber revisited the 1990s discussion and reconsidered the perceived failures of the United States' crop insurance program, pointing out the low penetration rate of crop insurance and poor actuarial performance throughout the 1980s and early 1990s. Recent empirical research, therefore, focuses on participation in agricultural insurance. Santeramo and Goodwin (2016) investigated what determines crop insurance participation in Italy and found that larger and wealthier farmers are more likely to purchase the insurance. Yang et al. (2015) revealed that level of awareness of the importance of insurance positively affects demand and willingness to pay for soybean crop insurance against the risk of natural disaster in China. Farzaneh et al. (2017) concluded that indemnity payment in a timely manner was significantly affect the farmers decision of insurance adoption by investigating the factors affecting the participation in silkworm insurance in Iran.

The earliest study on the application of crop insurance to a developing country was published by Ray in 1967, and the number of such studies has gradually increased since the late 1980s. In the initial stages, the primary insurer was government. Hazell (1992) advocated the potential for private sector crop insurance to expand in developing countries and raised the problem of overcoming such obstacles as legal restrictions, the absence of experienced private insurers, and an immature industry. Even recently, however, agricultural insurance in developing countries has still largely depended on government subsidy. Public insurers are likely to use single premium rates for specific target groups, crops, or regions (Mahul & Stutley, 2010). As a result, the cost of the public crop insurance schemes is very high, especially when the insurance is bundled with credit programs targeting the group identified by the government (Anderson, 2003).

Indemnity insurance is helpful for farmers, especially when their actual financial losses are catastrophic, and the premium subsidized by government tends to be quite low or even gratis. On the other hand, there is the potential risk of insolvency for private insurance companies if they insure unexpectedly high amounts of loss and damage. In such cases, the main insurance provider has been the government in both developed and developing countries. Much of the literature has indicated the problems of public crop insurance and advocated the promotion of private sector-led insurance. Despite the discussion about the development and expansion of crop insurance, the research which attempts to examine the relationship between indemnity insurance and vulnerability to climate change is still deficient. Falco et al. (2014), who used climate data and a dataset from Italian agriculture, showed that the use of crop insurance is likely to increase as weather risk exposure increases. Similar works should be implemented, particularly in low-income countries where climate vulnerability is a more salient issue.

2.2 Index-Based Crop Insurance

Innovative crop insurance, known as index-based insurance, has been used as a measure of climate change adaptation in developing countries and has realized private sector participation in the climate risk insurance market. In these schemes, insurance payout occurs when an observed weather indicator, such as temperature or rainfall, exceeds a specific index, which is determined based on historical weather data. Therefore, this type of insurance uses an index to determine losses caused by erratic events, unlike traditional insurance that indemnifies actual loss. This results in a more rapid cash payout, which provides farmers the money as soon as they are affected by a natural disaster. Index-based insurance overcomes moral hazard and adverse selection, which have been pointed out as problems of traditional insurance. (Collier et al., 2009) Since Skee et al. (1999) proposed the use of index-based insurance in poor countries in order to overcome the high government cost of indemnity-type insurance, index-based insurance has spread widely across developing countries as farmers' main risk management policy in both the public and private sectors.

Collier et al. (2009) suggested another advantage of index-based insurance, arguing that it promotes the uptake of new technologies such as drought-resistant seeds. Farmers are likely to overestimate the risk of unfamiliar technologies, so they were unable to gain access to loans for these high-yield varieties before the new insurance product was introduced. The insurance can lower the barrier to their uptake. Hess and Syroka (2005) validated and supported this hypothesis, whereas Giné and Yang (2009) contradicted it, though both studies dealt with the same index-based insurance products sold in Malawi. These two studies show that it is still unclear whether insurance can encourage the penetration of new technologies. The effect of index-based insurance on farmers' uptake of new technologies has not been sufficiently validated by empirical study, I will come back to it again in the discussion.

In spite of its attractive features, the use of index-based insurance is still low in developing countries because of credit constraint and the lack of an insurance market. Therefore, many researchers in the field of development economics have highlighted how demand for index-based insurance increases. Through empirical research based on randomized controlled trials—currently considered one of the most accurate policy evaluation methods in the field of development economics—a number of economists have attempted to gather accurate evidence to determine the price and non-price factors that reduce demand for index-based insurance in developing countries. Giné et al. (2008) conducted field research in rural India and argued that the uptake of rainfall-based insurance decreases with basis risk and credit constraints, and increases with household wealth. Likewise, Cole et al. (2013) explored the price and non-price factors in demand for a rainfall-based index insurance product designed to insure rural Indian households. The authors discovered that the adoption of insurance is significantly price-sensitive and that non-price factors such as lack of trust, liquidity constraints, and limited salience constrain demand. Other non-price factors which have been less considered in existing theoretical studies, such as village networks (Gine et al., 2008; J. Cai et al., 2015), familiarity with the insurance vendor (Cole et al., 2013), and both the individual's and society's prior experience of insurance (Matsuda and Kurosaki, 2017), showed positive correlation with the uptake rate. Disaster experience also positively influences the demand for insurance (J. Cai, 2017; Gallagher, 2013). In addition, correlation between insurance and informal risk sharing in a community is also a focus of attention. Mobarak and Rosenzweig (2013) examined whether and how informal risk sharing in a community affects the demand for insurance products, then used randomized offers of rainfall insurance to people living in Indian villages to compare the effects of index insurance and informal risk sharing on people's willingness to invest in risky production and technologies. Their results indicate that informal risk sharing may directly substitute for formal insurance.

On the other hand, some limitations and preconditions of index-based insurance are the collecting of reliable data, provision of education, and financing of large losses. One particularly characteristic disadvantage is the so-called basis risk, which is the gap between actual losses and the measured value of losses by the index (Skees, 2008, Barnett et al., 2008). Because of basis risk, it is possible that the farmers who are financially affected by the erratic weather event may receive no cash payment and some farmers may receive payment even if they do not actually experience financial loss. Although this is the most significant deficiency of index-based insurance, it also possibly motivates farmers to mitigate their risk at the same time. This is because all insured farmers will receive

the fixed payment from the insurance company regardless of the amount of their financial loss, which means they will directly benefit from any efforts to reduce the size of the loss.

3. Impact of Insurance on Farmers' Adaptation Behavior

3.1 Insurance and Adaptation Capacity

If government directly compensates for income shock with subsidies when farmers are exposed to an extreme weather event, insurance is apparently not required to recover their financial losses. Then the question that we should consider next is why insurance is effective as an adaptation measure. In the preceding part, I reviewed some existing literature on crop insurance, which showed us its potential advantage as an adaptation strategy for climate change. However, the main focus of research on crop insurance is how to increase the demand for it in countries where the uptake rate remains low. Few studies have focused on the effect of insurance on farmers' adaptation capacity.

The reason why insurance positively affects farmers' adaptation capacity is that some climate change adaptation measures that have been generally regarded as mitigating risk are actually "risky" investments. For example, shifting to new rice varieties that are more drought-resistant is one of the adaptation measures for rice farmers, but adopting such unfamiliar and expensive technology is risky for a farmer. This offers the key to understanding the effects of insurance on climate change adaptation. Hazell (1992) noted that, with insurance, farmers would be more likely to make risky investments, such as adopting new technologies. These investments would bring about more profit which, in turn, would lead to an increase in the farmers' incomes and a reduction in poverty. Even recently, some international organizations that promote insurance as a climate change adaptation measure have also advocated that insurance contributes to farmers' investment in high yield activities, which increases resilience and sustainable development (Warner et al., 2012). In a recent article published by the Munich Climate Insurance Initiative, which is one of the institutions promoting the climate risk insurance, the chairman proposed that insurance can help vulnerable people not only recover from damage, but also give them the confidence to invest in their futures, which helps them adapt to climate change challenges (MCII, 2014). However, the opinions mentioned above are not consistent with the model according to neoclassical theory. As stated by Ehrlich and Becker (1972), insurance decreases other risk-mitigation measures—in other words, it decreases adaptation to climate change. It sounds reasonable that insurance, which protects against future financial loss, induces farmers to become indolent in pursuing additional risk mitigation strategies.

As insurance and other adaptation measures are interactive, an integrated risk management approach has been advocated by some researchers (Zilberman et al., 2012; Warner et al., 2013). However, the relationship between the two concepts has not been fully examined. To answer the question "Does insurance have a positive effect on farmers' adaptation capacity or not?" requires consideration of how insurance affects farmers' decision-making and behavior. Understanding the decision-making process and the complexity of subsequent adaptation to adjust to environmental change is the essence of understanding how to develop adaptive capacity of farmers (Mendelsohn, 2001; Morton, 2007; Hallegatte, 2009).

3.2 The Effect of Insurance on Farmers' Decision-Making and Behavior

As seen above, several articles state that insurance could have a positive effect on farmers' adaptive capacity, but the study of the effect of climate risk insurance on individual adaptation behavior has been insufficiently validated by empirical research. Even though Mendelsohn et al. (1999) pointed out the insufficiency of the literature that considers crop choice and technology adaption in response to climate change, few studies since that time have dealt with the effects of crop insurance on such behavioral change in terms of adaptation to climate change.

On the other hand, correlation between indemnity insurance and farmers' behavior has been a topic of considerable debate for many years among scholars in the field of agronomy. Wu (1999) examined the effect of crop insurance on cropping patterns and chemical use in the United States and showed that providing insurance encourages farmers to change their crops to insured crops and to increase total chemical use. Likewise, many studies in the early 2000s on crop insurance in the United States revealed that uptake of insurance results in expansion of crops and increases in fertilizer use. Skees (2000) identified that crop insurance increased acreage allocations in risky agricultural regions. Young et al. (2001), using a policy simulation model, concluded that crop insurance subsidized by government provides an incentive to expand areas of crop production and influences farmers' decision-making. On the other hand, Goodwin et al. (2004) suggested that the effect of insurance participation on crop acreage responses was relatively small, which shows that the effect of insurance on farmers' productivity remains controversial among scholars. Likewise, it is not clear how insurance influences the application of fertilizers and chemicals. Horowitz and Lichtenberg (1993) estimated that the farmers who purchase crop insurance are more likely to use fertilizer and chemicals, whereas to the contrary, some studies observed that crop insurance brought about a decrease in their usage (Quiggin et al., 1993; Smith & Goodwin, 1996). What is more, crop diversification, which is one of the forms of adaptation strategy induced by participation in crop insurance, has been recently studied. Falco et al. (2014) showed that crop diversification can be a substitute for

insurance in hedging against climate risk exposure, and Santeramo and Goodwin (2016) and Yang et al. (2015) also showed the participation in indemnity-type agricultural insurance is negatively correlated with diversification of income source.

Even though some previous studies supposed that the behavioral change of farmers due to crop insurance could be attributed to moral hazard, very recent studies in the field of development economics provide evidence that farmers' behavior is altered even by index-based insurance, which is assumed to be immune from the moral hazard. Karlan et al. (2014) conducted several experiments in northern Ghana which showed insurance leads to significantly larger agricultural investment and riskier production choices in agriculture. Cole et al. (2017) showed the provision of index based influenced the production decisions among Indian farmers; facilitated them to invest in higher-return but rainfall-sensitive cash crops. Similarly, studies using field experiments in developing countries found that provision of insurance significantly increases farmers' investments in risky-but-profitable production activities as well as their productivity (J. Cai, 2016; H. Cai, 2015; Liu et al., 2016). On the other hand, there are also studies that have found a negative effect of insurance on poor farmers' investments in production (Falco et al., 2016).

4. Discussion

Insurance has hypothetical functions which affects farmers' decision-making processes. First, insurance gives an incentive to farmers to mitigate risks (Warner et al., 2009). Hudson et al. (2016) concluded that insurance-based incentives promote adaptation to flood risk. They showed that insurance encourages people to reduce residential flood risk in both Germany and France when the insurance premium accurately reflects the risk. Second, people's perceptions of risk could be affected by the risk-pricing function of insurance. Collier et al. (2009) mentioned that the price signals of index-based insurance might affect people's decision-making processes and allow them to consider changing their behavior to adapt to an erratic weather situation. People are likely to overestimate their own risk, which prevents farmers from taking up new technologies. Price signals from insurance give them estimates of the cost of the underlying risk, which they might never have otherwise considered. Finally, insurance is assumed to minimize income fluctuation by covering financial loss caused by unexpected disastrous events in the future, which makes farmers ensure to make an investment. Income smoothing is implemented by various measures among low income farmers (Morduch, 1995), but little attention has been given to the fact that insurance has the function of stabilizing income prospects. These are just some of the mechanisms through which insurance may affect farmers' decision-making processes; further research should model the theoretical implications and validate them empirically.

5. Conclusions and Further Research

We can identify an abundance of papers on U.S. crop insurance in particular, which dealt with intrinsic problems of indemnity crop insurance such as the moral hazard problem. Insurance has been attracting interest as a climate change adaptation measure. However, it is not a novel measure, but one of the traditional risk management tools for farmers. In fact, there is an abundance of past work on both traditional indemnity insurance and emerging index-based insurance offering numerous suggestions to the recent discussion of climate change adaptation. The accumulated knowledge and lessons learned from the many studies of crop insurance in the field of agronomics can provide useful insights when combined with the literature on climate change adaptation. Insurance and other adaptation activities are interdependent, so we should pay attention to the effects of insurance policy on other adaptation strategies. In fact, the interaction between insurance and other adaptation strategies is ambiguous. The primary question of interest is how insurance contributes to farmers' adaptation capacities. Even though several articles argue that climate risk insurance enhances farmers' adaptation capacities through their investments in a better future, no studies have validated this hypothetical opinion. Nonetheless, some studies of crop insurance have provided evidence that insurance encourages farmers to make risky investments. The author supposes that climate change adaptation, which is usually considered a risk-mitigation approach, includes aspects of potentially "risky" investment for farmers in developing countries. Based on this, insurance possibly promotes farmers' adaptation behaviors by making them invest in a better future. Therefore, it is reasonable to think that insurance may lead to increased capacity of farmers to adapt to climate change. Because the function of insurance related to individual behavior has been insufficiently comprehended, the effect of insurance on the process of individual decision-making and behavioral change should be carefully considered, and validation by empirical research in developing countries should be pursued as a future challenge. Studies on the influence of insurance on individual decision-making processes may be essential to gain a better understanding of interaction between insurance and other adaptation behavior against climate change risk, which leads to comprehensive risk management of vulnerable people. Building resilience not by focusing a single adaptation tool but by managing risk with multiple adaptation measures including climate risk insurance is needed.

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