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Agricultural risk management policies under climate uncertainty☆

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ABSTRACT

Climate change is forecasted to increase the variability of weather conditions and the frequency of extreme events. Due to potential adverse impacts on crop yields it will have implications for demand of agricultural risk management instruments and farmers' adaptation strategies. Evidence on climate change impacts on crop yield variability and estimates of production risk from farm surveys in Australia, Canada and Spain, are used to analyse the policy choice between three different types of insurance (individual, area-yield and weather index) and ex post payments. The results are found to be subject to strong uncertainties and depend on the risk profile of different farmers and locations; the paper provides several insights on how to analyse these complexities. In general, area yield performs best more often across our countries and scenarios, in particular for the baseline and marginal climate change (without increases in extreme events). However, area yield can be very expensive if farmers have limited information on how climate change affects yields (misalignment in expectations), and particularly so under extreme climate change scenarios. In these more challenging cases, ex post payments perform well to increase low incomes when the risk is systemic like in Australia; Weather index performs well to reduce the welfare costs of risks when the correlation between yields and index is increased by the extreme events. The paper also analyses the robustness of different instruments in the face of limited knowledge of the probabilities of different climate change scenarios; highlighting that this added layer of uncertainty could be overcome to provide sound policy advice under uncertainties introduced by climate change. The role of providing information to farmers on impacts of climate change emerges as a crucial result of this paper as indicated by the significantly higher budgetary expenditures occurring across all instruments when farmers' expectations are misaligned relative to actual impacts of climate change.

1. Introduction

Climate change affects the mean and variability of weather conditions and the frequency of extreme events, which to a great extent determines the variability of production and yields. The risk management response to these changes is part of farmers' adaptation strategies. Of relevance to risk management, the yield of crops is limited to differing degrees by water availability and temperature depending on the agro-ecological zone. Examples of impacts from extreme events and weather variability are the significantly increased costs resulting from the increased frequency of extremely hot days that cause heat stress in crops, or by the timing and amount of rainfall in a specific event.

Climate change affects the distribution of yields under a given set of management practices, which in turn affects the probability distribution for farmers' expected income. Farmers can adopt several adaptation strategies in response to these changes. Adaptation through cropping pattern change can in some cases ease the exposure of plants to critical higher temperatures (Peltonen-Sainio et al., 2011). Also, changing planting time may help avoid heat stress during the critical growth phases (Rötter et al., 2011). Another means is to introduce more diverse cultivars that differ genetically in their responsiveness to climate conditions (Howden et al., 2007). As regards precipitation changes and water shortage, farmers can adjust by improving soil water-holding capacity by adding crop residues or manure, or by adopting conservation tillage (Smith and Olesen, 2010; Känkänen et al., 2011). Altering fertiliser rates to maintain grain or fruit quality consistent with the climate is another option.

In a situation where farmers have no insurance, there should be in principle a strong incentive to adapt to climate change (Mendelsohn, 2010). Farmer reactions are more nuanced, however, and lack of insurance has shown that there is a lower likelihood of farmers adopting new technologies (Feder et al., 1985; Antle and Crissman, 1990), of lower investments (Skees et al., 1999), but also of greater diversification (Skees et al., 1999). Finally, even though certain practices may decrease risk once they are mastered by the

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farmer, the risk of crop-failure can increase initially because changing practices can be risky as farmers learn new technologies (Marra et al., 2003).

Risk management instruments, such as crop insurance and disaster assistance programme, and especially how they are designed, will affect incentives to adapt (Collier et al., 2009). For example, traditional agricultural insurance (which makes an indemnity payment when the farm incurs a verifiable production loss) can help to manage production risk but it is known to be expensive and will diminish incentives to adapt to climate change. Weather index insurance or area yield insurance, which do not require on-farm verification, can help keep administrative costs down as compared to individual yield insurance, and they do not discourage adaptation since indemnities are paid independently of actual loss incurred by a policyholder. However, they are not a means for structural adaptation. Farmers will incorporate any insurance subsidies or ex post disaster payments to their production decisions, which may favour insurance over crop diversification or other risk management and adaptation strategies.

Insurance is sometimes used as a disaster assistance tool. It has the advantage of a formal contract with the financial participation of farmers, the evaluation of damages and a relatively quick payment of indemnities. But support to insurance has also its drawbacks; in particular it can prevent the development of other fully private solutions and it typically does not fully replace *ex post* assistance.

Is climate change making insurance and other risk management policies more needed? How can policy makers take such decisions when the information about how different instruments would perform under an uncertain climate is very limited? Building on previous work examining risk management under climate change (Collier et al., 2009; Heltberg et al., 2009) this paper is the first to address, in an applied context, the risk and the uncertainties introduced by climate change in the probability of weather events, and the role of perceptions of this uncertainty in terms of how risk management policies would perform in practice. To investigate these issues we provide examples from Australia, Canada, and Spain, which highlight that the appropriateness of a policy's design depends on how climate change affects the risk structure facing farmers. The paper also analyses the robustness of policy instrument relative to current uncertainty on the impact of climate change on variability of yields.

The multidimensional, diverse and uncertain nature of the problem of risk management under climate change makes it difficult to identify an optimal policy choice. First, there is strong uncertainty about the quantitative impact of climate change on the variability of yields and production risks. Second there is uncertainty about farmer's perceived risks and their degree and direction of adaptation response to climate change. Third there is a strong farm-specific or idiosyncratic component because different farms have different risk profiles, are affected differently by climate change and have different adaptation responses. Finally the range of policy options is very large. In this paper we try to tackle each of these dimensions, respectively: analysing three climate scenarios (one standard or "marginal" climate change scenario, one with higher frequency of extreme events, and a baseline with no climate change); looking at three different responses by farmers (adaptation by diversification, structural adaptation and misalignment); characterising three types of farms according to their risk profile; and finally comparing four different policy options.

This is a highly complex decision making framework where bio-physical impacts of climate change interact with the human response. The strategy followed in this paper is to use science and economic empirical analysis to try to provide insight on these interactions and their policy relevance in three countries with different characteristics. Of course the reality is even more complex with many more possible scenarios and types of farms and with very limited information about their likelihood and frequency. An alternative strategy for our research would have been to simplify the problem by reducing its dimension. However, our analysis is already a simplification and our purpose is also using this example to illustrate the difficulties of analysing highly uncertain policy questions such as those related with climate change. One important conclusion of the analysis in this paper is that scientists and economists need to address the added uncertainty introduced by climate change if they are to give sound policy advice. The results of the analysis help to understand the dimensions and trade-offs of the policy question, and possible ways to get more robust policies.

The paper is structured as follows. Section 2 presents crop insurance instruments and ex post payments analysed in this paper. In Section 3, the data and the stochastic simulation model used for analysis are presented. Results under a climate change scenario without more extreme events and misalignment ("marginal" climate change scenario) are discussed in Section 4 while alternative climate change scenarios and robust policy choices under strong uncertainties are, respectively, presented in Sections 5 and 6. Section 7 concludes.

2. Risk management, insurance, and decision making under climate uncertainty

It is common in the literature to segment risk in a way that matches risky outcomes with different tools to transfer, pool or manage risk. These layers are typically defined in terms of the probability of occurrence and the magnitude of the losses, and, therefore, the extent to which risk is catastrophic. The most efficient instruments to manage risk may differ across layers. Following OECD (2009), in the *risk retention layer* of frequent events that cause relatively limited losses (normal risks), farmers are best placed to manage this risk efficiently and smooth their income; in the *market insurance layer*, risks are more significant but less frequent and there is scope for farmers to use insurance or other market options (marketable risks); finally, in the *market failure layer*, risks generate very large and systemic (correlated) losses at low frequencies which makes them difficult to pool through insurance (catastrophic risks). Government may decide to intervene after these catastrophic events, typically with *ex post* payments.

Even though this three-layer approach is conceptually straightforward, it can be challenging to implement in practice. The boundaries between layers are not well drawn and the definition of catastrophic risks is determined by how government responds to specific events and manages the demand for assistance. Subsidised insurance systems are sometimes used to assist farmers after disasters. When subsidised insurance becomes a tool to deliver disaster assistance the boundaries between catastrophic and marketable risk can become blurred.

Three types of crop production insurance are investigated and compared with *ex post* assistance: individual yield, area-yield and weather index insurance. They have different characteristics in terms of data requirements, administrative costs, distribution of risk, and its impact on farmers' incentives to adapt to climate change. Traditional individual-yield crop insurance makes an indemnity payment when the farm incurs a yield loss. To pay indemnities, the insurance provider must estimate the value of yield loss for each farm and commodity that makes a claim. Hail insurance is the most common peril insurance and is offered in the majority of OECD countries. Multiple-peril crop insurance, which covers losses due to multiple risks, is more complex and rarely