Is there a demand for multi-year crop insurance?

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In this paper we adapt a dynamic discrete choice model to examine the aggregated demand for single- and multi-year crop insurance contracts. We show that in a competitive insurance market with heterogeneous risk averse farmers there is simultaneous demands for both insurance contracts. Moreover, the introduction of multi-year contracts enhances the market penetration of insurance products. Using US corn yield data we empirically assess the potential of multi-year crop insurance.

1 Introduction

There is ample empirical evidence that traditional crop insurance does not attract high participation of producers without financial subsidies. In the U.S., for example, more than 60% of the total premiums paid by farmers are subsidized. In total, costs for the federal crop insurance program add up to $10 billion annually (Goodwin and Smith, 2013). These figures imply that traditional crop insurance would fiscally not be feasible for most developing countries. In view of considerable expenses for subsidizing traditional crop insurance programs, low participation for unsubsidized insurance and growing risk exposure due to climatic change, there is an urgent need for alternative, affordable crop insurance products.

Several alternative insurance instruments have been discussed in the literature, such as area yield insurance or weather derivatives (Mahul, 1999; Vedenov and Barnett, 2004). Another

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alternative, which has recently been proposed by Chen and Goodwin (2010), is multi-year crop insurance. Multi-year insurance, also known as long term insurance, is offered at a fixed premium per year and has a contract period of more than one year. In contrast to single year insurance it is not possible to raise the premium or to cancel the contract during the contract period. Apart from allowing stable premiums, multi-year insurance can also reduce administrative costs related to marketing and renewal of insurance contracts (Kunreuther and Michel-Kerjan, 2009). A further advantage, claimed by Chen and Goodwin (2010), is that fair premiums of multi-year crop insurance are smaller than of single-year contracts unless crop yields are perfectly correlated over time. This feature rests on a time diversification argument, i.e. payoff risks are pooled across time. A necessary condition for time diversification, however, is that all indemnity payments are granted at the end of the contract period. It is likely that this feature makes multi-year contracts less attractive to farmers because they may suffer liquidity problems before they receive indemnity payments. If, in contrast, indemnities are paid immediately in case of a yield loss, multi-year insurance is likely to be more expensive, since the insurance provider must be compensated for losing the flexibility of premium adjustments. The question arises whether multi-year crop insurance is still attractive for farmers and insurance providers under these conditions.

To answer this question, we develop a dynamic choice model of insurance alternatives, in which single- and multi-year insurance contracts are offered to heterogeneous risk averse farmers. Based on an inter-temporal utility maximization, we derive the aggregated demand for single- and multi-year insurance contracts. The theoretical model is then calibrated to U.S. corn yields.

2 Theoretical framework

2.1 Insurance market

Following Kleindorfer et al. (2012) we consider the simplest non-trivial setting, a two-period two-state model with complete information. We introduce an insurance market, in which insurance premiums reflect the expected loss plus a risk loading mainly for reinsurance cost. That is, premiums are exogenously given and not determined by an equilibrium model. The risk loading at t_1, denoted as r_1, is known, while the loading factor r_2^w at t_2 is uncertain and depends on the state of the world $w \in \{d, u\}$. It either increases to r_2^u with probability q or it decreases to r_2^d with probability $(1 - q)$ depending on a loss occurrence at t_1 and thus

$$r_2^d \leq r_1 \leq r_2^u. \tag{1}$$

The assumption of time varying risk premiums is plausible since they will be likely adjusted when new information on realized losses becomes available. In fact, crop insurance premiums in the US were subject to changes in recent years (Risk Management Agency 2012).

We focus on a specific type of crop insurance, namely area yield insurance. This is an index-based insurance where individual indemnity payments depend on the average yield in a region rather than on individual farm yields. This type of insurance is not subject to moral hazard and loss adjustment, and thus bypasses obstacles inherent to traditional crop insurance (Mahul, 1999). Actually, several index insurance programs have been implemented all over the world, particularly in developing countries, including India, Bangladesh, Mexico and China. The relation between the individual farm yields, $(y_{it})_{i=1,\dots,n}$ and the area yield y_t is assumed:

$$y_{it} - \mu_i = \beta_i(y_t - \mu) + \varepsilon_i, i = 1, \dots, n, \tag{2}$$

with $E\varepsilon_i = 0$, $\varepsilon_i^2 = \sigma_i^2$, $y_t \perp \varepsilon_i$ and $y_{it} \sim (\mu_i, \sigma_i^2)$, $y_t \sim (\mu, \sigma^2)$. $F_{\varepsilon_i}(\cdot)$ is the cumulative density function (CDF) of $\varepsilon_i \in [\varepsilon_{i,\min}, \varepsilon_{i,\max}]$ and $F_{y_t}(\cdot)$ is the CDF of area yield $y_t \in [0, y_{\max}]$. The coefficient β_i measures the sensitivity of the individual yield to the area yield. It determines the risk reduction potential and, in turn, the optimal coverage level of area yield insurance (Mahul, 1999). In our model β is a crucial parameter, because it allows to introduce heterogeneity of farmers. An empirical distribution of β was estimated by Miranda (1991) He finds that this parameter varies from 0.1 to 2.03 for US bean producers. $\mathcal{B}$ represents the set of heterogeneous farmers with different β, i.e. $\beta \in \mathcal{B}$. $F_\beta(\bar{\beta})$ denotes a counting function counting for the number of farmers with $\beta < \bar{\beta}$.

Two types of area yield insurances policies are provided: single-year contracts (SY) and multi-year contracts (MY). The indemnity payment for both contracts is: $I_t = \max\{y_c - y_t, 0\}$ paid after each period, where y_t is the realized area yield at t and y_c is a trigger value. MY contracts have a fixed annual premium P_{MY}[4]. The price of SY contracts at t_1, $P_{SY,1}$, is known, but $P_{SY,2}^w$ at t_2 can either increase to $P_{SY,2}^u$ or decrease to $P_{SY,2}^d$ depending on the level of reinsurance costs: it. Formally stated:

$$P_{SY,1} = (1 + r_1)E(I_1), P_{SY,2}^w = (1 + r_2^w)E(I_2), \tag{3}$$

$$2P_{MY} = P_{SY,1} + qP_{SY,2}^u + (1 - q)P_{SY,2}^d. \tag{4}$$

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[4] For simplicity, farmers are not allowed to cancel MY at t_2. In other words, the cancellation fee may be too high for farmers to terminate the MY contract within contract periods.

From Eq.(1) follows that $P^d_{SY,2} \leq P_{SY,1} \leq P^u_{SY,2}$. We assume that insurance premium increase on average due to climate change, i.e. $qP^u_{SY,2} + (1-q)P^d_{SY,2} \geq P_{SY,1}$. Moreover, it is assumed that: $P_{MY} \geq P_{SY,1}$, because insurers have to be compensated for bearing the risk of changing reinsurance costs[5]. Note that though MY is more expensive than SY on average, risk averse farmers might prefer MY to avoid price uncertainty.

2.2 Modeling farmers' insurance choices

Farmers are assumed to have an additive inter-temporal utility $V = U_1 + U_2$ where $U(\cdot)$ is a one-period utility function depending on net incomes at t_1 and t_2, respectively.[6]. Given Eq.(2), the expected utility of purchasing an insurance contract in one period is:

$$EU(-P,\beta_i) = E_{F_{y_t}}E_{F_{\varepsilon_i}}U(\mu_i + \beta_i(y_t - \mu) + I_t - P + \varepsilon_i), \qquad P \in \{P_{SY,1}, P^w_{SY,2}, P_{MY}\}, \tag{5}$$

and the expected utility without an insurance contract equals:

$$EU(0,\beta_i) = E_{F_{y_t}}E_{F_{\varepsilon_i}}U(\mu_i + \beta_i(y_t - \mu) + \varepsilon_i) \tag{6}$$

Farmers face a discrete choice set consisting of buying MY, SY, or choosing no insurance (NI) for two periods (Fig. 1).
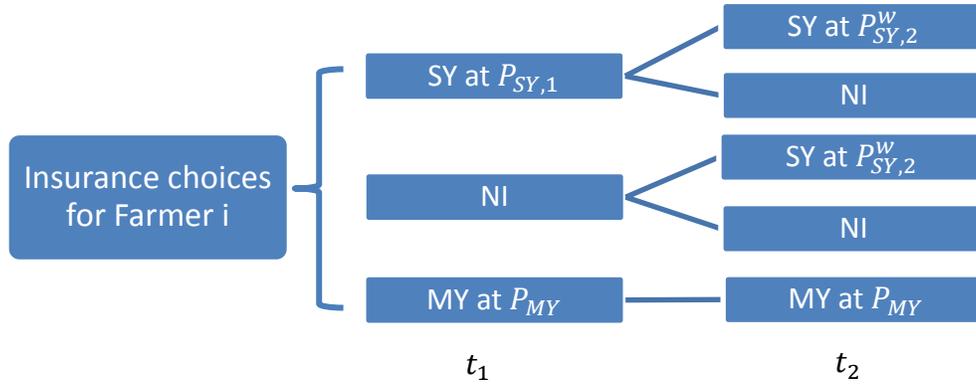
Fig.1 Farmers' insurance choices

We solve the decision problem via dynamic programming. The decision rule of farmer i $D_2(\beta_i, w)$ at t_2 follows:

$$D_2(\beta,w) = \begin{cases} MY, & \text{if the decision at } t_1, \ D_1(\beta_i) = MY, \\ SY, & \text{if } EU(-P^w_{SY,2},\beta_i) \geq EU(0,\beta_i) \text{ and } D_1(\beta_i) \neq MY, \\ NI, & \text{if } EU(-P^w_{SY,2},\beta_i) < EU(0,\beta_i) \text{ and } D_1(\beta_i) \neq MY. \end{cases} \tag{7}$$

Farmers, who buy MY at t_1, hold MY also at t_2 by definition. Otherwise, they decide to buy

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[5] A&O cost, which are probably smaller for MY than for SY, are not taken into account.
[6] We ignore discounting of utility at t_2.

SY or NI based on their expected utility under each state of world w. At t_1, the optimal choice set $D_1(\beta_i)$ is:

$$
D_1(\beta) = \begin{cases}
\text{MY, } EV_{MY}(\beta_i) = 2EU(-P_{MY}, \beta_i), \\
\text{SY, } EV_{SY}(\beta_i) = EU(-P_{SY,1}, \beta_i) + q\max\{EU(-P_{SY,2}^u, \beta_i), EU(0, \beta_i)\} \\
\qquad\qquad + (1-q)\max\{EU(-P_{SY,2}^d, \beta_i), EU(0, \beta_i)\} \\
\text{NI, } EV_{NI}(\beta_i) = EU(0, \beta_i) + q\max\{EU(-P_{SY,2}^u, \beta_i), EU(0, \beta_i)\} \\
\qquad\qquad + (1-q)\max\{EU(-P_{SY,2}^d, \beta_i), EU(0, \beta_i)\}
\end{cases}
\tag{8}
$$

and the optimal decision $D_1(\beta_i)$ for farmer i satisfies:

$$
D_1(\beta_i) = \arg\max_z [EV_z(\beta_i)|z], \quad z \in \{MY, SY, NI\}
\tag{9}
$$

To determine the aggregated demand $A_1(z)$ for insurance contracts, we introduce the indicator function $\mathbb{I}$ and define the aggregated demand for $z \in \{MY, SY, NI\}$ at t_1 and t_2 as:

$$
A_1(z) = \int_{\mathcal{B}} \mathbb{I}_{\{D_1(\beta)=z\}} dF_\beta; \quad A_2(z, w) = \int_{\mathcal{B}} \mathbb{I}_{\{D_2(\beta,w)=z\}} dF_\beta
\tag{10}
$$

When MY and SY are both offered in the insurance market, the total expected insurance demand for both periods is:

$$
A^{MY+SY} = \sum_{z \in \{SY, MY\}} \{A_1(z) + A_2(z, w)\}
\tag{11}
$$

If only SY is offered, it equals:

$$
A^{SY} = \sum_{z \in \{SY\}} \{A_1(z) + A_2(z, w)\}
\tag{12}
$$

2.3   Solution

In this section, we first derive the optimal insurance type for each farmer as function of the hedging effectiveness β. We strive for a closed form solution and to the end we make two simplifying assumptions. We assume an exponential utility function $u(x) = -\exp(-ax)$ with absolute risk aversion a. We further assume F_{ε_i}, F_{y_t} to be normal distributions truncated at $[\varepsilon_{i,\min}, \varepsilon_{i,\max}]$ and $[0, y_{\max}]$, respectively. Using the result of Norgaard and Killeen (1980), Eq. (5) becomes

$$
EU(-P, \beta_i) = -\exp\left(-a\mu_i + \frac{a^2\sigma_i^2}{2}\right)\phi_{\varepsilon_i}
$$

$$
\left\{\exp\left(-ay_c + a\mu + aP + \frac{a^2(1-2\beta_i)\sigma^2}{2}\right)\phi_1 + \exp(aP)\phi_2\right\}\exp(\frac{a^2\sigma^2\beta_i^2}{2}),
\tag{13}
$$

where

$$
\phi(x_{\min}, x_{\max}, \mu, \sigma) = \frac{\Phi\{a(\frac{x_{\max}-\mu}{\sigma}+\sigma)\}-\Phi\{a(\frac{x_{\min}-\mu}{\sigma}+\sigma)\}}{\Phi\{\frac{x_{\max}-\mu}{\sigma}\}-\Phi\{\frac{x_{\min}-\mu}{\sigma}\}},
\tag{14}
$$

$\Phi(\cdot)$ is standard normal CDF, $\phi_{\varepsilon_i} = \phi(\varepsilon_{i,\min}, \varepsilon_{i,\max}, 0, \sigma_i)$, $\phi_1 = \phi(0, y_c, \mu, \sigma)$, and $\phi_2 = \phi(y_c, y_{\max}, \mu, \sigma)$. Similarly, Eq. (6) becomes

$$EU(0, \beta_i) = -\exp(\frac{a^2 \beta_i^2 \sigma^2}{2}) \phi_0 \exp(-a\mu_i + \frac{a^2 \sigma_i^2}{2}) \phi_{\varepsilon_i}, \tag{15}$$

where $\phi_0 = \phi(0, y_{\max}, \mu, \sigma)$.

In a first step, we examine a situation where only SY is available. Given $P \in \{P_{SY,1}, P_{SY,2}^u, P_{SY,2}^d\}$, a farmer chooses SY only if $EU(-P, \beta) \geq EU(0, \beta)$. Inserting Eq. (13) and (15), this inequality becomes:

$$\exp\{a\mu - ay_c + aP + \frac{a^2 \sigma^2(1 - 2\beta)}{2}\}\phi_1 + \exp\{aP\}\phi_2 \leq \phi_0.$$

Solving for β yields:

$$\beta \geq \frac{1}{a^2 \sigma^2}\{C - \log(\frac{1}{\exp(aP)} - \frac{\phi_2}{\phi_0})\}, \tag{16}$$

where $C = \log(\phi_1/\phi_0) + a\mu - ay_c + a^2 \sigma^2/2$. Thus the critical βs for farmers to choose SY at t_2 and t_1 are:

$$\beta^{SY,2,w} = \frac{1}{a^2 \sigma^2}\{C - \log(\frac{1}{\exp(aP_{SY,2}^w)} - \frac{\phi_2}{\phi_0})\}, \tag{17}$$

and

$$\beta^{SY,1} = \frac{1}{a^2 \sigma^2}\{C - \log(\frac{1}{\exp(aP_{SY,1})} - \frac{\phi_2}{\phi_0})\}, \text{ respectively.} \tag{18}$$

Note that a critical β exists only if

$$\frac{1}{\exp(aP)} - \frac{\phi_2}{\phi_0} > 0 \rightarrow P < \frac{1}{a}\log(\frac{\phi_0}{\phi_2}), \tag{19}$$

implying that insurance premium depends on risk reduction determined by $y_{\max}$ and y_c in the insurance program. The critical βs are monotonously increasing in P. Thus, $P_{SY,2}^d \leq P_{SY,1} \leq P_{SY,2}^u$ implies $\beta^{SY,2,d} \leq \beta^{SY,1} \leq \beta^{SY,2,u}$. Thresholds $\beta^{SY,1}$ and $\beta^{SY,2,w}$ divide farmers into insureds and non-insureds (see Table 1). Farmers with $\beta \geq \beta^{SY,2,u}$ buy SY regardless the uncertainty of $P_{SY,2}^w$. If $\beta^{SY,1} \leq \beta < \beta^{SY,2,u}$, farmers prefer SY at t_1, but at t_2 they buy SY only if the price decreases. Farmers falling in the range $\beta^{SY,2,d} \leq \beta < \beta^{SY,1}$ will by SY in case that $P = P_{SY,2}^d$ at t_2. Farmers with $\beta < \beta^{SY,2,d}$ will not buy insurance in either period.

Next, we investigate a situation where both SY and MY contracts are offered. As $P_{MY} \geq P_{SY,1}$, MY can only be attractive for farmers who would also buy SY at t_1. Thus, only farmers with $\beta \geq \beta^{SY,2,u}$ and $\beta^{SY,1} \leq \beta < \beta^{SY,2,u}$ will possibly choose MY.

Farmers with $\beta \geq \beta^{SY,2,u}$ prefer MY to SY only if

$$2U(-P_{MY}, \beta) \geq U(-P_{SY,1}, \beta) + qU(-P^u_{SY,2}, \beta) + (1-q)U(-P^d_{SY,2}, \beta). \tag{20}$$

Eq. (20) holds if

$$2\exp(aP_{MY}) \leq \exp(aP_{SY,1}) + q\exp(aP^u_{SY,2}) + (1-q)\exp(aP^d_{SY,2}), \tag{21}$$

Eq. (21) is fulfilled due to Eq. (4) and the convexity of an exponential function. Thus, farmers with $\beta \geq \beta^{SY,2,u}$ choose MY.

Farmers with $\beta^{SY,1} \leq \beta < \beta^{SY,2,u}$ prefer MY to SY/NI only if

$$2U(-P_{MY}, \beta) \geq U(-P_{SY,1}, \beta) + qU(0, \beta) + (1-q)U(-P^d_{SY,2}, \beta). \tag{22}$$

Analogously we obtain:

$$\beta \geq \frac{1}{a^2\sigma^2}\{C - \log(\frac{q}{C_1} - \frac{\phi_2}{\phi_0})\} \equiv \beta^{MY}, \tag{23}$$

where $C = \log(\phi_1/\phi_0) + a\mu - ay_c + a^2\sigma^2/2$ and $C_1 = 2\exp(aP_{MY}) - \exp(aP_{SY,1}) - (1-q)\exp(aP^d_{SY,2})$.

According to Eq. (23) farmers with $\beta^{MY} \leq \beta < \beta^{SY,2,u}$ choose MY whereas farmers with $\beta^{SY,1} \leq \beta < \beta^{MY}$ prefer SY at t_1; at t_2 they choose SY given that $P = P^d_{SY,2}$. Table 1 summarizes the optimal decision space as a function of the hedging effectiveness β. Note that farmers with $\beta \geq \beta^{MY}$ exchange SY for MY when it is offered. As a result, the total expected insurance participation increases because farmers with $\beta^{MY} \leq \beta < \beta^{SY,2,u}$ hold MY at t_2 ($w = u$) instead of NI.

Table 1: Thresholds for Farmers' Decision between MY, SY, and NI

Threshold	Only SY			SY and MY		
	t_1	t_2		t_1	t_2	
		$w = d$	$w = u$		$w = d$	$w = u$
$\beta \geq \beta^{SY,2,u}$	SY	SY	SY	MY	MY	MY
$\beta^{MY} \leq \beta < \beta^{SY,2,u}$	SY	SY	NI	MY	MY	**MY**
$\beta^{SY,1} \leq \beta < \beta^{MY}$				SY	SY	NI
$\beta^{SY,2,d} \leq \beta < \beta^{SY,1}$	NI	SY	NI	NI	SY	NI
$\beta < \beta^{SY,2,d}$	NI	NI	NI	NI	NI	NI

With the threshold values for β at hand, we can derive the expected total insurance demand A

without and with MY as follows:

$$
\begin{aligned}
A^{SY} &= 2n - \{F(\beta^{SY,1}) + qF(\beta^{SY,2,u}) + (1-q)F(\beta^{SY,2,d})\}, \\
A^{MY+SY} &= 2n - \{F(\beta^{SY,1}) + qF(\beta^{MY}) + (1-q)F(\beta^{SY,2,d})\}.
\end{aligned}
\tag{24}
$$

PROPOSITION 2.1 *(i) the expected total demand with MY and SY is greater or equal to that with only SY, i.e.* $A^{MY+SY} \geq A^{SY}$.

(ii) The variance of the total insurance demand over time with MY and SY is smaller or equal to that with only SY, i.e. $Var(A^{MY+SY}) \leq Var(A^{SY})$.

Proof. (i) We rewrite $A^{MY+SY} - A^{SY} = q\{F(\beta^{SY,2,u}) - F(\beta^{MY})\}$ via Eq. (24). Using Eq.(16) and (23) yields:

$$\beta^{MY} \leq \beta^{SY,2,u} \Leftrightarrow C_1 \leq q\exp(aP_{SY,2}^u)$$

$$\Leftrightarrow 2\exp(aP_{MY}) - \exp(aP_{SY,1}) - (1-q)\exp(aP_{SY,2}^d) \leq q\exp(aP_{SY,2}^u),$$

which holds under Eq.(21). Thus, $F_\beta(\beta^{MY}) \leq F_\beta(\beta^{SY,2,u})$ completes the proof.

(ii) Demand variances at t_2 are:

$$
\begin{aligned}
Var(A^{SY}) &= (q - q^2)\{F_\beta(\beta^{SY,2,u}) - F_\beta(\beta^{SY,2,d})\}^2 \\
Var(A^{MY+SY}) &= (q - q^2)\{F_\beta(\beta^{MY}) - F_\beta(\beta^{SY,2,d})\}^2
\end{aligned}
$$

and the assertion follows from $F_\beta(\beta^{MY}) \leq F_\beta(\beta^{SY,2,u})$.

We conclude that the introduction of MY can in fact increase and stabilize insurance participation provided that potential buyers of insurance are sufficiently heterogeneous.

3 Illustration for US Corn Producers

In this section, we illustrate how multi-year area yield insurances might perform for US corn producers. Due to the lack of individual farm data, we use county-level corn yield data and consider these as representative corn producers. Area yields refer to the state level.[7] The annual county and state yields (bushels per acre) between 1975-2012 are collected from 9 states, located in "Corn Belt". To calculate the income from corn production, we choose the prices ($ per bushels) in 2012 for each state. Price and yield data are made available by the USDA National Agricultural Statistical Service.

Coefficients β_i that measure the sensitivity of representative producers yield at county level to area yield at a state level is presented in Fig (2). The estimates of β_i are derived from the

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[7] In practice, area yields are usually measured at county levels, for example in the Group Risk Plan offered by the Risk Management Agency (Deng et al., 2007).

empirical distribution of county level corn yields[8]. In Fig.(2), representative farmers' βs vary from 0.2 to 2.3, but most values fall in the range between 1.3 and 1.9. Among 9 states, Nebraska and Kansas are most heterogeneous in terms of the β distribution. By contrast, Iowa is most homogeneous. Recalling the theoretical result from the previous section it is more likely to see a coexistence of SY and MY in the former states than in the latter.
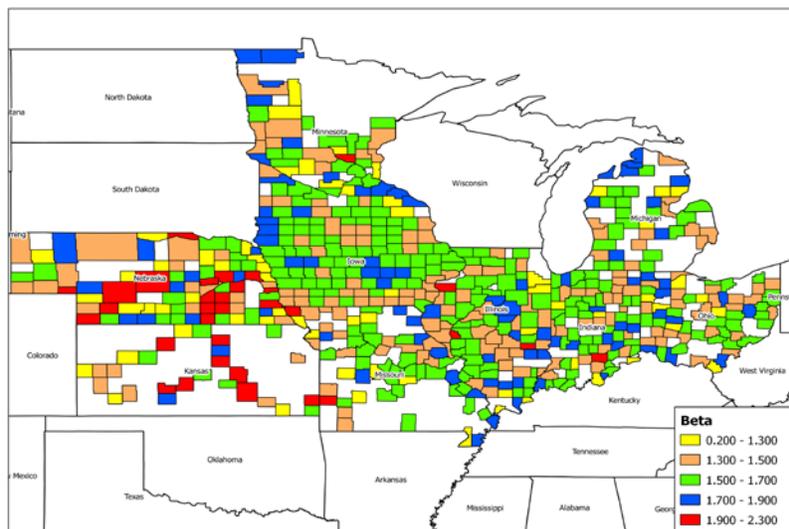
Figure 2: βs for Representative Farmers

The calculation of farmers' optimal insurance decision requires the specification of the absolute risk aversion a as well as parameters $\{r_t^w, q\}$ that determine insurance premiums for SY and MY. Following Kirkwood (1997) we assume average absolute risk aversion for all farmers in each state by $\frac{1}{0.1 \times (\text{Income}_{max} - \text{Income}_{min})}$. The strike value y_c is defined as the 30% quantile of y_t. The probability q of $w = u$ is assumed to be 0.5 as in Kleindorfer et al. (2012). The risk loading in the first period, r_1, is 0.1, which follows actual Group Risk Plan rating procedure in the U.S. (Deng et al., 2007). Finally, we assume that the insurance premiums in the second period either increase or decrease by 20%[9]. These specifications are the same for all considered states, however, the insurance premiums P_{SY} or P_{MY} and critical βs vary across states

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[8] It is well-known using county level data leads to biased estimates of farm-level variances and correlation (Coble et al., 2007). To mitigate the bias in β_i, we inflate standard deviations of county-level yields by a factor 1.67 and deflate the correlation between county yields and state yields by a factor 0.94These factors are borrowed from Coble et al. (2007) who report variances and correlations for corn at the farm level, county level and state level in the United States.

[9] The US Risk Management Agency, for example, adjusted premium rate for 2013, resulting in maximal 20 percent change (increase or decrease) in yield protection premium on average compared to 2012 (Risk Management Agency, 2012).

depending on the average corn yields of each state.

Fig.(3) depicts the representative farmers' decisions when only SY contracts are offered (left panel) and when SY and MY contracts are both offered in the market (right panel). Given the assumed risk aversion and risk loading, a rather low participation in (unsubsidized) SY can observed with the exception of Iowa and Minnesota. The results confirm that area yield insurance is more attractive in homogeneous regions, like Iowa. SY demands vary considerably between t_1 and t_2 due to the change in insurance premiums. Fig.(3d-3f) show that MY and SY coexist if both contract types are offered. Comparing the left and the right panel of Fig. 3 reveals that the main effect is a substitution of SY by MY contracts. Moreover, the number of uninsured farmers decreases. The increase of the total insurance participation, however, is rather moderate.

4 Conclusion

This paper investigates if farmers' participation in private, unsubsidized crop insurance can be increased by offering multi-year insurance contracts with stable insurance premiums in addition to single-year insurance contracts. By means of a dynamic choice model, we show that there is a demand for multi-year insurance and that both types of insurances co-exist. In contrast to previous studies this result is not based on a time diversification argument. Moreover, we show that the total expected insurance participation increases when both insurance contracts are offered to farmers, i.e., the introduction of multi-year insurance contracts enhances the market penetration of insurance products. It turned out that this effect is moderate when applying the model to US corn production. In practice, however, the increase of insurance demand could be more pronounced, because we did not consider marketing and administrative costs and thus ignore a cost reduction potential of multi-year insurance.
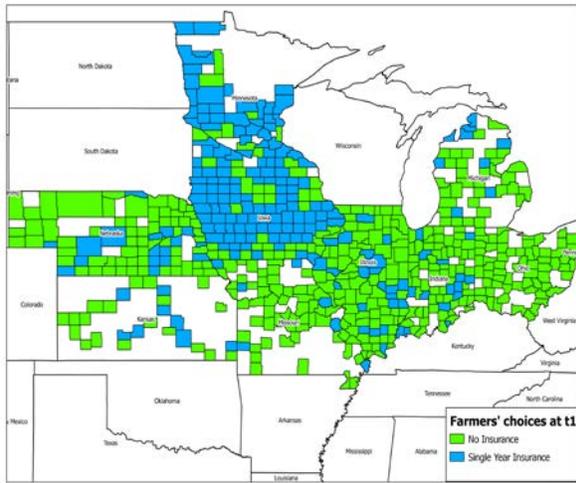
a:SY distribution at t_1
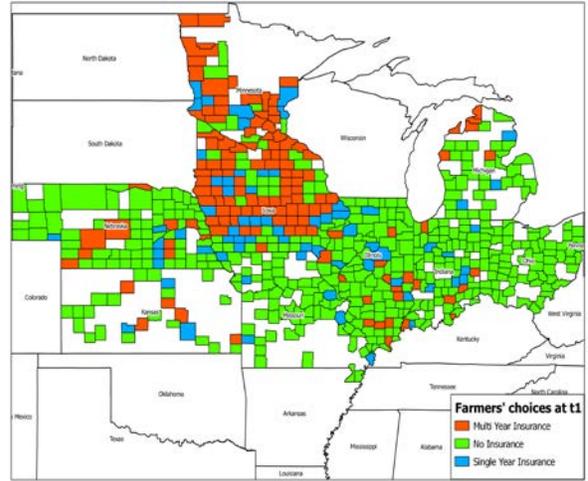
d:SY and MY distributions at t_1
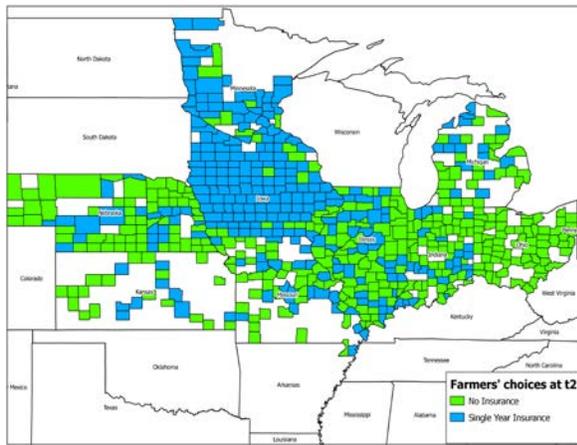
b: SY distribution at t_2 for $w = d$
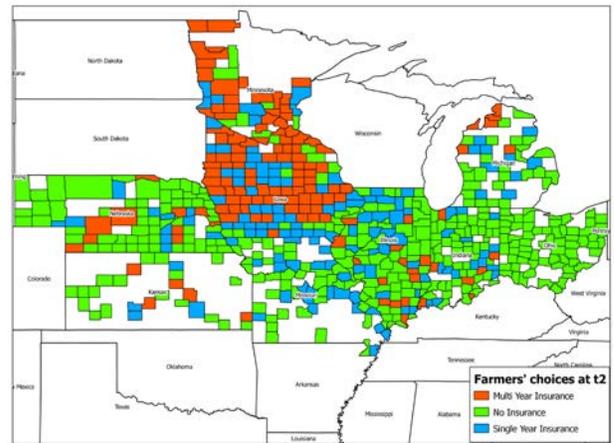
e:SY and MY distributions at t_2 for $w = d$
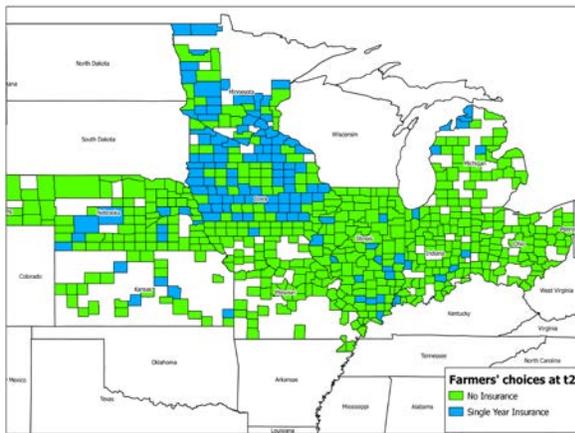
c:SY distribution at t_2 for $w = u$
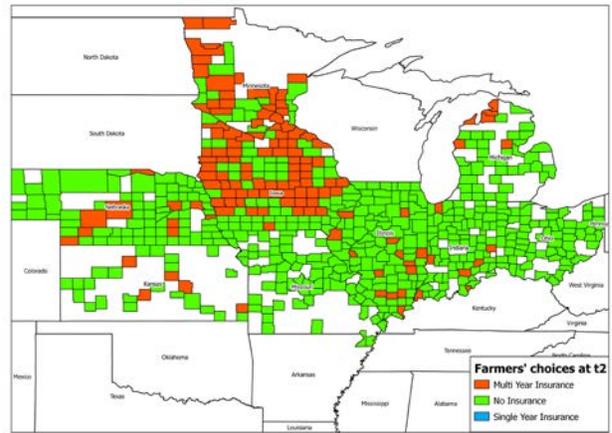
f:SY and MY distributions at t_2 for $w = u$

Figure 3: Farmers' optimal insurance choices

References

Chen, Y.-E. and Goodwin, B. K. 2010. The design of multiyear crop insurance contracts. Paper presented at American Agricultural and Applied Economics Association annual meeting, July 25-27.

Coble, K. H., Dismukes, R. and Thomas, S. E. 2007. Policy implications of crop yield and revenue variability at differing levels of disaggregation. Paper presented at the American Agricultural and Applied Economics Association annual meeting, July 29-August 1.

Deng, X., Barnett, B.J. and Vedenov, D.V. 2007. Is there a viable market for area-based crop insurance? Am. J. Agric. Econ, 89(2), 508-519.

Goodwin, B. K. and Smith, V. H. 2013. What harm is done by subsidizing crop insurance? Am. J. Agric. Econ 95(2), 489–497.

Kleindorfer, P., Kunreuther, H. and Ou-Yang, C. 2012. Single-year and multi-year insurance policies in a competitive market. J. Risk Uncertainty 45(1), 51–78.

Kirkwood, C. 1997. Notes on attitude toward risk taking and the exponential utility function, working paper, Arizona State University, Tempe, AZ, USA.

Kunreuther, H. and Michel-Kerjan, E. 2009. Managing catastrophes through insurance: Challenges and opportunities for reducing future risks. *working paper*. The Wharton School. Philadelphia

Mahul, O. 1999. Optimum area yield crop insurance. Am. J. Agric. Econ 81(1), 75–82.

Miranda, M. J. 1991. Area-yield crop insurance reconsidered. Am. J. Agric. Econ 73(2), 233–242.

Norgaard, R. and Killeen, T. 1980. Expected utility and the truncated normal distribution. Manag. Sci. 26(9), 901–909.

Risk Management Agency. 2012. Premium rate adjustment.

http://www.rma.usda.gov/news/2012/11 /2013premiumrateadjustment.pdf

Vedenov, D.V., and Barnett, B.J. 2004. Efficiency of weather derivatives as primary crop insurance instruments. J. Agric. Res. Econ. 29(3), 387-403.