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Rental arrangements and risk mitigation of crop insurance and marketing

Impacts in the Corn Belt

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Abstract

Purpose – This study seeks to evaluate the impacts of land rental arrangements on crop insurance and grain marketing decisions.

Design/methodology/approach – The analysis is conducted in an Illinois corn-soybean setting in which optimal marketing and crop insurance decisions are estimated for a risk-averse producer under typical cash rent and share rent agreements using numerical simulation methods.

Findings – Results indicate that the availability of crop insurance impacts the intensity of use of put options under both cash and share rent arrangements. Similar to previous work in this area, revenue insurance is found to cause a substitution away from marketing using put options, while yield insurance is complementary to price risk management alternatives. However, while insurance and marketing play a role under both types of land tenure arrangements, shifting from a cash rent to a share rent agreement provides a relatively greater degree of risk reduction.

Practical implications – The results suggest that additional research is needed to explain trends in land rental contracts. Crop insurance and other federal programs may provide incentives to switch from share leases to cash rent arrangements. Changes to the design of these programs could facilitate risk management for producers more efficiently.

Originality/value – The unique contribution of this study is the comparison of insurance and marketing decisions under both cash rent and share rent agreements for crop land.

Keywords Crops, Insurance, Land, Risk management, Marketing strategy, United States of America

Paper type Research paper

Much of the federal government's response to risk in agriculture has been to develop and rely on subsidized crop insurance. As instituted in the Federal Crop Insurance Act of 1980, crop insurance was intended to be a cornerstone of risk management and was intended to replace *ad hoc* programs as the principal means of providing disaster assistance to farmers. The agricultural economics literature has shown crop insurance to reduce the production and price risks faced by farmers in a variety of contexts (see e.g. Coble *et al.*, 2000, 2004; Barnett *et al.*, 2005; Schnitkey *et al.*, 2003; Deng *et al.*, 2008). Furthermore, crop insurance use has increased over time as subsidy levels have increased and new policy designs for a wider variety of crops have been introduced (Glauber and Collins, 2002). Program participation rates in Illinois, illustrated in Figure 1, have increased from around 55 percent of total planted acres being insured in 1997 to 76 percent in 2009. Similar increases in participation have been realized in other Corn Belt states (RMA, 2010).

Other factors, however, may be mitigating the advances made towards reducing income risk from the increase in use of crop insurance. One of the more apparent factors is the shift in land rental arrangements over time. Figure 1 reports the percentage of total tillable acres owned, cash-rented, and share-rented by operators cooperating in the Illinois Farm Business Farm Management (FBFM) association[1]. The proportion of land operated under a cash rent agreement has increased from

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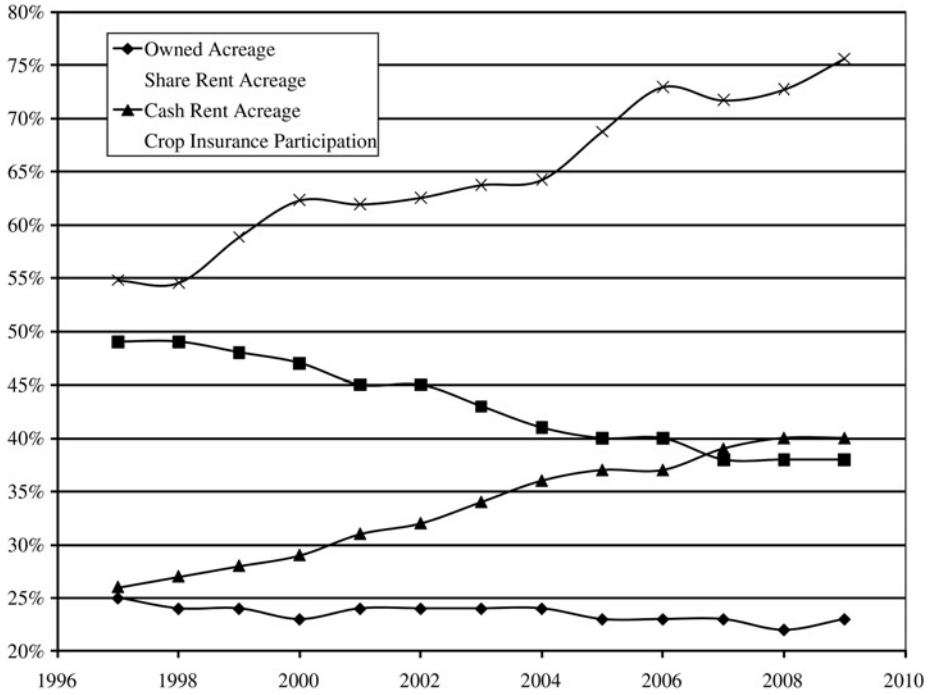

Sources: Illinois FBFM, USDA-RMA State Profiles, and USDA-NASS

Figure 1.
Owned, cash rented, and share rented tillable acres and crop insurance participation rates in Illinois (1997-2009)

26 percent in 1997 to 40 percent in 2009. In contrast, the proportion of share rented acres has declined from 49 percent in 1997 to 38 percent in 2009. Over the same time period, the proportion of land farmed directly by the owner has remained relatively steady within a range of 22-25 percent of total tillable acres.

Farmland rental arrangements are known to impact both the returns and risks associated with crop production. Share rent arrangements involve pre-specified allocations between tenants and landlords of the revenues, production costs, and resulting risks from agricultural production. In contrast, cash rent arrangements involve the tenant paying the landlord a fixed dollar amount regardless of production outcomes. Because cash rent payments do not vary with returns, cash rent arrangements are more risky to the tenant than share rental arrangements. As a result, the use of share rent arrangements is often cited as a highly effective method for farmers to more efficiently manage risks (Harwood *et al.*, 1996).

Moreover, land value and rental markets are often viewed as the residual market for the balancing of the relationship between risk and returns in agriculture. Previous work has linked a number of economic factors to adjustments in land values, cash rent levels, and the terms of share rent agreements. These factors include the characteristics of and opportunity costs associated with the land, commodity and input prices, government support and conservation programs, and various development pressures (Atwood *et al.*, 1996; Barry *et al.*, 2000; Du *et al.*, 2007; Featherstone and Baker, 1988; Goodwin and Ortalo-Magne, 1992; Huang *et al.*, 2006; Kirwan, 2009; Lence and Mishra, 2004; Patton *et al.*, 2008).

While the simultaneous increase in crop insurance participation and trends in land tenure may be related, Barry *et al.* (1998-99) cite several alternative reasons for the

movement towards cash rental arrangements. A primary factor from the landowner's perspective is the avoidance of risk sharing. Tenants may also find cash rental arrangements more appealing due to relatively simpler leasing specifications and the avoidance of shared management and marketing decisions.

There exists an extensive literature which evaluates the impacts that crop insurance has on acreage, input decisions, and other risk management activities (Horowitz and Lichtenberg, 1993; Babcock and Hennessy, 1996; Sherrick *et al.*, 2004; Smith and Goodwin, 1996; Wu, 1999). Several studies have specifically examined the relationship between crop insurance decisions and marketing activities (Wang *et al.*, 1998; Coble *et al.*, 2000, 2004). One of the consistent results from this literature is the increased use of forward and option contracts in the presence of yield insurance. Coble *et al.* (2000, 2004) extended the menu of insurance programs considered to include revenue policies, finding that optimal hedging activity declines in the presence of revenue coverage.

Conceptually, one could expect similar interactions between land rental agreements and marketing and crop insurance decisions. Since share rental arrangements implicitly include risk sharing between tenant and landlord, marketing and crop insurance as risk management alternatives may need to be used less intensively by producers who are primarily involved in share leases. Conversely, the use of crop insurance and marketing may increase with cash rent arrangements to achieve an equivalent level of risk reduction.

We expand on the existing literature in this area by characterizing the risk-return relationship among crop insurance, marketing decisions, and land tenure. A stylized modeling approach is adopted where crop insurance and marketing decisions are optimized under both cash and share rent agreements. Our results illustrate the difference in risk exposures resulting from cash and share rent agreements, even when crop insurance and marketing alternatives are available. Consistent with previous studies, we also find that yield (revenue) insurance and marketing are complements (substitutes). Furthermore, this result holds for both cash and share rent arrangements, although the intensity of marketing activities is lower under a share lease regardless of the type of insurance policy chosen by the producer.

Methods

Consider a producer who farms an acre of crop land owned by a landlord who leases the land to the farmer under either a crop share or cash rent arrangement. In any period t the land can be used to produce a range of potential crops i whose yields y_{it} and prices p_{it} are uncertain at the time marketing and crop insurance decisions are made. The proportion of land used to produce crop i in period t is given by $\alpha_{it} \geq 0$, where $\sum_i \alpha_{it} = 1$. Non-land production costs for crop i in year t are given by ϕ_{it}. The land rental agreement in period t is characterized by two parameters; λ_t denotes the farmer's share of revenue and production costs and τ_t denotes a fixed payment amount. The typical cash rent contract would be characterized by $(\lambda_t = 1, \tau_t > 0)$, while a standard share rent agreement would be given by $(0 < \lambda_t < 1, \tau_t = 0)$[2].

The producer is also assumed to have access to at-the-money (ATM) put options and a menu of crop-specific revenue and yield insurance policies to manage both price and production risk. Net option gains (i.e. option gains less the premium and associated interest, and option trading transaction costs[3]) are denoted by O_{it} and are a function of expected and realized prices and realizations, transactions costs, and the put ratio elected by the producer θ_{it}. Net insurance gains (i.e. insurance indemnities less premiums) for policy type j are denoted by I_{jit} and are a function of expected and

realized prices and yields and the coverage level elected by the producer C_{jit}.

$$O_{it} = O(\theta_{it}, y_{it}, p_{it}) = \theta_{it}\bar{y}_{it}\max[0, \bar{p}_{it} - p_{it}] - (1 + r_t)\upsilon_{it} - 100\frac{\theta_{it}\bar{y}_{it}}{5{,}000} \quad (1)$$

$$I_{jit} = I(C_{jit}, y_{it}, p_{it}) = \begin{array}{ll} \bar{p}_{it}\max[0, (C_{jit}\bar{y}_{it} - y_{it})] - \omega_{jit} & \text{for } j = yield \\ \max[0, C_{jit}\bar{p}_{it}\bar{y}_{it} - p_{it}y_{it}] - \omega_{jit} & \text{for } j = revenue \\ \max[0, C_{jit}\max[\bar{p}_{it}, p_{it}]\bar{y}_{it} - p_{it}y_{it}] - \omega_{jit} & \text{for } j = hro \end{array} \quad (2)$$

The set of choice variables for the farmer depends largely on timing. The approach used considers this problem during the time period immediately leading up to planting which, for corn and soybean production throughout the Midwest, would coincide with the months of February and March. At this time crop rotation, land tenure agreements, and a number of input decisions would largely be determined for the current crop year, while the farmer would be considering both marketing and crop insurance decisions.

The producer then maximizes the expected utility of profits with respect to marketing and crop insurance program and coverage level decisions, conditional on crop rotation, rental arrangement, and costs of production. The optimization problem is modeled in two steps, with the producer first choosing the optimal combination of marketing and insurance coverage level decisions across a menu of insurance programs and then choosing the expected utility maximizing insurance program,

$$\max_j \left\{ \max_{\theta_{it}, C_{jit}} \int U\left(\sum\nolimits_i \alpha_{it}\pi_{it}\right) dF_t(\boldsymbol{y}, \boldsymbol{p}) | j \right\} \quad (3)$$

where $\pi_{it} = \lambda_t(p_{it}y_{it} - \phi_{it}) - \tau_t + I_{jit} + O_{it}$ and $F_t(\boldsymbol{y}, \boldsymbol{p})$ denotes the period t joint cumulative distribution function of the vectors of random crop yields and prices. Insurance plan choices were limited to those most popular in Illinois for corn and soybean production, $j \in (yield, revenue, HRO)$, and coverage levels were restricted to those available for buy-up policies under those insurance plans, $C_{jit} \in (0.65, 0.7, 0.75, 0.8, 0.85)$.

The solution to the producer's conditional expected utility maximization problem is given by optimal put ratios and insurance program coverage levels for all crops produced. Analytical approaches to comparing the optimal mix of put options and crop insurance would require assumptions related to the joint distribution of prices and yields. Moreover, analytic results would be limited by the effects of truncation introduced by put options and insurance. As an alternative, numerical simulation methods using 10,000 iterations for random yields and prices were applied to stylized cases tailored to crop production in the Corn Belt.

Yield and price distributions

Following Schnitkey *et al.* (2003), crop yields were assumed to follow Weibull distributions. Yield distribution parameters were calibrated to farm level data from the Illinois Farm Business Farm Management (FBFM) database from 1972 through 2006. To reflect a typical high productivity central Illinois farm, corn, and soybean yields from farms located in Logan county were detrended to 2008 levels using linear regression techniques. Weibull distribution parameters were then fit to the detrended yields using a simple method-of-moments approach. The procedure yielded Weibull distribution parameters which map directly to expected yield levels (standard deviations) of 180 (27)

and 51 (7) bushels per acre for corn and soybeans, respectively[4]. The process for recovering yield parameters has been used extensively in past crop insurance evaluations including the University of Illinois *iFarm* model (see url: www.farmdoc.illinois.edu/cropins/index.asp) and are further reported in Schnitkey *et al.* (2003).

Corn and soybean prices were assumed to follow lognormal distributions which were parameterized to the corn and soybean harvest futures and options contracts traded on the Chicago Board of Trade (CBOT) during the month of February 2008. Expected price levels were set equal to the price guarantee levels established by the risk management agency for revenue insurance policies for each crop. These guarantees are the simple average of settlement prices for the harvest futures contracts in the month of February.

Price volatilities were based on the average implied option volatilities for the harvest futures contracts during February 2008. Daily implied volatilities were computed based on daily settlement prices for each actively traded put and call option strikes on the harvest futures contracts. The parameters of a lognormal distribution are fully characterized by its mean and volatility. Using the daily settlement price as the mean of the lognormal price distribution, the price volatility was set equal to the value that minimized the sum of squared deviations between the implied and actual option premia. Implied option premia were calculated as the fair premium values implied by the corresponding lognormal distribution[5]. The parameterization of the price distributions is provided in Table I.

Imposing correlation

Correlation among the random yields and prices was imposed using the method originally outlined by Iman and Conover (1982). The method lends itself well to analyses which include multiple correlated risks as it is transparent and easy to implement. Given a positive definite target correlation matrix D, there exists a lower triangular matrix T, where $TT' = D$. The product of any random matrix (X), whose columns are independent, and the transpose of the transformation matrix results in a matrix XT' whose columns have the desired rank correlation matrix D. As long as the dimensions of X match that of the random processes being modeled (i.e. yields and prices), the rank ordering of X can be applied to the random draws from the desired marginal distributions to impose the desired rank correlation structure. In summary, the independent marginal distributions are simply re-sorted based on the Cholesky decomposition T of the target rank correlation matrix D. Since the Iman and Conover method is based on Spearman rank, rather than simple Pearson correlation, it is more

Parameter	Value
Corn production cost ($/acre)	$400
Soybean production cost ($/acre)	$230
Cash rent	$197
Corn basis ($/bu)	−$0.40
Soybean basis ($/bu)	−$0.80
Corn insurance price ($/bu)	$5.40
(annualized volatility)	(34%)
Soybean insurance price ($/bu)	$13.37
(annualized volatility)	(35%)

Sources: Illinois FBFM, USDA-AMS, and Chicago Board of Trade

Table I. Model parameter values

appropriate for use with skewed distributions such as those used to model crop yields and prices (Iman and Conover, 1982). This method has been used by other authors to examine the specification and rating of whole-farm insurance policies (Hart *et al.*, 2006) and gross margin index insurance for the ethanol industry (Paulson *et al.*, 2008).

Here the independent marginal distributions refer to the Weibull crop yields and lognormal prices. The imposed rank correlation matrix (D) is provided in Table II. The imposed correlation structure was based on the historical rank correlations among FBFM farms in Logan county Illinois and settlement prices for CBOT harvest futures contracts data from 1972 through 2006. The correlation values are also consistent with those used in the 2008 version of the *iFarm* model.

Net option gains and insurance indemnities

The distribution of ATM put option gains O_{it} was calculated for each crop using the corn and soybean price distributions; option premiums were set to actuarially fair levels equal to the average value of the option calculated over the 10,000 price draws. The insurance program options included a standard APH yield policy and revenue insurance analogous to the revenue assurance program. The revenue insurance policy was analyzed both with and without harvest price protection, or the harvest revenue option endorsement[6]. Distributions of net insurance gains I_{jit} were calculated using the correlated corn and soybean yield, price, and revenue distributions. The yield guarantee for the yield insurance policy was set equal to the product of the coverage level and expected yield (180 bu/acre), while revenue guarantees for the revenue insurance policies were set equal to the product of the coverage level, insurance price, and expected yield for each crop and year. Insurance premiums were set equal to their actuarially fair levels implied from the correlated yield and price draws.

Crop mix and production costs

To further focus the analysis on optimal marketing and insurance program decisions, we analyzed the case of a 55-45 corn-soybean rotation and limited the menu of land rental agreements to a standard fixed cash rent contract and a 50/50 share rental agreement. These represent the predominant crop mixes and share rent agreements employed by farmers and landlords in central Illinois (FBFM). Results were also generated for 80-20 and 20-80 corn-soybean crop mixes to characterize the effects of crop rotation choice.

Non-land production costs and cash rent levels were set equal to values based on springtime budgets produced by the University of Illinois for the 2008 crop year. These budgets are formulated based on the FBFM data, and capture averages for farms in central Illinois having high productivity farmland. Non-land costs include direct crop production costs (seed and chemicals), machinery and power, buildings, and labor.

	Corn yield	Soybean yield	Corn futures price	Soybean futures price
Corn yield	1			
Soybean yield	0.60	1		
Corn futures price	−0.52	−0.40	1	
Soybean futures price	−0.40	−0.45	0.60	1

Table II.
Imposed correlation structure

Note: Correlations based on historical relationships between farm yield in central IL and CBOT futures prices

Realized crop production was assumed to be marketed at a cash price set equal to the realized futures price plus a basis. The corn and soybean bases were set equal to the difference between cash grain bids for central Illinois during the first week of March 2008[7] and the insurance price guarantees used in the analysis. The production costs, cash rents, and basis values are provided in Table I.

Optimization and risk-return measures

A mean-variance approach with constant absolute risk aversion δ was used to model the farmer's utility function, $U(\pi) = E[\pi] - \delta/2Var[\pi]$. For each unique pairing of insurance policy and land rental agreement type, the insurance coverage levels and put option ratios for both corn and soybeans which maximized expected utility were computed using optimization procedures in *Matlab*. A scenario without crop insurance was also considered, where only the corn and soybean put ratios which maximized expected utility were computed. Results were generated for constant absolute risk aversion coefficients ranging from 0.0015 to 0.004. These parameter values were calibrated following Babcock *et al.* (1993), and correspond to risk premium levels ranging from 15 to 30 percent of expected profits for a farmer using a share rent agreement without put options or crop insurance.

For each scenario, expected profits, the standard deviation of profits, and the 5 and 10 percent conditional values-at-risk (*cVaR*) were calculated and reported to provide comparisons of expected returns and risk exposures. The *cVaR*s provide measures of downside risk across the scenarios, and are of particular importance as much of the political justification for crop insurance and disaster programs is to protect farmers from particularly severe outcomes.

Results

The optimal mix of put option ratios and insurance coverage levels for a farmer with a coefficient of absolute risk aversion equal to 0.003 are reported for each of the three insurance programs considered and for both cash and share rental agreements in Table III[8]. The baseline scenarios summarize the profit distribution faced by the producer in the absence of marketing and insurance mechanisms. The standard deviation of profits under the share rent agreement is \$98.65, which is 50 percent lower than the \$197.31 standard deviation associated with the cash rent agreement. Under the share rent arrangement baseline, the 10 and 5 percent *cVaRs* of the profit distribution are \$74.80 and \$54.78, respectively. The *cVaR* values for the baseline cash

	Baseline		Yield insurance		Revenue insurance		Revenue-HRO insurance	
	Cash rent	Share rent	Cash rent	Share rent	Cash rent	Share rent	Cash rent	Share rent
Corn put ratio (%)	–	–	81	15	34	0	43	0
Soybean put ratio (%)	–	–	108	28	55	0	63	0
Insurance coverage (%)	–	–	85	85	85	85	85	85
Expected profit	\$248.99	\$223.00	\$205.23	\$209.09	\$213.45	\$213.36	\$210.89	\$212.36
Std of profit	\$197.31	\$98.65	\$134.49	\$82.88	\$136.44	\$80.16	\$138.80	\$84.21
10% cVaR	(\$47.40)	\$74.80	\$71.96	\$110.65	\$103.09	\$146.93	\$98.39	\$140.93
5% cVaR	(\$87.45)	\$54.78	\$58.25	\$98.75	\$91.68	\$145.48	\$86.72	\$139.47

Table III. Optimal marketing and insurance decisions, and profit distribution summary statistics (\$/acre)

rent scenarios are considerable lower (−$47.40 and −$87.45). Comparison of these risk measures illustrates the greater risk exposure faced under a cash rent agreement.

Next, a scenario with put options but no crop insurance is reported. For the cash rent contract, the farmer would choose to buy put options covering 73 (106) percent of their expected corn (soybean) yield. The standard deviation of profit is reduced by 28 percent, while the 10 (5) percent *cVaR* is increased by $85.94 ($91.50) relative to the baseline. For the case of the share rent agreement, the farmer would choose to purchase put options for just 11 (25) percent of their expected corn (soybean) production. Compared to the baseline share rent case, the standard deviation of profits is reduced by 12 and the 10 (5) percent *cVaR* is increased by $25.32 ($30.32). The amount of additional risk reduction achieved by purchasing put options is relatively lower for the share rent agreement as compared to the cash rent agreement. For both types of land rent contracts, expected profits are reduced when put options are introduced due to transactions costs.

The introduction of insurance products continues to reduce risk for both share rent and cash rent arrangements. Because insurance premiums were set equal to their actuarially fair values, the producer chooses the maximum coverage level available of 85 percent. The standard revenue insurance policy, along with put options, provides the highest level of risk reduction as measured by the standard deviation and *cVaR*s of the profit distributions. Under the cash rent arrangement, for example, the 10 percent *cVaR* increases from the baseline level of −$47.40 to $103.09 with revenue insurance and put options. Under the share rent arrangement, the 10 percent *cVaR* increases from $74.70 to $146.93. Similar to the case with option but not insurance, the additional risk reduction achieved by the introduction of insurance is greater for cash rent contracts than for share rent agreements.

Insurance and put options

A producer who purchases yield insurance will buy put options covering greater shares of their expected production of both corn and soybeans compared to the scenario where insurance is not available. This holds for both cash and share rent contracts. In contrast, producers who purchase some form of revenue insurance will buy put options covering smaller shares of their expected corn and soybean production. In fact, for share rent contracts, the producer will not buy any amount of put options for corn or soybeans.

Figure 2 illustrates the effect of insurance coverage levels on the optimal put ratio for corn, conditional on a given coverage level (optimal soybean put ratios follow a similar pattern). The results for the cash rent scenarios follow those reported by Coble *et al.* (2000) in that revenue insurance acts as a substitute for marketing with put options while yield insurance creates a complementary effect with put option use. Both the complementary effect on put option use associated with yield insurance and the substitution effect associated with revenue coverage have intuitive explanations. The use of options to reduce price risk leaves the producer exposed to production risk. However, the presence of yield insurance reduces production risk, allowing the producer to market their crop more aggressively. Alternatively, revenue insurance provides protection for both price and yield risk, rendering price risk management through marketing relatively less effective.

Marketing decisions begin to be affected at insurance coverage levels above 50 percent, with the scale of the effect being exacerbated as the coverage level is further increased. The preferred put option ratio is just over 70 percent of expected production

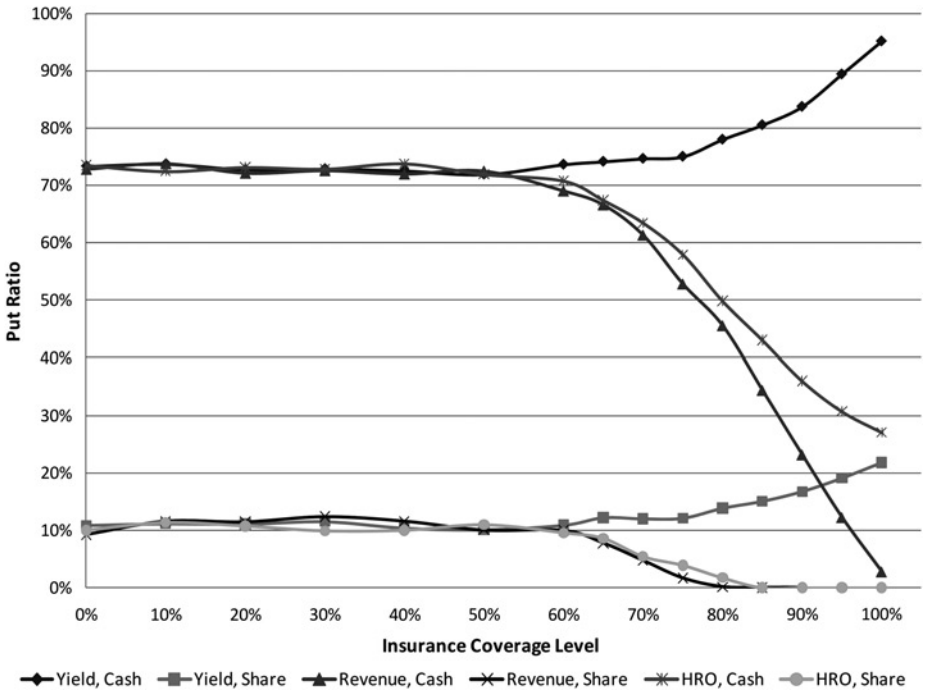

Figure 2.
Optimal corn put ratios for different insurance programs and coverage level

for all three types of insurance at coverage levels below 50 percent. At low coverage levels, the risk-reducing impact of the insurance contracts is low relative to the risk gains achieved through the purchase of put options. Above the 50 percent coverage level, preferred put option ratios with yield (revenue) insurance begin to increase (decline). At higher coverage levels the insurance contract takes the primary role in risk mitigation. Note that the substitution away from the use of options is estimated to occur at coverage levels currently available through federal programs.

A similar relationship between insurance coverage level and optimal put ratios is also observed for the share rent contract. Under a share rent agreement, revenue insurance also acts as a substitute while yield insurance is complementary to put option use. However, the change in intensity of put option utilization is significantly lower under share rent compared to a cash rent agreement. The optimal put ratio with yield (revenue) insurance increases (declines) by about ten percentage points for a producer who has a share rent arrangement. Put ratios with yield insurance increase by more than 20 percentage points as the insurance coverage level is increased to full coverage when a cash rent contract is used, and put ratios with revenue insurance decline by more than 45 percent as the policy approaches full coverage.

Insurance and rental arrangements

The introduction of insurance also narrows the gap between the risk exposures resulting from the cash rent and share rent arrangements. In other words, the relative risk "gains" (i.e. reductions in variability and/or downside risk) in moving from a cash rent to a share rent arrangement are reduced when insurance and marketing options are made available to the producer. In the baseline scenario, the 10 percent *cVaR* for the share rent contract is

$122.20 greater than the same measure of the profit distribution under the cash rent arrangement. The difference between share and cash rent *cVaR*s narrows to $43.38 when the producer buys standard revenue insurance and put options. The standard deviation of share rent profits is 41 percent lower than the cash rent profits when revenue insurance and put options are used, compared with a full 50% percent difference between the standard deviation of share and cash rent profits in the baseline case.

The four panels provided in Figure 3 further illustrate this finding, where the profit distributions and cumulative density curves for the cash and share rent scenarios are shown for each insurance program. When insurance and marketing are not available, or not utilized by the farmer (upper left panel of Figure 2), the spread of the profit distribution under cash rent is noticeably wider than under share rent. The introduction of insurance and put options reduces the risk gains in moving from cash to share rent, as illustrated by the relative spreads in the profit distributions reported in the remaining panels of Figure 2.

A comparison between the share rent profit distributions in the no insurance scenario to the cash rent scenarios which include insurance coverage reveals some interesting insights. The share rent scenario results in a smaller standard deviation of profit ($86.59) than any of the cash rent scenarios with insurance ($134.49-$138.80). However, the cVaRs of the cash rent profit distributions with the revenue insurance policies are greater than those for the share rent distribution without insurance. This indicates that while the introduction of revenue insurance cannot fully offset increases in risk associated with a shift from a share rent to cash rent contract, the risk exposures are comparable.

Different crop mixes and risk aversion levels

Results for alternative crop mixes and risk aversion levels were also generated to examine the robustness of our findings. Crop mixes that included 80 and 20 percent corn were both found to provide qualitatively similar results. The main difference noticed across the crop mix scenarios was that of the relative shares of expected production covered by put options. For example, the crop mix with 80 percent corn resulted in larger (smaller) put option ratios for corn (soybeans) relative to the 55 percent corn scenario reported above. The opposite result was found for the 20 percent corn crop mix. These results are not surprising; the farmer shifts price risk management activity towards the more dominant crop in their rotation.

The effects of changing the level of risk aversion were also as expected. More risk-averse producers choose to purchase put options for a relatively greater share of expected production for both crops than farmers who are less risk averse. This was found to occur for all three insurance policy types considered, and also across all coverage levels. For example, reducing the coefficient of absolute risk aversion to 0.0015 reduces the optional corn (soybean) put ratio to 22 (52) percent in the case of no insurance and a cash rent contract for the 55-45 crop mix. For the scenario with standard revenue insurance the optimal put ratios decline to zero with a cash rent contract.

Discussion

A striking feature of the above results is the illustration of the relative levels of risk protection offered to farmers under share rent vs cash rent arrangements. Although the gap between cash and share rent risk exposures declines, this relationship holds true even when crop insurance and put options are made available to producers. A related result is the comparable risk exposures resulting from share rent contracts with insurance to cash rent contracts with revenue insurance.

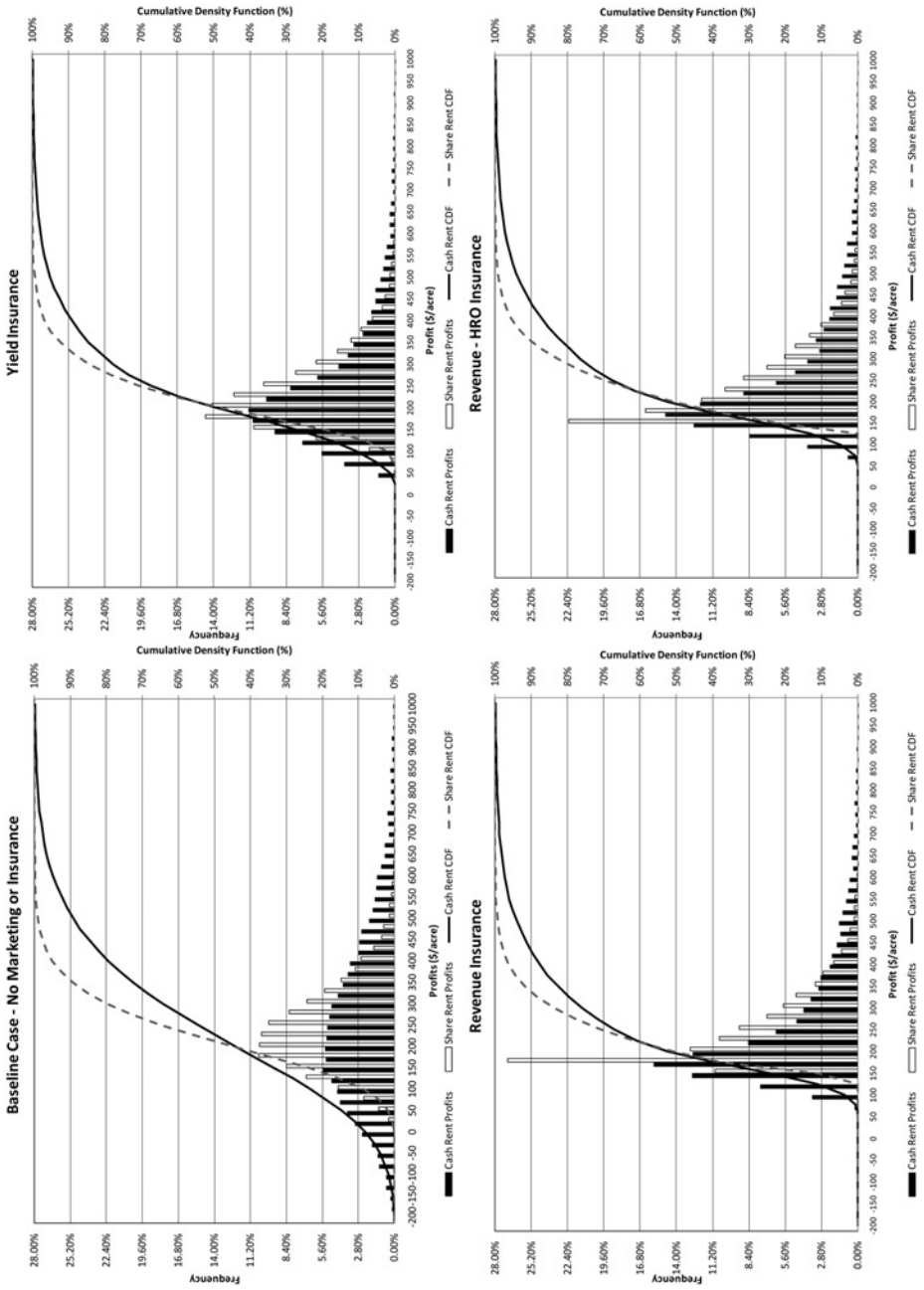

Figure 3.
Share and cash rent profit distributions for the baseline scenario, and with optimal marketing and insurance decisions with yield, revenue, and revenue-HRO insurance plans

As noted above, land tenure in Illinois has been trending away from share rental agreements to cash rent contracts. Over the same time period, crop insurance participation rates have been increasing through the Corn Belt. Recognizing the trend in crop insurance use without recognition of the trend in land tenure patterns may overstate

risk reductions that have occurred. The examination of producers' net risk positions, considering all of these factors, should be encouraged and emphasized in future work.

Furthermore, additional research is needed to investigate these land use trends and to determine their causes. For example, the potential for a causal relationship between increased crop insurance participation and the movement away from share rent arrangements would be an interesting topic to explore. If such a relationship is found to exist, considerations for alternative crop insurance program designs which provide incentives for share rent contracts may increase risk management opportunities for producers.

Additionally, the design of other existing federal support programs may be impacting land rental decisions. While it is doubtful that any program has the intent of encouraging a specific type of land rent agreement, there are some policies that may in fact cause landlords to favor cash rent arrangements. Currently, the farm service agency requires that commodity payments be split between landlords and tenants under share or variable cash rent arrangements. Cash rent arrangements do not require the landlord to be involved with administrative activities associated with commodity program payments. In addition to any administrative burdens, income limitations for receiving commodity program payments may impact some landlords, potentially incentivizing a shift from share to cash leases to avoid these payment limitations.

Finally, our results indicate that the impact of the availability of crop insurance on marketing decisions presents a potential public policy concern. As previously noted, revenue insurance programs are preferred by the majority of producers who purchase crop insurance coverage. Our results and previous work by other authors indicates a substitution effect between revenue insurance and marketing alternatives used for price risk management. Thus, subsidized crop insurance may be creating a crowd-out effect on other private, unsubsidized risk management alternatives. As producers implement risk-balancing strategies, shifts away from price risk management activities towards crop insurance results in subsidy costs borne by taxpayers.

Conclusions

Optimal marketing and crop insurance decisions were derived for a central Illinois high productivity farmland setting under share rent and cash rent arrangements, with yield and price distributions being parameterized to the 2008 crop year. The results illustrate the potentially large difference between risk exposures of producers under cash and share rent agreements. Consistent with previous work (Coble *et al.*, 2000), this study finds that the availability of revenue insurance may cause substitution away from marketing through put options while yield insurance increases the intensity of price risk management. Yield insurance provides production risk coverage, allowing the producer to be more aggressive in their marketing strategies. Revenue insurance protects against both price and production risk, reducing the relative effectiveness of marketing alternatives to manage the price risk faced by the producer.

The additional contribution of these results lies in the examination of the interactions between land rental agreements and marketing and crop insurance decisions. Share leases provide a significant amount of risk reduction relative to cash rent agreements. Crop insurance and put options continue to play a role in terms of risk management even under a share lease. However, the marginal reduction in risk offered by crop insurance and price risk management under a share lease are significantly lower. Because crop insurance is fairly priced, the risk-averse producer will continue to purchase the maximum coverage level. Due to transactions costs, the extent to which

put options are purchased in the presence of crop insurance under a share lease arrangement is much lower than in the case of a cash rent contract.

The substitution and complementary effects of revenue and yield insurance, respectively, are still present under a share lease, but are also smaller in magnitude. Additionally, these findings indicate that these effects begin to be relevant over the range of insurance coverage levels currently available under federal programs, indicating that there may be a crowd-out effect caused by the availability of revenue insurance.

Give the significant impacts of land rental agreements on producer risk exposures reported in this study, additional research efforts are needed to explain the recent trends in land tenure relationships. Future studies examining whether subsidized crop insurance has contributed to the apparent shift from share to cash rent leases would be particularly interesting. If crop insurance or other federal programs are found to encourage this shift away from share rental arrangements, a reconsideration of their design may lead to efficiency gains in the provision of risk management alternatives available to agricultural producers.

Notes

1. The Illinois FBFM association is a cooperative service program assisting farmers with management decision making and is comprised of more than 6,000 cooperating farmer members.
2. The notation could be further generalized to capture variable cash leases if the fixed payment amount was modeled as a function of price and/or yield realizations, i.e. $\tau_t = \tau(y_t, p_t)$.
3. Transaction costs include a round-turn fee of $100 per option contract (5,000 bushels) and a 7 percent annual interest rate charged on the option premium from the time of purchase until the option's maturity.
4. By fixing the parameters of the yield distribution we are implicitly assuming that there is no moral hazard effect from the introduction of insurance. Previous work on moral hazard and crop insurance as it pertains to input use (and the resulting effects on crop yield distributions) has produced mixed results (Babcock and Hennessy, 1996; Horowitz and Lichtenberg, 1993; Quiggin *et al.*, 1993; Smith and Goodwin, 1996). In a more recent study, Roberts *et al.* (2006) find little to no evidence of moral hazard among insured producers.
5. This procedure is similar to that used in Sherrick *et al.* (1996). However, they solved for both of the lognormal distribution parameters simultaneously, conditional on the daily settlements for the menu of options contracts. Here, we solve for the implied volatility conditional on both the menu of options contracts and the daily futures settlement price.
6. According to summary of business statistics maintained by the risk management agency (www.rma.usda.gov), 57 percent of the corn acres insured in Illinois in 2007 were insured using crop revenue coverage or revenue assurance. Actual production history insurance had a 11 percent share and group risk income plan had a 30 percent share. Revenue policy options comprised 89 percent of the total liability in Illinois in 2007. Choosing revenue assurance as the product to model replicates most policies purchased in Illinois.
7. Cash grain bids for central Illinois were obtained from USDA Ag Marketing Service reports through the farmdoc website at: www.farmdoc.illinois.edu/weatherprices/index.asp
8. The coefficient of absolute risk aversion was calibrated such that the farmer's risk premium was 25 percent of expected profits without marketing or insurance mechanisms following the recommendations of Babcock *et al.* (1993).

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