Received: 17 October 2020 | Accepted: 6 December 2021

DOI: 10.1002/aepp.13223

SUBMITTED ARTICLE

The impact of crop insurance on farm financial outcomes

Nathan D. DeLay[1] | Brady Brewer[1] | Allen Featherstone[2] | David Boussios[3]

[1]Department of Agricultural Economics, Purdue University, West Lafayette, Indiana, USA

[2]Department of Agricultural Economics, Kansas State University, Manhattan, Kansas, USA

[3]US Department of Agriculture, Office of the Chief Economist, Washington, D.C., USA

Correspondence
Nathan D. DeLay, 403 W. State Street, West Lafayette, IN 47907, USA.
Email: ndelay@purdue.edu

Funding information
National Institute of Food and Agriculture, U.S. Department of Agriculture, Grant/Award Number: 1019254; Purdue Center for Commercial Agriculture

Editor in charge: Mindy Mallory

Abstract

We use data from the Kansas Farm Management Association to estimate the impact of crop insurance liability and insurance indemnities on farm debt. Subsidized crop insurance may increase farms' financial risk through a mechanism known as "risk balancing." Previous findings in support of risk balancing may suffer from bias due to unobservable farm characteristics and simultaneity in insurance and debt decisions. Employing a simultaneous equations model with farm fixed effects, we find no statistical relationship between crop insurance liability and debt, calling into question the risk balancing hypothesis in federal crop insurance. We show that large insurance indemnity payments reduce farms' reliance on short-term debt, but leave the total debt level unchanged.

KEYWORDS

crop insurance, farm debt, risk balancing

JEL CLASSIFICATION

Q14, Q18

Over 300 million acres of cropland are insured each year by the U.S. federal crop insurance program, covering $100 billion of liability. Though both farmers and the government contribute to the cost of crop insurance, the government pays the largest share, covering roughly 60% of premiums, or $6 billion annually. While farming is generally recognized as a risky endeavor due to uncertain weather, pests, and prices, the impacts of insuring those risks on farm financial well-being are less well-known.

While research has analyzed the impact of the federal crop insurance program on everything from enrollment decisions (Babcock, 2015; Du et al., 2017; Serra et al., 2003; Sherrick et al., 2004; Smith & Goodwin, 1996) to land allocation decisions (Goodwin et al., 2004; Wu, 1999; Yu et al., 2018), few have examined the program's effects on farms' financial health. The relative lack of attention may be due to several factors, including the inherent simultaneity between debt and crop insurance decisions. Many lenders require crop insurance to obtain a production loan. Farms that are more indebted may carry higher crop insurance coverage due to their greater financial risk (FR) exposure. Similarly, farms with more comprehensive insurance may be more leveraged for reasons unrelated to their crop insurance decisions (e.g., capital structure, farm size, operator demographics). This simultaneity makes it difficult to obtain empirical estimates of the impact of crop insurance on debt and may potentially bias research that does not account for simultaneity. Given its current size and scope, important questions remain regarding the impact of the federal crop insurance program on farmers' finances.

Crop insurance lowers a farm's risk by reducing business risk (BR),[1] relieving credit constraints, and improving farm liquidity through indemnity payments. Seminal work by Gabriel and Baker (1980), Collins (1985), and Featherstone et al. (1988) provide the theoretical basis for how subsidized crop insurance can increase the overall risk exposure of the farm through risk balancing. This may be counterproductive to the purpose of federal crop insurance if the increased debt load raises the FR of the farm more than it lowers its BR.[2] Little is known about the dynamic effects of risk balancing behavior and the occurrence of realized crop insurance indemnities. A similar concept to risk balancing is the theory of risk homeostasis. This theory posits that each farmer has a target level of risk they find acceptable. If a farmer's overall level of risk falls below that threshold, they will adjust their behavior so that they achieve the targeted level of risk (Slovic & Fischhoff, 1982; Wilde, 1982). Thus, risk balancing is one mechanism through which farmers exhibit risk homeostasis, but implies a higher standard of causality between government policy and debt accumulation such that if there is an external policy that decreases one form of farm risk, they will achieve their targeted risk threshold by increasing risk elsewhere.

Understanding whether farmers exhibit risk balancing behavior and the magnitude of its effects on farm finances is important for policy makers. The U.S. government spends an average of $7.7 billion every year to deliver the crop insurance program, made up of premium subsidies, indemnity payments for losses, reimbursements to crop insurance companies for administrative and operating expenses, and underwriting losses shared with insurance companies. Public funding of the crop insurance program is justified on the basis that in its absence, insurance would be under-supplied in the market, leading to higher rates of farm failure and costly ad-hoc disaster relief borne by taxpayers. However, if the program does not decrease farms' overall risk, these resources would be better allocated elsewhere. Examining the link between crop insurance coverage and risk balancing behavior can help improve the program.

This research contributes to the literature in three ways. First, we update the literature on the link between crop insurance and debt using longitudinal data at the farm level. Most of the existing literature rely on cross-farm comparisons that cannot control for unobserved farm-specific differences. Second, we address potential simultaneity bias between the crop insurance coverage and debt decisions. This allows for the examination of how an external shock to insurance coverage impacts a farm's debt decision. Third, we empirically examine how crop insurance indemnity payments affect a farm's balance sheet in the presence of risk balancing behavior. Knowing how farmers fare over time after insured loss events—given their increased debt obligations—is useful in informing future policy for crop insurance and will help develop strategies for farmers and agricultural lenders.

THE ROLE OF CROP INSURANCE IN FARM FINANCIAL DECISIONS

Risk management plays a major role in the financial health of a farm. Given the degree of variability in net farm income, through both price and yield uncertainty, federal crop insurance has become the primary risk management tool among American farmers (Glauber, 2012). Pflueger and Barry (1985) argue that crop insurance may lead to improved liquidity positions for high-risk farms as crop insurance reduces BR enough to allow for a greater amount of credit to be made available to the farm. This behavior is supported by Lee and Djogo (1984), who show that crop insurance reduces loan losses for agricultural lenders. Kim et al. (2019) find that farms that use crop insurance survive an average of 7 years longer than farms that do not and reduce their probability of farm exit by about 70%. These findings demonstrate the positive effects of crop insurance on farm survival and BR, mainly by improving liquidity.

However, Ifft et al. (2015) find a positive relationship between federal crop insurance and short-term debt use and Ifft et al. (2013) show that farms that participate in federal crop insurance have higher credit default risk. This type of risk balancing behavior may be detrimental to farms as they are now more leveraged, less liquid, and have a higher probability of equity loss (Featherstone et al., 1988; Uzea et al., 2014). Agricultural lenders have long used crop insurance as a condition for loan approval, especially for short-term operating notes or uncollateralized production loans. But these results suggest that farmers would increase their financial leverage even without these loan covenants. Thus, as farmers reduce their BR using crop insurance, they may increase their FR.

Crop insurance indemnities mitigate fluctuations in farm business revenue. Positive and negative effects of this income-smoothing on farm survivability, risk-management, and profitability and have been demonstrated throughout the literature (Du et al., 2015; Kim et al., 2019; Kirwan, 2017), but its implications for farm debt have yet to be addressed. An insured farm that suffers a loss and receives an indemnity payment sees their liquidity improved, which could reduce debt if the payment exceeds the sum of lost revenue and out-of-pocket premium costs. Conversely, revenue generated from insurance claims may lead, all else equal, to greater debt use by raising expected income and reshaping the income distribution. This would have the unintended consequence of raising the farm's exposure to FR. In this paper, we explore both the ex-ante risk balancing effects and the ex-post income-smoothing effects of crop insurance on farm debt.

THEORETICAL FRAMEWORK

The risk balancing hypothesis derives from two foundational lines of research. The first is that of Gabriel and Baker (1980) who assume farms make decisions subject to an overall risk constraint. A farm's total risk level (TR) is equal to the sum of its BR—risk endemic to production, output prices, and input costs—and FR—the risk of insolvency arising from the use of debt.

$$\text{TR} = \frac{\sigma_\pi}{E[\pi]} + \frac{\sigma_\pi I}{E[\pi](E[\pi] - I)} \leq \beta. \tag{1}$$

The first term in Equation (1) represents BR where $E[\pi]$ is the expected value of net operating profit before interest expenses and σ_π is its standard deviation. An increase in production or price variability raises the BR of the farm while an increase in expected income will lower it. The farm's FR, captured by the second term in Equation (1), shows that as the farm incurs more debt, it increases the risk of insolvency due to higher interest payments I. Note that the degree of FR is proportional to the farm's underlying BR. That is, additional financial leverage has a larger impact on TR in a risky production environment.

Gabriel and Baker (1980) argue that TR is limited to some maximum acceptable level β. Actions that increase the farm's BR (e.g., adopting an untested production system) are balanced by efforts to reduce FR. Conversely, increasing the farm's debt burden, leading to an increase in FR, will offset actions that mitigate BR such as diversifying crops, using marketing contracts, or hedging with futures. This hypothesis has two implications. First, if the TR constraint in Equation (1) is binding, it means the farm manages its business and FR simultaneously to satisfy the TR constraint. This joint management is consistent with the more general behavioral theory of risk homeostasis proposed by Wilde (1982).

Second, it implies that exogenous changes that shrink the farm's exposure to one source of risk cause the farm to increase their exposure to the other. Government programs designed to reduce the risk inherent to farming (e.g., the Agriculture Risk Coverage program, the Price Loss Coverage program, or subsidized federal crop insurance) will reduce σ_π, while income-support programs such as direct payments raise $E[\pi]$. Both have the effect of lowering BR and creating slack in the TR constraint. This may encourage the farm to take on more debt, raising the likelihood of default or insolvency. It is this channel that is most commonly associated with the risk balancing hypothesis and has been of greatest interest to agricultural economists.

Another line of research, put forth by Collins (1985) and Featherstone et al. (1988), uses a mean–variance expected utility model to derive the optimal debt level. We adapt their approach to include the optimal crop insurance decision and analyze risk balancing in the context of the federal crop insurance program.[3] A representative, risk averse producer chooses the optimal amount of debt, D^*, and crop insurance liability, L^*, to maximize the expected utility of their rate of return on equity, R_E.[4] The DuPont Identity relates the rate of return on equity to the rate of return on assets after debt servicing and a measure of financial leverage as follows:

$$R_E \equiv \frac{R}{E} = \frac{\pi(r,c,L) - iD}{A - D}, \tag{2}$$

where R is the farm's net return from producing agricultural goods after debt servicing, E is the owner's equity in the farm enterprise, A represents the farm's total assets, and i is the expected interest rate for debt incurred by the farm. As before, π is pre-interest net operating profit which we assume to be a general function of farm revenue r, operating costs c, and the chosen level of crop insurance liability—the total dollar amount insured by the farm.[5] Due to variability in production and prices, r and c are random variables. More comprehensive crop insurance policies carry higher premiums but potentially higher indemnity payments in the event of a loss, making the partial effect of L on profit indeterminate.

Due to underlying risks in production, output prices, and input prices, return on equity is a random variable with mean $\overline{R}_E$ and variance σ_E^2 which are expressed as:

$$\overline{R}_E = \frac{E[\pi(r,c,L)] - iD}{A-D} = \frac{\pi(\overline{r},\overline{c},L) - iD}{A-D}, \tag{3}$$

$$\sigma_E^2 = \frac{\sigma_\pi^2(L)}{(A-D)^2}, \tag{4}$$

where σ_π^2 measures variability in the farm's profitability and is the primary source of the farm's BR. Note that σ_π^2 is decreasing in the choice of L, that is, a higher level of insurance liability effectively truncates the profit distribution from below while greater production variability widens it. FR—as captured by σ_E^2—is increasing in both BR and the amount of debt financing.

The producer maximizes the expected utility of return on equity according to a mean–variance tradeoff derived from the negative exponential utility function.

$$\max_{D,L} E[U(R_E)] = \frac{\pi(\overline{r},\overline{c},L) - iD}{A-D} - \frac{\alpha}{2}\frac{\sigma_\pi^2(L)}{(A-D)^2}, \tag{5}$$

where α represents the producer's absolute risk aversion coefficient. Taking the first order condition of (5) with respect to L and setting it to zero generates the following condition for the optimal crop insurance coverage choice:

$$\frac{\partial \pi(\overline{r},\overline{c},L)}{\partial L} = \frac{\alpha}{2}\left(\frac{1}{A-D}\right)\frac{\partial \sigma_\pi^2}{\partial L}, \tag{6}$$

which equates the change in expected nominal returns from insurance resulting from an increase in insurance liability to the producer's level of risk aversion, farm equity, debt choice, and the marginal reduction in BR due to an increase in coverage. If the producer is risk averse, the right side of Equation (6) is necessarily negative, meaning the producer will tolerate paying more for crop insurance than they receive in indemnities (in expectation) as long as the additional liability sufficiently reduces the variability of operating profit. We express the optimal crop insurance choice in general terms as:

$$L^* = L(\alpha,\overline{r},\overline{c},A,D). \tag{7}$$

Differentiating (5) with respect to D and setting to zero provides the optimal condition for debt accumulation.

$$\frac{\pi(\overline{r},\overline{c},L) - i(A-D) - iD}{(A-D)^2} - \frac{\alpha\sigma_\pi^2(L)}{(A-D)^3} = 0. \tag{8}$$

Rearranging Equation (8) to solve for the optimal debt decision as a function of parameters and the insurance liability choice produces the following equation:

$$D^* = D(\alpha, i, \bar{r}, \bar{c}, A, L) = A - \frac{\alpha \sigma_\pi^2(L)}{\pi(\bar{r}, \bar{c}, L) - iA}. \tag{9}$$

From Equation (9), equilibrium farm debt is negatively related to the risk aversion parameter, the fixed interest rate, and the variability in BR. An increase in expected business income—either by raising revenue or by lowering costs—raises the optimal amount of debt. For a given level of crop insurance liability insured, an increase in indemnity payments should have a positive effect on debt accumulation equal to that of an increase in regular farm revenue.

$$\frac{\partial D^*}{\partial \sigma_\pi^2(L)} = -\frac{\alpha}{\pi(\bar{r}, \bar{c}, L) - iA} < 0. \tag{10}$$

The standard risk balancing result is captured by Equation (10) which shows that an exogenous reduction in BR incurs an offsetting increase in the optimal choice of debt, exposing the farm to greater FR.[6] However, (10) ignores the sources of change in business variability and assumes participation in federal crop insurance is equivalent to an exogenous reduction in BR due to factors outside of the farmer's influence. In reality, farmers choose their optimal crop insurance liability and debt load jointly. Note that L and D are endogenous variables, appearing in both Equations (7) and (9). This complicates the empirical relationship between debt and insurance usage, which previous studies have not modeled. To test for risk balancing in federal crop insurance, a simultaneous equations model (SEM) is used that reflects the bi-directional relationship between insurance and debt. Moreover, the literature has yet to consider the income-smoothing effects of ex-post insurance indemnities on debt accumulation.

DATA

The primary data used in this study come from the Kansas Farm Management Association (KFMA) farm database. The KFMA offers accounting, tax assistance, benchmarking, and other financial management services to its members. The database contains farm-by-year production and financial information for a nonrandom sample of over 3,000 farm operations observed over multiple years.[7] We note that inclusion in the KFMA sample is not representative of farms within Kansas or across the country due to self-selection of farms into the association. Farms in the KFMA tend to have greater crop acreage, more assets, larger liabilities, and higher debt-to-asset ratios. The data include farm demographics, production practices, harvest outcomes, and farm financial indicators. The selection of relevant variables from the KFMA was informed by the variables shown in Equations (7) and (9) of the theoretical framework.

The KFMA dataset includes yearly crop insurance expenditures (total premiums paid) and revenue from crop insurance (indemnities).[8] Because producer-paid premium rates are influenced by several factors outside the farm's control (e.g., commodity prices, the actuarial risk of the area, government-determined subsidy rates), total premium expenditure is a poor measure of crop insurance choices. Instead, we impute the farm's crop insurance liability using data from USDA Risk Management Agency's (RMA) summary of business. The RMA data include the total premiums paid, government subsidies, and the total liability value insured annually for each county in Kansas. We use these totals to construct the county average subsidized premium rate—the percentage of each dollar insured that is paid by the farmer, net of government subsidies.

Given that the farm's reported crop insurance expenditure is the product of subsidized out-of-pocket premiums and insured liability, we compute the following:

$$\text{Prem Rate}_{c,t} = \frac{\text{Prem}_{c,t} - \text{Subsidy}_{c,t}}{\text{Liab}_{c,t}}, \tag{11}$$

$$\text{Liab}_{i,c,t} = \frac{\text{CI Exp}_{i,t}}{\text{Prem Rate}_{c,t}}, \tag{12}$$

where $\text{CI Exp}_{i,t}$ is farm i's total crop insurance expenditure for year t, $\text{Prem}_{c,t}$ is total premiums (including government-paid subsidies) collected in county c during the year t, and $\text{Subsidy}_{c,t}$ is all government subsidies for crop insurance premiums paid in county c in year t.

Financial indicators in the KFMA database include farm financial liabilities, farm assets, income, and expenditures recorded on an accrual accounting basis. Outstanding farm debt includes long-term liabilities—consisting mostly of debt for real-estate and capital equipment—and short-term, or "current," farm debt—consisting of debts used to finance current assets. End-of-year balances are used for the financial variables to capture all relevant changes that take place throughout the year.

A number of variables within the raw dataset may contain outliers. Visual inspection of the data leads us to discard observations in the top 2% of values for each of the primary variables used in our analysis. In addition, we restrict the sample to farms with at least 50 acres planted to crops and non-zero operating expenses and gross farm revenue to limit the influence of primary livestock operations (who may purchase little or no crop insurance but carry high levels of debt) as well as non-working or "hobby" farms. We are left with an un-balanced panel dataset that includes over 3000 different farm operations observed between 2002 and 2018 for a total of 17,958 observations. Each farm in the restricted dataset is observed an average of 5.8 times.[9]

Table 1 displays summary statistics for select variables. The average farm in the KFMA dataset has over \$179,000 in outstanding long-term debt and about \$102,500 in current (short-term) debt to cover year-to-year production expenses. Current (liquid) farm assets average about \$311,500 while fixed assets—as measured by the total value of owned land, buildings, equipment, and vehicles—average nearly \$889,000. The average farm debt-to-asset ratio of 28.04% suggests that the sample is more leveraged and less solvent than the national average for the time period (Key et al., 2019). Farms in the KFMA are also larger—total crop acres are about twice that of the average American farm—and report higher revenues and expenses. This reflects the fact that commercial-scale operations in Kansas are more likely to be members of the KFMA. Interpretation of the results should be kept in this context. We calculate effective interest rates for each farm-year by dividing member-reported interest expenses by total farm liabilities, which average 5.5%.

The estimated farm crop insurance liability averaged nearly \$161,000 while indemnities (payouts to insured farms) averaged over \$13,000 (Table 1). Farmers in the KFMA can expect crop insurance indemnities worth 14.9% of their insured liability on average (i.e., an average loss cost ratio of 0.149). This compares favorably to an average county-level premium rate of 14.3%. However, these averages mask a great deal of variation over time and ignore the fact that 39% of the sample observations report zero crop insurance indemnities. Extreme drought events

TABLE 1 Farm-level and regional summary statistics

Variable	Obs.	Mean	SD	Min	Max
Long-term farm debt	17,958	179,692	216,984	0	1,379,876
Current farm debt	17,958	102,495	150,851	0	1,082,592
Debt to asset ratio (%)	17,958	28.04	25.86	0	115.70
Interest rate (%)	17,958	5.51	2.78	0	19.97
CI total premium ($)	17,884	8837	9937	0	56,702
CI liability ($)	17,884	160,876	186,208	0	2,335,504
CI indemnity ($)	17,958	13,058	24,202	0	148,340
CI premium rate (%)[a]	17,884	5.66	1.47	1.90	12.06
Gross farm revenue ($)	17,958	407,208	348,360	4100	2,940,956
Off-farm income ($)	17,958	27,437	56,074	0	3,223,168
Farm operating expenses ($)	17,958	296,121	289,213	245	2,629,107
Total crop acres	17,958	1162	793	50	4000
Current farm assets ($)	17,958	311,529	278,774	0	2,121,593
Owned land value ($)	17,958	633,686	712,890	0	5,326,191
Buildings and structures value ($)	17,958	27,507	51,436	0	1,051,315
Equipment and machinery value ($)	17,958	84,487	85,003	0	1,077,571
Vehicles value ($)	17,958	143,193	142,986	0	1,636,053
Operator age	17,958	55.91	13.56	18	98

Note: Kansas Farm Management Association database 2002–2018. The sample is an un-balanced panel dataset of over 3000 individual farm operations observed annually for an average of 5.8 years.
Abbreviation: CI, crop insurance.
[a]Premium rate is the county average producer-paid premium rate per dollar of insured liability after the application of government subsidies.

in 2011 and 2012 triggered large-scale payments that skews the distribution of insurance payouts. At the median, indemnities are only 2% of crop insurance liabilities.

Figure 1 displays averages for long-term and short-term farm debt outstanding and farm-level crop insurance liabilities by year. Both long-term debt and crop insurance coverage are trending upward during the early part of the decade, though the rate of increase is more dramatic for crop insurance. This is likely the result of increased premium subsidies for high-coverage "buy-up" and revenue type policies brought on by the Agricultural Risk Protection Act (ARPA) of 2000. ARPA raised participation in federal crop insurance and increased demand for insurance liability. The trends in Figure 1 do not impart an obvious relationship between debt and insurance take-up. In the following section, we formally estimate the relationships between farm debt and crop insurance.

EMPIRICAL MODEL

Given the bi-directional relationships between debt and crop insurance coverage established in Equations (7) and (9) of the theoretical framework, we have the following simultaneous equations:

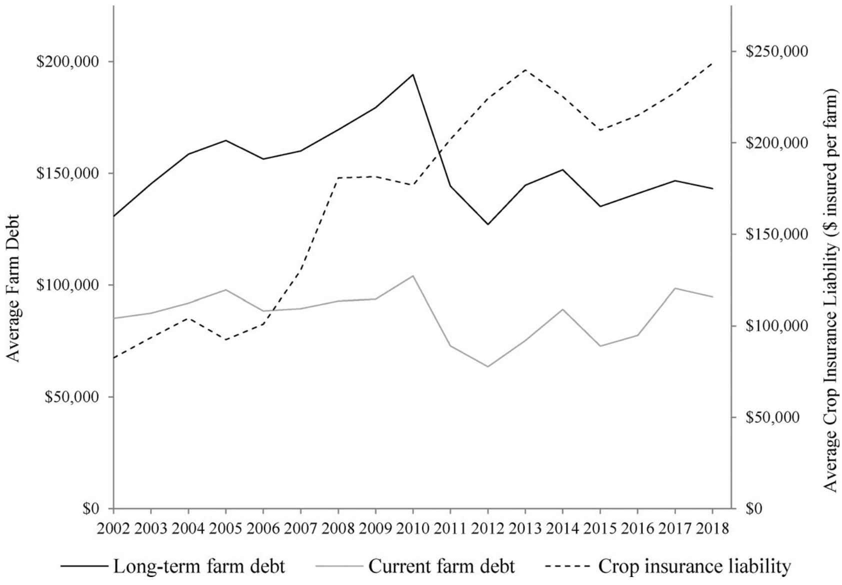

FIGURE 1 Kansas Farm Management Association total farm debt and crop insurance liability (2002–2018)

$$\text{Debt}_{i,t} = \mu_i + \tau_t + \beta_1 \text{Liab}_{i,t} + \beta_2 \text{Ind}_{i,t} + \beta_3 \text{Int Rate}_{i,t} + \mathbf{X}'_{i,t} \boldsymbol{\varphi} + v_{i,t}, \tag{13}$$

$$\text{Liab}_{i,t} = \delta_i + \lambda_t + \gamma_1 \text{Debt}_{i,t} + \gamma_2 \text{Prem Rate}_{i,t} + \mathbf{X}'_{i,t} \boldsymbol{\omega} + u_{i,t}, \tag{14}$$

where $\text{Debt}_{i,t}$ represents farm indebtedness in year t. We use two measures of farm solvency: long-term farm debt and current (short-term) farm debt outstanding for farm i recorded at the end of year t.[10] The variables Liab_{it} and Ind_{it} represent farm i's total crop insurance liability during year t (i.e., the amount the policy would pay out in the event of a total loss) and the total dollar amount of crop insurance indemnities received in year t, respectively.

The vector $\mathbf{X}_{i,t}$ contains the set of exogenous covariates common to both debt and insurance equations that vary across farms and over time. This include measures of farm income and costs (gross farm revenue, off-farm income, and non-crop insurance farm operating expenses); farm characteristics (total crop acreage, operator age, age squared, and the organizational structure of the farm business [e.g., corporation, sole proprietorship, etc.]); and farm assets (value of short-term liquid assets and long-term farm assets such as real estate, equipment and machinery, and vehicles).[11] The interest rate faced by the farm ($\text{Int Rate}_{i,t}$) is included in (13) to capture the cost of capital, which only affects debt and does not factor into crop insurance decisions. Similarly, the average crop insurance premium rate in farm i's county during year t ($\text{Prem Rate}_{i,t}$), affects the amount of insurance liability farm i elects but does not directly influence the farm's indebtedness.

All unobserved factors that affect farm balance sheets and insurance decisions uniformly in a given time period such as changes in government policy or large-scale production and price shocks are captured by the year fixed effects τ_t and λ_t. Unobserved farm characteristics that do not vary over time but that affect debt and crop insurance are controlled for with the farm-specific fixed effects μ_i and δ_i. These characteristics include soil quality and agro-climatic conditions as well as operator risk-aversion, which is important in both leverage and insurance decisions. We do not observe farm succession in our sample, which may change the level of risk-aversion within a farm over time. However, by controlling for principal operator age and business structure we can mitigate any bias resulting from a change in risk-aversion.

The coefficients β_1, β_2 in Equation (13) and γ_1 in Equation (14) form the relationships of interest for this study. A positive and statistically significant estimate of β_1 provides evidence of the risk balancing phenomenon in federal crop insurance. We test the assumption that the income smoothing effect of crop insurance indemnities is equal to that of regular business income by comparing our estimate of β_2 with the estimated coefficients on gross farm revenue. Rejecting the null hypothesis of equivalence would suggest that indemnities increase FR by encouraging farms to take on additional debt. The estimate of γ_1 mirrors the risk balancing effect captured by β_1. It measures the extent to which farms compensate for an increase in FR by raising their crop insurance coverage, thereby reducing their BR exposure.

The relative magnitudes of these parameters help identify the channels through which the insurance-debt relationship is facilitated. Because crop insurance coverage decisions are made by the spring-time sales closing date for spring-planted crops, positive estimates of β_1 and γ_1 would indicate that risk balancing takes place through the ex-ante insurance coverage decision that reduces BR for the upcoming crop year. If $\text{Ind}_{i,t}$ has a significantly larger (or smaller) effect than other revenue variables, then the debt-insurance response is a function of realized returns from insurance for losses experienced during the crop year.

Previous studies of risk balancing in the U.S. federal crop insurance program have relied upon cross-sectional comparisons between farms with different levels of crop insurance participation. Crop insurance decisions may be correlated with other farm characteristics that influence indebtedness and liquidity but that cannot be readily unobserved by the researcher, for example, operator risk-aversion. The generally positive relationship found between crop insurance use and farm debt in the literature may be due to unobservable farm traits. Our empirical strategy controls for any bias resulting from these unobservable traits. However, this is not the only source of bias that must be addressed. The coefficients in Equations (13) and (14) will suffer from simultaneity bias if estimated independently as single-equation models, because farmers may jointly determine their level of debt and their level of crop insurance coverage.

To address simultaneity, we take the additional step of modeling a SEM using instrumental variables for endogenous farm debt and crop insurance liability that are excluded from their respective equations. We perform separate two-stage least squares (2SLS) estimation using the county average premium rate to instrument for crop insurance liability in Equation (13), and the imputed interest rate to instrument for short- and long-term debt in Equation (14). Both premium rates and interest rates play the role of prices in debt and crop insurance decisions. Changes in these "prices" induce demand responses that are exogenous to the other decisions.

Crop insurance premium rates are set by USDA RMA to reflect the level of actuarial risk in the county, but are unrelated to the FR of any one farm located in that county. Rising premium rates cause the farm to reduce their insurance liability, allowing us to isolate the variation in insured liability that is unrelated to debt. Similarly, changes in interest rates cause the farm to take on more or less debt in response to the price signal, but will not affect the farm's demand for crop insurance. Note that while the crop insurance indemnities variable satisfies the exclusion restriction—appearing in Equation (13) but not (14)—it does not qualify as a valid instrument for farm debt in the crop insurance equation. This is because revenue from crop insurance is highly correlated with the level of crop insurance coverage. As a farm insures more, the likelihood of receiving an indemnity and the potential size of the payout rise.

To compare our results and evaluate any bias resulting from unobservable farm traits and simultaneity, we estimate pooled ordinary least squares (OLS), panel fixed-effects (FE), and 2SLS models for farm debt (both long- and short-term) and crop insurance liability. All equations are estimated using conventional packages in STATA 15.

RESULTS

Table 2 displays the estimation results for Equation (13) above. For each dependent variable (long-term debt and current/short-term debt), a pooled OLS model, a farm fixed effects model, and a 2SLS model are estimated.[12] We present the results side-by-side for comparison. In general, control variable coefficients are of the expected sign and size across the models. A 1% increase in the interest rate faced by the farm is associated with a 0.14%–0.19% reduction in long-term debt and a 0.23%–0.25% reduction in short-term leverage. Current debt being more responsive to the cost of capital likely reflects the fact that long-term debt carries over from year to year and is more likely to have a fixed interest rate. The marginal effect of operator age is positive until about the age of 53 for long-term debt and about 57 for short-term debt, after which age is negatively related to debt accumulation.

The relationship between crop insurance liability and farm debt is positive and statistically significant in both pooled OLS models—confirming that farms with high crop insurance coverage tend to carry higher debt levels (Table 2). An additional dollar of liability insured is associated with increases in short-term and long-term debt of \$0.10 and \$0.11, respectively. However, the coefficients on crop insurance liability decrease and, in the case of long-term debt, become statistically insignificant when farm fixed effects are applied (see columns [2] and [5] in Table 2). In the case of current debt, the estimated effect of insurance liability falls to \$0.04 (a 60% decrease) but remains statistically significant at the 0.01 level.

Directionally, our estimates are consistent with Ifft et al. (2015) who find a large effect of crop insurance use on short-term debt and no effect on long-term debt. While we also fail to find a relationship between crop insurance and long-term debt using farm fixed effects, we find a smaller relationship between insurance and short-term debt. The point estimate of 0.04 translates to a mere 0.06% increase in short-term debt for every 1% increase in insurance liability for the average farm in our sample. Put another way, if the average farm in the KFMA database doubled its crop insurance liability, we would expect short-term debt to increase by a mere 6.3%. Moreover, despite the panel data structure, the direction of the relationship remains unclear because lenders may require farmer-customers to carry a certain amount of crop insurance liability, which serves as collateral in the event of default on operating loans (Ifft et al., 2015). Producers with higher coverage are therefore more eligible for short-term credit. The mechanism at work in such a scenario is not driven by risk balancing.

Nevertheless, the large change in the magnitude of the coefficient on crop insurance liability between the pooled OLS and fixed effects models is informative. It tells us that—to the extent present—the relationship between crop insurance coverage and current debt will be exaggerated if farm fixed effects are not controlled for. It also suggests that the evidence for risk balancing in short-term debt found in the prevailing literature is in part driven by unobserved farm characteristics. Examining the intra-class correlation coefficients (suppressed in Table 2) confirms the importance of controlling for unobserved farm characteristics; farm fixed effects capture over 70% of the variance in farm debt.

TABLE 2 The impact of crop insurance liability and indemnities on farm debt

	Long-term farm debt			Current farm debt		
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	OLS	FE	2SLS	OLS	FE	2SLS
CI liability	0.11*** (0.01)	0.02 (0.02)	0.21 (0.15)	0.10*** (0.01)	0.04*** (0.01)	0.05 (0.10)
CI indemnities	0.68*** (0.09)	0.25*** (0.07)	0.11 (0.13)	−0.08 (0.05)	−0.19*** (0.04)	−0.20** (0.09)
Interest rate (%)	−4617.52*** (430.59)	−5992.30*** (371.74)	−6034.80*** (332.32)	−4710.43*** (271.17)	−4195.42*** (272.86)	−4197.97*** (225.60)
Gross farm revenue	0.45*** (0.03)	0.18*** (0.03)	0.13*** (0.04)	0.06*** (0.02)	−0.04** (0.02)	−0.04 (0.03)
Off-farm income	−0.01 (0.03)	−0.01 (0.02)	−0.02 (0.02)	−0.01 (0.02)	−0.03* (0.02)	−0.03* (0.02)
Farm operating expenses	−0.24*** (0.03)	−0.05* (0.03)	−0.02 (0.03)	0.25*** (0.02)	0.24*** (0.02)	0.24*** (0.03)
Total crop acres	4.60 (2.81)	34.79*** (5.67)	25.38*** (8.90)	3.51* (1.83)	16.42*** (4.17)	15.86*** (6.09)
Current assets	−0.23*** (0.01)	−0.10*** (0.02)	−0.11*** (0.01)	0.01 (0.01)	0.08*** (0.01)	0.08*** (0.01)
Owned land	0.07*** (0.00)	0.05*** (0.01)	0.05*** (0.00)	0.01*** (0.00)	0.01* (0.00)	0.01*** (0.00)
Buildings	0.19*** (0.05)	0.34*** (0.10)	0.31*** (0.07)	−0.18*** (0.03)	0.02 (0.06)	0.02 (0.04)
Equipment	0.13*** (0.04)	0.09 (0.06)	0.05 (0.05)	−0.05** (0.02)	−0.04 (0.03)	−0.04 (0.03)
Vehicles	0.13*** (0.02)	0.17*** (0.04)	0.13*** (0.04)	−0.11*** (0.01)	−0.01 (0.02)	−0.02 (0.03)
Operator age	2753.45*** (569.01)	16,698.28*** (2154.44)	15,904.00*** (1432.53)	2764.10*** (321.07)	8143.67*** (1320.95)	8095.86*** (1009.48)
Operator age squared	−50.88*** (5.07)	−157.90*** (18.27)	−150.62*** (12.22)	−30.07*** (2.88)	−71.79*** (10.79)	−71.36*** (8.10)
Farm business type[a]	Yes	Yes	Yes	Yes	Yes	Yes
Farm fixed effects[b]	No	Yes	Yes	No	Yes	Yes
Year fixed effects[c]	Yes	Yes	Yes	Yes	Yes	Yes

TABLE 2 (Continued)

	Long-term farm debt			Current farm debt		
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	**OLS**	**FE**	**2SLS**	**OLS**	**FE**	**2SLS**
Observations	17,884	17,884	17,281	17,884	17,884	17,281
Farms	3095	3063	2460	3095	3063	2460
R^2	0.32	0.21	0.19	0.43	0.24	0.24
First stage F-stat			44.41			44.41

Abbreviations: 2SLS, two-stage least squares; CI, crop insurance; FE, fixed-effects; OLS, ordinary least squares.

[a]Dummy variables identifying the farm business type (sole proprietorship, partnership, corporation, etc.) are included and suppressed in the results table.

[b]Specifications (1) and (4) are estimated via OLS without farm fixed effects. Specifications (2), (3), (5), and (6) control for time-invariant farm characteristics with farm fixed effects.

[c]All specifications control for temporal heterogeneity using year fixed effects.

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. White's heteroscedasticity robust standard errors are shown in parenthesis.

When accounting for the simultaneity of the debt and crop insurance decision with the 2SLS model (columns [3] and [6] of Table 2), the coefficients for both long-term debt and short-term debt are statistically insignificant. For short-term debt this result is in contrast to both the pooled OLS and FE models, which show positive and statistically significant coefficients at the 0.01 level. Like the change in magnitude between the pooled OLS and FE model, this loss of statistical significance is informative. It means that once we account for the simultaneity between the debt and crop insurance decisions, we find no evidence of crop insurance increasing debt usage for either long-term or short-term debt. An exogenous shock to crop insurance liability does not lead to an increase in debt usage for the farm. This result is in contrast to previous findings in the literature that do not account for this simultaneity when analyzing risk balancing behavior. However, we cannot rule out the presence of the risk homeostasis as the statistically significant variables in both the pooled OLS and FE models show that debt and crop insurance liability are correlated.

Conversely, crop insurance indemnities are positively related to long-term debt in the pooled OLS and FE models, and negatively related to short-term (current) debt in FE and 2SLS models. Conditional on farm characteristics, if crop insurance indemnities rise by one-dollar, long-term debt will rise by an average of \$0.25 while current debt will fall by an average of \$0.19 according to the FE results. Though statistically significant at the 0.01 level, these effects translate to a 0.03% increase in long-term debt and a 0.04% decrease in current debt due to a 1% rise in indemnity payments.[13] These offsetting effects appear to shift the makeup of total farm debt from short- to long-term but leave its overall level unaffected.[14]

The effect of crop insurance indemnities is robust to the instrumental variables approach of the 2SLS in the case of short-term debt, which increases slightly in magnitude to −0.20, while the effect shrinks and becomes statistically insignificant for long-term debt. Crop insurance payouts may allow producers to pay down—or take on less—short-term debt to finance their seed, fertilizer, and crop protection needs while the income-smoothing effect increases non-current debt which may put the farm at greater FR. However, any negative outcomes of this realignment will be negligible given the small effect sizes at work. Like insurance revenue, gross farm revenue adds to long-term debt. Off-farm income is negatively related to both long- and short-term debt, though its impact is only statistically significant for current debt in FE and 2SLS models. To test whether crop insurance claims are treated differently from traditional sources of farm income, we perform an *F*-test for the equivalence of the coefficients on crop insurance indemnities and gross farm revenue. The null hypothesis of equality cannot be rejected for long-term debt at any conventional significance levels. We cannot conclude that crop insurance indemnity payments alter long-term debt in a way that is different from typical revenues. This result implies that the farmer treats revenues from either farming or crop insurance equivalently; the farmer's long-run debt accumulation would behave the same if they increased profitability or simply received a payout from their crop insurance policy.

The short-term debt effect of crop insurance indemnities however, is significantly larger (in magnitude) than that of gross farm revenue. An addition dollar generated by farm business reduces short-term debt use by about \$0.04, though the effect of farm revenue is not statistically significant in all specifications. An *F*-test confirms that indemnities have a larger negative effect on short-term debt than other income sources. Producers may be more likely to use proceeds from crop insurance claims narrowly to finance inputs or pay off their existing operating loan, while other sources of income serve multiple purposes.

Examining the marginal effect of crop insurance indemnities may not be appropriate given that 39% of observations receive no indemnity payments. We re-estimate our model with

TABLE 3 The impact of crop insurance liability and indemnities on farm debt using indemnity thresholds

	Long-term farm debt			Current farm debt		
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	**OLS**	**FE**	**2SLS**	**OLS**	**FE**	**2SLS**
CI liability	0.10*** (0.01)	0.03 (0.02)	0.21 (0.15)	0.10*** (0.01)	0.04*** (0.01)	0.05 (0.10)
CI indemnities ($1–$4999)	15,659.20*** (3461.95)	1906.36 (2505.51)	987.95 (2548.72)	2466.23 (2205.21)	−235.53 (1764.13)	−277.58 (1738.11)
CI indemnities ($5000–$9999)	22,242.86*** (4945.87)	6346.66* (3347.98)	4246.47 (3834.32)	7917.39** (3175.39)	2866.84 (2279.24)	2770.68 (2527.15)
CI indemnities ($10,000–$24,999)	26,569.45*** (4482.61)	4728.89 (3213.78)	1093.81 (4242.98)	6493.36** (2929.66)	815.49 (2411.25)	649.06 (2990.94)
CI indemnities ($25,000–$49,999)	42,793.81*** (6059.41)	11,521.67*** (4225.53)	6796.07 (5637.00)	7834.45* (4012.47)	−3080.14 (3024.86)	−3296.51 (3854.80)
CI indemnities (≥$50,000)	60,178.35*** (7505.46)	18,624.08*** (5561.17)	6502.31 (11,117.37)	−4108.74 (4806.29)	−13,857.98*** (3628.90)	−14,413.00** (7214.92)
Interest rate (%)	−4628.37*** (430.02)	−5977.89*** (371.94)	−6022.59*** (332.72)	−4727.49*** (270.99)	−4208.93*** (273.13)	−4210.98*** (225.69)
Gross farm revenue	0.44*** (0.03)	0.18*** (0.03)	0.13*** (0.04)	0.07*** (0.02)	−0.03** (0.02)	−0.04 (0.03)
Off-farm income	−0.01 (0.03)	−0.01 (0.02)	−0.02 (0.02)	−0.01 (0.02)	−0.03* (0.02)	−0.03* (0.02)
Farm operating expenses	−0.24*** (0.03)	−0.05* (0.03)	−0.02 (0.03)	0.24*** (0.02)	0.23*** (0.02)	0.23*** (0.02)
Total crop acres	2.94 (2.86)	34.73*** (5.68)	25.30*** (8.83)	2.40 (1.86)	16.16*** (4.19)	15.73*** (6.05)
Current assets	−0.23*** (0.01)	−0.10*** (0.02)	−0.10*** (0.01)	0.01 (0.01)	0.08*** (0.01)	0.08*** (0.01)
Owned land	0.07*** (0.00)	0.05*** (0.01)	0.05*** (0.00)	0.01*** (0.00)	0.01** (0.00)	0.01*** (0.00)
Buildings	0.20*** (0.05)	0.34*** (0.10)	0.31*** (0.07)	−0.18*** (0.03)	0.02 (0.06)	0.01 (0.04)
Equipment	0.13*** (0.04)	0.09 (0.06)	0.05 (0.05)	−0.05** (0.02)	−0.04 (0.03)	−0.04 (0.03)
Vehicles	0.13*** (0.02)	0.17*** (0.04)	0.13*** (0.04)	−0.11*** (0.01)	−0.01 (0.02)	−0.02 (0.03)
Operator age	2648.38*** (568.00)	16,697.54*** (2159.19)	15,904.00*** (1429.23)	2728.20*** (321.27)	8090.19*** (1319.03)	8053.86*** (1003.69)

(Continues)

TABLE 3 (Continued)

	Long-term farm debt			Current farm debt		
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	OLS	FE	2SLS	OLS	FE	2SLS
Operator age squared	−49.74*** (5.07)	−157.89*** (18.31)	−150.61*** (12.20)	−29.57*** (2.88)	−71.42*** (10.79)	−71.09*** (8.07)
Farm business type[a]	Yes	Yes	Yes	Yes	Yes	Yes
Farm fixed effects[b]	No	Yes	Yes	No	Yes	Yes
Year fixed effects[c]	Yes	Yes	Yes	Yes	Yes	Yes
Observations	17,884	17,884	17,281	17,884	17,884	17,281
Farms	3095	3063	2460	3095	3063	2460
R^2	0.33	0.21	0.19	0.43	0.24	0.24
First stage F-stat			45.21			45.21

Abbreviations: 2SLS, two-stage least squares; CI, crop insurance; FE, fixed-effects; OLS, ordinary least squares.

[a]Dummy variables identifying the farm business type (sole proprietorship, partnership, corporation, etc.) are included and suppressed in the results table.

[b]Specifications (1) and (4) are estimated via OLS without farm fixed effects. Specifications (2), (3), (5), and (6) control for time-invariant farm characteristics with farm fixed effects.

[c]All specifications control for temporal heterogeneity using year fixed effects.

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. White's heteroscedasticity robust standard errors are shown in parenthesis.

TABLE 4 The impact of short-term and long-term farm debt on crop insurance coverage

	Crop insurance liability			Crop insurance liability		
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	**OLS**	**FE**	**2SLS**	**OLS**	**FE**	**2SLS**
Long-term farm debt	0.07*** (0.01)	0.02 (0.02)	−0.07 (0.05)			
Current farm-debt				0.13*** (0.01)	0.05*** (0.02)	−0.09 (0.07)
Premium rate (%)	−21,154.64*** (928.87)	−10,837.98*** (2371.85)	−11,042.87*** (1561.94)	−21,167.74*** (923.17)	−10,875.02*** (2354.02)	−10,919.06*** (1563.51)
Gross farm revenue	0.27*** (0.02)	0.16*** (0.02)	0.17*** (0.02)	0.29*** (0.02)	0.16*** (0.02)	0.16*** (0.02)
Off-farm income	0.05** (0.02)	0.03 (0.02)	0.03 (0.02)	0.05** (0.02)	0.03 (0.02)	0.03 (0.02)
Farm operating expenses	−0.27*** (0.02)	−0.06** (0.03)	−0.07*** (0.02)	−0.31*** (0.02)	−0.08*** (0.03)	−0.04 (0.03)
Total crop acres	89.66*** (2.10)	55.51*** (5.13)	58.87*** (4.44)	89.71*** (2.09)	55.56*** (5.10)	57.92*** (4.19)
Current assets	−0.02*** (0.01)	0.02 (0.01)	0.01 (0.01)	−0.04*** (0.01)	0.01 (0.01)	0.03** (0.01)
Owned land	−0.01*** (0.00)	0.01 (0.00)	0.01*** (0.00)	−0.01** (0.00)	0.01 (0.00)	0.01*** (0.00)
Buildings	−0.00 (0.05)	0.19* (0.10)	0.23*** (0.07)	0.03 (0.05)	0.20* (0.10)	0.20*** (0.07)
Equipment	0.13*** (0.03)	0.24*** (0.05)	0.25*** (0.04)	0.15*** (0.03)	0.24*** (0.05)	0.24*** (0.04)
Vehicles	0.23*** (0.02)	0.24*** (0.03)	0.26*** (0.03)	0.25*** (0.02)	0.24*** (0.03)	0.24*** (0.02)
Operator age	−106.87 (441.71)	4604.85*** (1730.46)	6169.83*** (1371.32)	−252.62 (447.71)	4595.34*** (1717.90)	5788.59*** (1189.95)
Operator age squared	−0.02 (3.99)	−41.51*** (14.43)	−56.17*** (12.11)	0.13 (4.07)	−41.68*** (14.40)	−52.10*** (10.07)
Farm business type[a]	Yes	Yes	Yes	Yes	Yes	Yes
Farm fixed effects[b]	No	Yes	Yes	No	Yes	Yes
Year fixed effects[c]	Yes	Yes	Yes	Yes	Yes	Yes
Observations	17,884	17,884	17,281	17,884	17,884	17,281

(Continues)

TABLE 4 (Continued)

	Crop insurance liability			Crop insurance liability		
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	**OLS**	**FE**	**2SLS**	**OLS**	**FE**	**2SLS**
Farms	3063	3063	2460	3063	3063	2460
R^2	0.51	0.42	0.41	0.52	0.42	0.41
First stage F-stat			330.11			354.54

Abbreviations: 2SLS, two-stage least squares; CI, crop insurance; FE, fixed-effects; OLS, ordinary least squares.

[a]Dummy variables identifying the farm business type (sole proprietorship, partnership, corporation, etc.) are included and suppressed in the results table.

[b]Specifications (1) and (4) are estimated via OLS without farm fixed effects. Specifications (2), (3), (5), and (6) control for time-invariant farm characteristics with farm fixed effects.

[c]All specifications control for temporal heterogeneity using year fixed effects.

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. White's heteroscedasticity robust standard errors are shown in parenthesis.

indemnity size categories of $0, $1–$4999, $5000–$9999, $10,000–$24,999, $25,000–$49,999, and over $50,000. These results are shown in Table 3. Generally, long-term debt increases steadily with higher indemnity payment categories when looking at the pooled OLS and panel FE models, supporting a linear relationship.[15] However, the effects of different indemnity classes on long-term debt weaken and become statistically insignificant when we control for endogenous debt and insurance choices. The relationship between crop insurance indemnities and short-term debt is clearly nonlinear and only emerges for very large indemnity payments. Receiving an indemnity payment of $50,000 or more reduces short-term debt by $13,858, or about 13.5%, in the FE model, and $14,413, or about 14%, in the 2SLS model (see columns [5] and [6] in Table 3).

Our results suggest that farms use a significant portion (about 18%) of indemnity payments received for large losses to pay down outstanding current debt or reduce their reliance on short-term debt to finance upcoming operating expenses.[16] The positive long-run debt effects of indemnities are not distinguishable from that which would result from traditional sources of farm revenue, indicating that indemnities are not causing producers to take additional long-term FR.

We now turn our attention to the effect of financial leverage on crop insurance decisions. Our estimates of Equation (14) for both long-term and current debt are reported in Table 4. Results generally mirror those of Table 2. Producer-paid premium rates are strongly negatively related to crop insurance liability in all specifications; results imply a demand elasticity for crop insurance liability of between -0.38 and -0.75, consistent with Goodwin (1993). Column (1) of Table 4 shows that farms with higher long-term debt have higher values of insured liabilities. Within-farm variation in long-term debt is not related to changes in crop insurance coverage.

For current farm debt, the pattern is similar—farms that take out larger operating notes are also highly insured. This positive relationship weakens but remains statistically significant when we apply farm fixed effects. In percentage terms, a 1% increase in a farm's short-term debt load is associated with a 0.03% increase in the farm's total crop insurance liability. This is comparable to the proportional change in current debt in response to a 1% in increase in crop insurance liability (see Table 2).

The mirrored effects underscore the joint nature of these farm decisions and the importance of using a simultaneous equations approach with 2SLS. Isolating the exogenous variation in long- and short-term farm debt allows us to test for a uni-directional causal effect of financial leverage on crop insurance coverage. As before, we do not find a statistically significant response in crop insurance coverage due to exogenous increases in either short-term or long-term farm debt (see Table 4, columns [3] and [6]).

DISCUSSION AND CONCLUSIONS

While crop insurance premium subsidies have become a large expenditure for the U.S. government each year, limited research has evaluated their impact on farm financial well-being. By subsidizing crop insurance, and thereby reducing farms' BR exposure, farms may accumulate more debt to maintain their operation's overall level of risk. This "risk balancing" phenomenon posited by Gabriel and Baker (1980), Collins (1985), and Featherstone et al. (1988), implies that the government may in effect be increasing the risk of financial insolvency due to greater debt accumulation. Conversely, subsidizing leverage through government loan programs may cause farmers to increase their crop insurance coverage to offset the increase in

FR. The more general concept of "risk homeostasis" predicts that farmers jointly manage their business and FRs to maintain a constant overall level of farm risk.

A theoretical framework is proposed building on the classic work of Collins (1985) and Featherstone et al. (1988). Unlike traditional risk balancing models, we show the effect of crop insurance coverage on debt cannot be equated to an exogenous change in BR, but is endogenous to the chosen debt level and must be modeled as such.

Using farm-level longitudinal data from the KFMA, we estimate the effects of crop insurance coverage (total insured liability) and insurance outcomes (indemnity payments) on farm solvency. Previous research that measures the effect of crop insurance on farm financials may have been confounded by two sources of endogeneity: one, unobserved farm-level characteristics that may bias cross-sectional identification, and two, the natural simultaneity of the debt and crop insurance decision that may bias estimates even if farm-level characteristics are controlled for. We address the first source of bias by using fixed effects that capture all unobserved farm and operator characteristics. We address the second source of bias by employing a SEM approach that accounts for the bi-directional relationship between debt and crop insurance decisions, and identifies casual effects. Given the attributes of this study, we believe our results can be extended to farmers in other geographic locations as well as when analyzing other risk mitigation policies.

Our empirical results do not show compelling evidence for risk balancing between insurance coverage and long-term debt. We do find a positive relationship between farm crop insurance liability and short-term debt consistent with previous work. However, the relationship we find is small in economic terms. A 1% increase in farm crop insurance liability is associated with a 0.06% increase in short-term financing. Furthermore, once we account for the simultaneous debt and crop insurance decision using a 2SLS model, the effect becomes statistically insignificant. An exogenous increase in crop insurance use does not lead to a higher debt level for the farm. Estimating the relationship in reverse produces similar results. Higher levels of debt—particularly current debt—are associated with higher crop insurance liabilities, but exogenous changes in debt do not influence crop insurance coverage decisions.

This suggests that previous findings in support of risk balancing in crop insurance may be driven by latent farm or operator characteristics where highly leveraged producers are more likely to participate in federal crop insurance, confounding the debt and crop insurance relationship. However, the statistically significant coefficients in the FE models support the broader risk homoeostasis theory that farmers set a target threshold for risk. As farmers increase debt, crop insurance helps limit the overall risk of the farm so that they remain at their chosen threshold. Given a farm's existing liabilities, the level of crop insurance coverage that balances the farm's overall risk load may be relatively low. This could explain why some farms do not elect the maximum subsidized coverage amount.

We find that crop insurance indemnity payments have a negative effect on current (short-term) debt that is partially offset by an increase in long-term debt, changing the composition of total farm debt in favor of longer-term loans but leaving the overall debt level relatively unchanged. The effect of indemnities on short-term debt is not linear, mainly appearing for large claims (over $50,000). Importantly, indemnity payments do not affect long-term debt differently than traditional sources of farm revenue, that is, the income-smoothing effect of crop insurance does not create an additional long-term debt burden. The negative relationship between indemnities and current debt suggests that farms experiencing large losses use insurance proceeds to pay down their outstanding operating notes or substitute cash for new debt when financing new input purchases.

These results have several important policy outcomes. First, the lack of support for the presence of risk balancing behavior caused by an increase in crop insurance coverage shows that exogenously increasing crop insurance subsidies does not lead to higher farm debt use in that a farmer does not take on more debt than they otherwise would have without the subsidy. However, our results do support the less restrictive risk homeostasis theory by showing that farms simultaneously manage their crop insurance liability and financial debt levels. This could be facilitated through lenders requiring crop insurance coverage in proportion to the loan amount. Increases in insurance subsidies have likely helped facilitate this mechanism over time, making it easier to reduce risk, thus allowing farmers to achieve their desired risk threshold.

Secondly, we show that crop insurance indemnity payments help farmers pay down short-term debt but are also correlated with negligible increases in long-term debt. The net effect is a small change in the makeup of total farm debt in favor of long-term liabilities. Importantly, the impact of indemnities on long-term leverage is consistent with that of normal sources of farm revenue. Together, we find that when insured farms suffer a loss, crop insurance indemnities can help cash flow their short-term operating needs without leading to additional FR.

ACKNOWLEDGMENTS

The authors would like to thank the two anonymous reviewers for their helpful comments and suggestions on an early draft of this paper. This research was supported by funding from the Purdue Center for Commercial Agriculture and the National Institute of Food and Agriculture, U.S. Department of Agriculture, Hatch project 1019254. The findings and conclusions in this publication are those of the author(s) and should not be construed to represent any official USDA or U.S. Government determination or policy.

ENDNOTES

[1] Business risk is defined as the risk inherent in the firm that is independent of the way it is financed (Gabriel & Baker, 1980).

[2] Financial risk is defined as the added variability of the net cash flows from the fixed financial obligations associated with debt financing and cash leasing (Gabriel & Baker, 1980). For the purposes of this study, we are only considering the debt financing portion of this risk.

[3] We acknowledge the mean–variance utility functional form used here has drawbacks relative to the more flexible expected utility framework à la (Von Neumann & Morganstern, 1944). However, assuming farm return on equity is approximately normally distributed, the mean–variance specification is justified.

[4] In contrast to Collins (1985) and Featherstone et al. (1988), we model a producer's decision over the absolute debt level as opposed to the debt-to-asset ratio.

[5] Farm revenue is a function of variable output (bushels produced) and output prices, while costs depend on variable input prices. We use general revenue and cost variables for simplicity. Crop insurance liability is the amount of the farm's total value of production being insured. It is the dollar amount the policy would pay out in the event of a total loss.

[6] The sign of the comparative static in (10) assumes that (i), farm assets are fixed (i.e. not endogenously chosen), (ii), the producer is risk averse ($\alpha > 0$), and (iii), average returns to farming outweigh the opportunity cost of farm capital ($\pi(\bar{r}, \bar{c}, L) - iA > 0$).

[7] Currently, the KFMA database contains about 2000 farm operations but over 3000 farms were observed at least once during the time period used for this analysis.

[8] The KFMA data does not include insurance details such as the type, unit structure, coverage level, or subsidy rate of policies purchased by a farm in a given year. We impute the farm's insured liability using known values from USDA RMA.

[9] Results are robust to the inclusion of outlier observations.

[10] Debt measures are recorded on an accrual accounting basis. We use values from the end of the calendar year to capture the effects of all factors that occur within the year. This is particularly important for sources of revenue including crop insurance indemnities as these are not realized until late in the year.

[11] Revenue and expenditure variables are recorded on an accrual accounting basis and reflect accounts receivables and accounts payables.

[12] See Supplemental appendix for first-stage regression results. First-stage regression *F*-statistics are highly significant in all cases, confirming that the chosen instruments are highly relevant to the endogenous variables.

[13] The elasticity is computed for the average farm that suffers a loss and receives an indemnity payment from crop insurance.

[14] The net estimated effect of insurance indemnities on total debt is 0.06 and is not statistically significant.

[15] We test for a non-linear relationship between long-term debt and crop insurance payments by including a squared term in the original model estimated in Table 2. The squared term does not enter the model significantly, leading us to reject the possibility of a quadratic relationship.

[16] For indemnity payments in the $50,000 or higher category, the mean indemnity is $82,260. The marginal effect of $14,413 is about 18% of this average.

REFERENCES

Babcock, Bruce A. 2015. "Using Cumulative Prospect Theory to Explain Anomalous Crop Insurance Coverage Choice." *American Journal of Agricultural Economics* 97(5): 1371–84.

Collins, Robert A. 1985. "Expected Utility, Debt-Equity Structure, and Risk Balancing." *American Journal of Agricultural Economics* 67(3): 627–9.

Du, Xiaoxue, Jennifer Ifft, Liang Lu, and David Zilberman. 2015. "Marketing Contracts and Crop Insurance." *American Journal of Agricultural Economics* 97(5): 1360–70.

Du, Xiaodong, Hongli Feng, and David A. Hennessy. 2017. "Rationality of Choices in Subsidized Crop Insurance Markets." *American Journal of Agricultural Economics* 99(3): 732–56.

Featherstone, Allen M., Charles B. Moss, Timothy G. Baker, and Paul V. Preckel. 1988. "The Theoretical Effects of Farm Policies on Optimal Leverage and the Probability of Equity Losses." *American Journal of Agricultural Economics* 70(3): 572–9.

Gabriel, Stephen C., and C.B. Baker. 1980. "Concepts of Business and Financial Risk." *American Journal of Agricultural Economics* 62(3): 560–4.

Glauber, Joseph W. 2012. "The Growth of the Federal Crop Insurance Program, 1990-2011." *American Journal of Agricultural Economics* 95(2): 482–8. https://doi.org/10.1093/ajae/aas091

Goodwin, Barry K. 1993. "An Empirical Analysis of the Demand for Multiple Peril Crop Insurance." *American Journal of Agricultural Economics* 75(2): 425–34.

Goodwin, B., Monte L. Vandeveer, and John L. Deal. 2004. "An Empirical Analysis of Acreage Effects of Participation in the Federal Crop Insurance Program." *American Journal of Agricultural Economics* 86(4): 1058–77.

Ifft, Jennifer E., Todd Kuethe, and Mitchell Morehart. 2013. "Farm Debt Use by Farms with Crop Insurance." *Choices* 28(3): 1–5.

Ifft, Jennifer E., Todd Kuethe, and Mitchell Morehart. 2015. "Does Federal Crop Insurance Lead to Higher Farm Debt Use? Evidence from the Agricultural Resource Management Survey (ARMS)." *Agricultural Finance Review* 75(3): 349–67. https://doi.org/10.1108/AFR-06-2014-0017.

Key, Nigel, Christopher Burns & Greg Lyons 2019. "Financial Conditions in the U.S. Agricultural Sector: Historical Comparisons." U.S. Department of Agriculture, Economic Research Service, Bulletin No. 211, Washington, D.C.

Kim, Youngjune, Jisang Yu, and Dustin L. Pendell. 2019. "Effects of Crop Insurance on Farm Disinvestment and Exit Decisions." *European Review of Agricultural Economics* 47(1): 324–47.

Kirwan, Barrett E. 2017. "The Benefits of Crop Insurance." AAEA Annual Meeting, Chicago, IL. July 30–Aug 1.

Lee, Warren F., and Amadje Djogo. 1984. "The Role of Federal Crop Insurance in Farm Risk Management." *Agricultural Finance Review* 44: 15–24.

Pflueger, Burton W. & Peter J. Barry 1985. "Crop Insurance and Credit: A Farm Level Simulation Analysis." Proceedings of Regional Research Committee NC-161 Seminar, St. Louis, Missouri .

Serra, Teresa, Barry K. Goodwin, and Allen M. Featherstone. 2003. "Modeling Changes in the U.S. Demand for Crop Insurance during the 1990s." *Agricultural Finance Review* 63(2): 109–25.

Sherrick, Bruce J., Peter .J. Barry, Paul N. Ellinger, and Gary D. Schnitkey. 2004. "Factors Influencing Farmers' Crop Insurance Decisions." *American Journal of Agricultural Economics* 86(1): 103–14.

Slovic, Paul, and Baruch Fischhoff. 1982. "Targeting Risks." *Risk Analysis* 2(4): 227–34.

Smith, Vincent H., and Barry K. Goodwin. 1996. "Crop Insurance, Moral Hazard, and Agricultural Chemical Use." *American Journal of Agricultural Economics* 78(2): 428–38.

Uzea, Nicoleta, Kenneth Poon, David Sparling, and Alfons Weersink. 2014. "Farm Support Payments and Risk Balancing: Implications for Financial Riskiness of Canadian Farms." *Canadian Journal of Agricultural Economics* 62: 595–618. https://doi.org/10.1111/cjag.12043

Von Neumann, John, and Oskar Morganstern. 1944. *Theory of Games and Economic Behavior*. Princeton, NJ: Princeton University Press.

Wilde, Gerald J. S. 1982. "The Theory of Risk Homeostasis: Implications for Safety and Health." *Risk Analysis* 2(4): 209–25.

Wu, JunJie 1999. "Crop Insurance, Acreage Decisions, and Nonpoint-Source Pollution." *American Journal of Agricultural Economics* 81(2): 305–20.

Yu, Jisang, Aaron Smith, and Daniel A. Sumner. 2018. "Effects of Crop Insurance Premium Subsidies on Crop Acreage." *American Journal of Agricultural Economics* 100(1): 91–114.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

How to cite this article: DeLay, Nathan D., Brady Brewer, Allen Featherstone, and David Boussios. 2022. "The impact of crop insurance on farm financial outcomes." *Applied Economic Perspectives and Policy* 1–23. https://doi.org/10.1002/aepp.13223