The modern Federal Crop Insurance Program (FCIP) has its roots in the 1930s and has been revised and expanded several times throughout its history (Shields 2012). Notably, the program was viewed so dismally that it was "earmarked for elimination from the 1990 farm bill" (Glauber 2013, p.487), but has grown to be considered the most important part of the farm safety net (Glauber 2013; Shields 2012; Shields 2013). The program has evolved into a relevant program for producers with a variety of coverages and policies. Increased reliance on crop insurance in contrast to other support measures reflect a shifting political and philosophical position from price supports to risk management (Novak 2013)[1].

Recently, the FCIP has come under fire from popular press (e.g. Nixon 2012), the academic press (e.g. Hennessy 2011; Wright and Wimberly 2013), and this criticism is reflected in government publications (e.g. Shields 2012; US GAO 2007). The common argument is that subsidized crop insurance encourages expansion of cropping into otherwise unsuitable land. In particular, the argument equates low productivity or high yield risk with environmental sensitivity (Nixon 2012; Hennessy 2011). In part, this conflation is due to the concern over land use change from the Conservation Reserve Program (CRP) to cropping. CRP was, by construction, designed to take low productivity land out of production. In addition to CRP conversion, concern has focused on grassland conversion to crop land (Archer 2011; Johnston 2011; Hennessy 2011; Wright and Wimberly 2013). The United States Government Accountability Office (GAO) recognized the possibility that federal

[1] Novak (2013) presents a very accessible and lucid discussion of this philosophical shift and its roots in the debate between Keynesian and Austrian (primarily Hayak) economic viewpoints in the larger picture of the 2013 Farm Bill debate.

programs were influencing land use choices and recommended that the executive branch investigate. The GAO report's recommendations were addressed in June 2011 and land use changes will be compiled by the USDA's Farm Service Agency (US GAO 2007). The environmental effects of increased cropping use of environmentally sensitive land include erosion (which would lead to increased nutrient and sediment pollution), carbon release in conversion and reduction in carbon sequestration in future periods, and decreased wildlife habitat (Wright and Wimberly 2013).

There are not very many previous studies looking at this topic. Young, Vandeveer, and Schept (2001) looked for a response to crop insurance subsidies in planted acres and found small responses. Goodwin, Vandeveer, and Deal (2004) examined this question with policy simulations finding modest responses. Both of these were published before the most recent period of prosperity in US agriculture. This article will empirically test the assertion that crop insurance, broadly stated, is a causal factor in increased cropping of land use of environmentally sensitive land. The remainder of this paper will briefly introduce additional factors that should be considered in testing this criticism, describe data used in this and other analysis, define more precisely what notions of crop insurance and cropping land use are being tested, describe models used by this analysis, and compare results.

Additional factors

Additional factors could drive the expansion of cropland. These factors could be commodity prices, profitability, or access to credit. One could expect higher profitability to encourage farmers to farm more, increasingly marginal, land. Credit could have both an enabling effect and an effect relating to desperation to repay loans by cropping increasingly marginal land. Finally, an additional factor that could drive down yields is moral hazard in insurance.

Commodity prices and farm profitability

US agriculture over the past century has been characterized by boom and bust cycles. Extremely profitable years in US agriculture during the 1970s led to many operations to expand using debt and many of those operations failed in the first half of the 1980s (Henderson, Gloy and Boehlje 2011). Also during the early 1980's "farmers planted fence row to fence row" to expand production.

The conservation reserve program, a program which pays farmers to temporarily retire land, was established in 1985 with 1.9 million acres retired by 1986 (USDA FSA 2014). Similar programs had existed prior to CRP with shorter contract durations. CRP is worth mentioning in this section because it had a modest positive effect on land prices and temporarily retired millions of acres of environmentally sensitive land (Wu and Lin 2010). Following the mid-1980s was a period of relatively low and stable profitability. The current era of prosperity began in 2006 and again farmers expanded production. CRP enrollment peaked in 2007 with 36.7 million enrolled acres and with rising commodity prices by 2013 enrollment fell to 26.8 million acres (USDA FSA 2014). In addition to decreasing enrollment in CRP nearly 400,000 acres of non-cropping land was converted from non-cropland to cropland in 2012 alone (USDA FSA 2013). Farmers were now farming "road ditch to road ditch." Figure 1 illustrates the eras described above in terms of grain prices received. Henderson, Gloy and Boehlje (2011) address profitability in the context of US agricultural boom cycles and their results will be used to define eras.

Credit

Farms with higher debt to asset ratios tend to have higher discount rates and have been shown to be less likely to utilize conservation tillage techniques (Gould, Saupe and Klemme 1989). Farmers have become increasingly reliant on off-farm employment to service debt leading farms with high levels of debt to be more vulnerable to non-agricultural sector economic shocks (Briggeman 2011) and interest rate hikes.

Readers familiar with the turmoil of the 1980s in farm lending will be relieved to know that much of the higher priced land purchased in the most recent era of prosperity (since 2006) has been purchased with cash leading researchers at the Federal Reserve Bank of Kansas City to conclude that the end of this golden era will not result in another crisis (Henderson, Gloy and Boehlje 2011). There have also been structural changes in lending requirements over this period as well. From the literature it is unclear if credit capacity enables expanded cropping or if expanded cropping is a result of the added pressures of loan servicing. While not the focus of this article, a credit indicator based on debt loads, borrowing capacity, and interest rates will be used to control for this concern.

Moral hazard.

A common argument in the literature reviewed for this article was that enrollment in crop insurance resulted in a moral hazard problem evidenced by links between lower input use and increased crop insurance participation (Goodwin et al. 2004; Olen and Wu 2013). An interesting contrast to moral hazard is that Du, Hennessy and Feng (2013) found lower risk farms purchasing higher levels of coverage.

At first blush it seems like the FCIP is fairly well constructed with regard to moral hazard. Policies sold through the FCIP (with the exception of rarely participated in group risk policies) are based on actual production history (the previous four to ten years) and only protect up to eighty-five percent of that actual production is protected (Shields 2013). In other words, poor cropping practices will catch up to a farmer in the form of lower and lower guarantees. Additionally, the Risk Management Agency is mandated to strive for actuarial soundness (Shields 2013). Changes in 2013's premiums were to reflect a greater weight on more recent history after a 2011 review of premium calculation practices (Shields 2013). The premium subsidy is a percentage, which would pass a portion of higher premiums on to producers with habitually poor management practices. Further analysis of moral hazard and the incentives provided by crop insurance are worth pursuing in another article. This remainder of this article will not explicitly consider moral hazard in its analysis.

Theoretical Model and Empirical Application

This section will discuss the model built to test for a link between increased use of crop insurance and increased cropping of environmentally sensitive land. If we accept that environmentally sensitive and marginal land are the same, as the press suggesting the existence of a link propose, one should expect that county yields would fall with higher levels of insurance participation. Further, if the effect is linear one would expect a statistically significant negative link between the proportion of land enrolled in crop insurance and county yields.

Supposing the relationship to be linear, the model is expressed below in equation 1. As a dependent variable, yield was measured by county level yield data as reported by The United States Department of Agriculture's National Agricultural Statistics Service Quick Stats tool (NASS 2014). Price is the fundamental signal to plant and should be included as an independent variable. Assuming that planting decisions are made based on the price received the prior year, price for the previous period at the county level was used for the price variable as reported by NASS (2014). Crop insurance participation is measured by dividing insured acres by the planted acres for each county in the panel. The United States Department of Agriculture's Risk Management Agency (RMA) is charged with administering the FCIP. A wealth of data is available in the RMA Information Browser. The RMA Information Browser was used to collect data on insured acres in each county of the study area. Figures for net planted acres by county were collected from NASS (2014). As insured acres cannot logically exceed planted acres, observations for which this variable is greater than one were dropped (results for estimations without this treatment are available in the appendix).

As described in previous sections additional factors need to be controlled for in the form of independent variables. Credit factors can impact planting decisions and should be included. Interest rate information is available from the Board of Governors of the Federal Reserve System Economic Research and Data page and a quarterly bankers survey (Selected Indicators of Credit Conditions) is available from The Federal Reserve Bank of Kansas City (Federal Reserve Bank of Kansas City 2014; Federal Reserve Bank Board of Governors 2014). This survey data is available dating back to 1980 and only for the tenth (Kansas City) district including Colorado, Kansas, Nebraska, Wyoming, Oklahoma, the western third of Missouri and northern New Mexico. This limitation was the factor that limited the scope of this particular study to the tenth district excluding New Mexico and including all of Missouri. Principal components analysis (PCA) was used to derive orthogonal data that would have sufficient variation, but not cause problems for the analysis. Since the focus of this analysis was on crop insurance and prices, it seemed fitting to eliminate possible data problems that could have arose from less than perfect measures.

Weather has an obvious effect on yield and should be controlled for. Weather was derived from state and county thirty year weather normals, annual temperature, heating days, cooling days, and precipitation from data from the National Oceanic and Atmospheric Administration (NOAA 2014). The same principal components analysis techniques were used to derive a weather index. Even using PCA did not prevent this data from proving to be very problematic. Several observations were dropped due to no weather data for a given county.

Technology has progressed through time and should be controlled for with a trend variable. As discussed in the profitability section, there have been eras of expansion that should be controlled for. Eras were defined as dummy variables coded 1 if the year was before 1986, 0 otherwise and a second era as 1 if year was after 2005, 0 otherwise.

(1) $$Yield = \beta_{1it} + \beta_{2it}Time + \beta_{3it}Weather + \beta_{4it}Credit + \beta_{5it}Percent\ Insured\ Acres + \beta_{6it}Price + \beta_{7it}Pre86 + \beta_{8it}Post05 + \varepsilon$$

Panel data from the area encompassed by the Federal Reserve Bank of Kansas City has been compiled from several sources in Stata®. New Mexico was deemed to be too different than the rest of the district and the remainder of Missouri was deemed similar enough to be included. The final list of included states is: Colorado, Kansas, Nebraska, Missouri, Oklahoma, and Wyoming. In 2013, these states grew twenty percent and eighteen percent of the corn and soybean, respectively, produced in the US. Corn and Soybean production made up fifty and twenty-two percent of these states total crop production. These states are important to national production of corn and soybeans and these two crops are important to these states. The dataset encompasses each county within these states from 1981-2013.

The model was estimated using a robust random effects linear regression technique. The random effects model seemed most consistent with the data and hypothesis tests indicated that the random effects model was the appropriate choice (Breusch and Pagan Lagrangian multiplier test for random effects and Hausman specification test, Stata® output in the appendix). Panel data could have both heteroskedasticity and autocorrelation problems leading to selection of a heteroskedasticity-autocorrelation robust estimation technique.

Results

Again, if increased crop insurance participation is encouraging conversion marginal and environmentally sensitive land to cropping production we expect to observe a negative relationship between yield and crop insurance participation. First estimated was the corn model (table 1) followed by the soybean model (table 2). Consistent with previous literature crop insurance participation does seem to have a small, statistically significant, negative effect on yield in both models. The coefficient is small for corn and somewhat larger for soybeans. The insured proportion of planted (corn or soybeans) variable lies between zero and one and a one unit increase reflected in the coefficient needs to be multiplied by 0.01 in order to interpret it as a one percent increase or decrease in the proportion of land that is insured in a given county. Price coefficients were highly significant as expected.

Conclusion

In this article, a link between crop insurance participation and expansion of cropping land was tested by examining a fixed effects model with a panel data set. Cropping expansion into environmentally sensitive land was measured by following county level yield data over thirty-three years. Credit, weather, output prices and time were controlled for. Regression results indicate that it does appear that over the period of between 1981-2013 crop insurance participation has something to do with increased cropping of environmentally sensitive land. The results were not conclusive.

Caution should be exercised with these results. There are several limitations to the study at this point. The first and most obvious is that environmentally sensitive and marginally productive are not necessarily the same. The ideal study would look at actual land-use change. The obvious dependent variable would look at acres, however with the length of CRP contracts, crop rotation, and the possibility of pasture or woodlot conversion to cropland suggested that the dependent variable would have to measure the quality of production rather than the acres carried out on. As of this writing the land use change data discussed in response to US GAO (2007) (available at http://1.usa.gov/1il8Lfk) was extremely limited with data on conversions occurring in 2011 and 2012 crop years for all states. Wright and Wimberly (2013) were able to find data on land use change dating back to 2006 for a limited number of states. The second limitation is that several observations were dropped due to poor measurement of weather and the proportion of insured acres. Future research needs to address these data problems. The models have only been estimated for corn and soybeans. To provide a more complete picture additional crops need to be added. Finally, the coefficients are statistically significant, however economic significance to their magnitude is unclear. The link exists statistically, but it implication for policy is unclear. Future research should look at subsidy payments and coverage levels while keeping in mind the endogeniety of contract choice. As more data on land use change becomes available that data would be ideal for testing this hypothesis.

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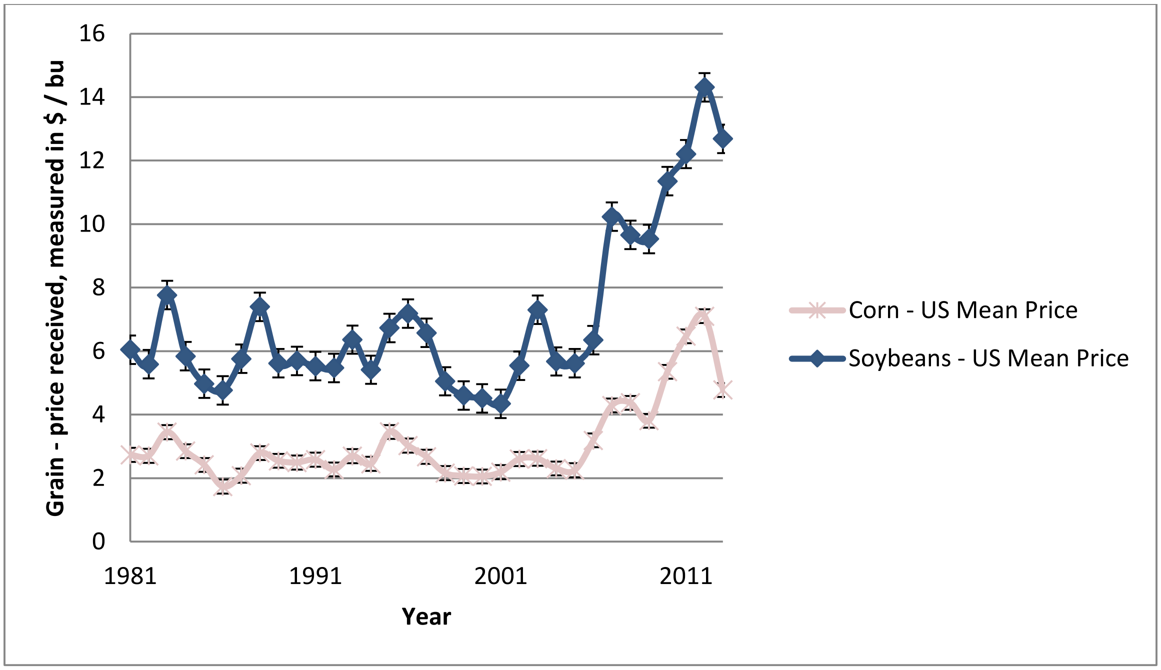

Figure 1. Grain price received measured in $ / BU, data from (USDA NASS 2014)

Table 1. Regression Results: Robust Random-effects GLS regression, Dependent Variable: Corn Grain Yield in Bushels per Acre

	Coefficient	Standard Error	P>z
Year	1.072821	0.1289402	0.000
Weather Index	2.277613	0.4475849	0.000
Credit Index	1.17251	0.2715144	0.000
Insured Proportion of Planted Corn	-8.71162	2.919534	0.003
Corn Grain Price Received (t-1)	-1.56348	0.3847299	0.000
Before 1986 (binary)	-7.83009	1.432134	0.000
After 2005 (binary)	4.041813	1.194719	0.001
Constant	-2018.3	255.7451	0.000

Table 2. Regression Results: Robust Random-effects GLS regression, Dependent Variable: Soybean Yield in Bushels per Acre

	Coefficient	Standard Error	P>z
Year	0.322368	0.034	0.000
Weather Index	1.893497	0.104	0.000
Credit Index	0.829861	0.110	0.000
Insured Proportion of Planted Soybeans	-3.50936	0.740	0.000
Soybean Price Received (t-1)	0.288461	0.064	0.000
Before 1986 (binary)	-5.42451	0.503	0.000
After 2005 (binary)	1.218922	0.384	0.002
Constant	-606.127	68.253	0.000