How will changes in Title II of the 2018 Farm Bill affect CRP Acreage?

by

Brian Jarod Cornish

A thesis submitted to the Graduate Faculty of

Auburn University in partial
fulfillment of the requirements
for the Degree of

Master of Science Agricultural Business and Economics, Minor in Statistics

Auburn, Alabama

December 14, 2019

Keywords: Conservation, Farm Bill, Land Economics, Policy Analysis

Approved by

Department of Agricultural Economics and Rural Sociology

Dr. Ruiqing Miao, Assistant Professor in Agricultural Economics

Dr. Patricia Duffy, Professor in Agricultural Economics

Dr. Denis Nadolnyak, Professor in Agricultural Economics

Table of Contents

List of Figures

List of Tables

`

List of Abbreviations

CRP Conservation Reserve Program

EBI Environmental Benefits Index

USDA United States Department of Agriculture

FSA Farm Service Agency

SRR Soil Rental Rate

EQIP Environmental Quality Incentives Program

CSP Conservation Stewardship Program

NASS National Agricultural Statistics Service

Abstract

The 2018 Farm Bill, added new regulations under its conservation title that have made changes to various conservation programs. For the Conservation Reserve Program (CRP) rental payments have been lowered to 85% of the average county rental rate for general signup and 90% for continuous signup. The acreage enrollment cap has also been increased by 3 million acres (from 24 million to 27 million acres). This paper aims to examine what effect these policy changes in the new bill could have on CRP acreage. Mainly, we first seek to understand how the rental payment will affect CRP enrollment by estimating a reduced- form supply function of CRP acreage. We then discuss how the policy changes may impact the overall goal of the program. Elasticity estimates show that CRP acreage with respect to aggregated crop prices is -0.07 and elasticity of CRP acreage with respect to CRP rental payments is around 0.18.

Introduction

The Conservation Reserve Program (CRP) has yielded many positive environmental benefits and is at the forefront of conservation programs in the United States. The CRP is the most extensive private-land retirement program in the United States. As of June 2018, current CRP enrollment is about 23 million acres. The CRP pays an annual rental payment to landowners in exchange for removing environmentally sensitive land out of production and growing plant species that improve the health of the natural environment. Objectives of the CRP include reducing soil erosion, decreasing surplus production of agricultural commodities, improving environmental health and biodiversity, as well as providing income support for landowners (Ribaudo et al, 2001). CRP land is enrolled through a competitive bidding process during both general and continuous sign-up periods.

There are certain requirements that a parcel of land must meet if a landowner intends to enroll his or her acres into the program. Generally, the land offered to the program must have had crops planted on it at least four of the past six years and must also be capable of growing agricultural commodities (USDA, 2008). Landowners enter into 10 - 15 year contracts that ensure the government will pay the landowners for their land if they refrain from growing crops. The received payment will remain constant throughout the duration of the contract. Landowners can offer an unlimited amount of acres for enrollment and may request a specified payment amount up to the maximum rental amount offered by the government.

Due to the competitiveness of the program, lower rental payments offered by landowners have a higher chance of their bid for a contract getting accepted. Acceptance of a bid is also based on the environmental benefits that a landowner's acres have to offer. The environmental benefits index (EBI) is a formula created by the USDA that is used to gauge the environmental benefits and cost of an offered parcel. A parcel of land is more likely to be accepted if its EBI score is greater than the CRP cut-off EBI score. The criteria listed in the EBI ranges from potential wildlife and native plant species benefits, air and water quality benefits, and wind and water erosion potential of the land in question. Figures 1-2 show maps for CRP acreage enrollment and rental payments. These maps help us gain a better understanding of the areas where the CRP has received much of its enrolled acreage from.

Figure 1 shows a map of acres enrolled in the program as of 2017. A large number of CRP acres come from states such as Iowa, Texas, Oklahoma, Colorado, Minnesota, Washington, and many other states where the soil is fertile and where conservation and environmental health are important social issues. States with more dry climates such as California, Nevada, Arizona, and New Mexico tend to have less CRP enrollment. Figure 2 shows a map of the average rental payments received by landowners across counties. We can see that states in the Northern United States such as Iowa, Illinois, and

Washington receive higher rental payments per acre than in other states. One reason for this is the quality of land in these areas. The annual payment rate for each CRP offer is calculated as the average of the soil rental rates (SRRs) for the three predominant soils on the parcel of land being offered for enrollment (USDA, 2007). SRRs are obtained by multiplying the respective county-average SRR which are based on the best available estimates for cash rents by a soil-specific productivity factor (USDA, 2007).

There are many benefits that accrue to landowners and the natural environment through the CRP. Contracts provide a consistent source of income for landowners, especially when farm incomes are low. Since CRP contracts can last for a decade or more this allows natural cover and wildlife habitats more time to grow and develop thus providing more ecological welfare. Due to the volatile nature of crop prices, producers who have CRP contracts may forgo profits gained by producing agricultural commodities because they are unable to plant crops on their contracted CRP acres. Because CRP contracts can last for up to 10 or 15 years, landowners must consider the long-term opportunity cost of entering into a CRP contract. During periods when agricultural commodity prices are low, there may be incentives for farmers to offer acres into the program. Once enrolled in the program, landowners are limited in terms of how they can utilize their contracted acreage. In some cases landowners can utilize their land for activities such as grazing but harvesting for forage and other commercial activity for the length of the CRP contract is strictly prohibited (Stubbs, 2014). Other than the annual payment provided by the government, landowners are generally unable to earn additional profits from their enrolled acres. In some instances CRP participants can lease hunting rights and charge fees to hunters during the hunting season for the pursuit of game on their enrolled CRP acres (Cacek, 1988).

With the 2018 farm bill signed into law, it is important to take a look at how past farm bills have made alterations to the program and how the program has changed over its time. Figure 3 shows the total amount of acreage enrolled into the CRP along with the acreage cap from when the program was first established in the mid-1980's to 2017. From Figure 3 we gain a better image of CRP acreage enrollment throughout the history of the program. When the CRP was established in the Food Security Act of 1985 over the course of the first few years the major goal of the program was to try to enroll as many highly erodible acres as possible. The Federal Agriculture Improvement and Reform Act of 1996 made changes to the eligibility requirements for acres enrolled in the program by adding new criteria to the EBI (Heimlich, 2003). The Farm Security and Rural Investment Act of 2002 further expanded the eligibility of acres enrolled into the program by allowing expiring CRP contracts to be eligible for automatic re-enrollment (USDA, 2008). This provision made it much easier for landowners who already had land enrolled in the program to get their contracts renewed once their contracts expired. Both the Food, Conservation, and Energy Act of 2008 and the Agricultural Act of 2014 reduced that the maximum number of acres enrolled be reduced along with other minor provisions (Claassen, 2014). From this, we can see that throughout the programs history farm bills have played a very important role in the development and design of the CRP.

Objective

With the expansion of the CRP acreage enrollment cap and reduction in rental payments in the 2018 Farm Bill, a vital question to ask is what impacts could this have on the program? Generally, once a CRP contract has been made landowners cannot freely withdraw their acres from the program. To opt out of the contract, producers will have to pay substantial fees and meet certain criteria. When applying for a CRP contract, landowners need to carefully evaluate the flow of revenue to be gained from the CRP over a decade and be willing to accept potential opportunity cost lost by taking their agricultural acres out of crop production.

The CRP first began enrolling acres in 1986 and by 1990 it had expanded to more than 30 million acres. From 1993-1995 the number of CRP enrolled acres leveled off at around 35 million acres. CRP enrollment peaked in 2007 when CRP total enrolled acres was around 36.8 million acres. Around the time of 2008 Farm Bill commodity prices began to rise and since then the amount of CRP acreage has declined every year. This change in enrolled acres could be the result of several reasons such as high crop prices, strong farm incomes, and cutbacks in federal budgets. Removed acres from the CRP could have been put back into agricultural production, or maybe enrolled in other land conservation programs.

If rental payments are reduced, how will it affect overall CRP acreage supply? Is the CRP likely to gain or lose acreage enrollment and by how much? To address these questions, a robust econometric model is needed. For this research, it is necessary to understand the relationship between the CRP acreage enrollments and its response to CRP rental rates. Understanding the relationship between CRP acreage and rental rates is useful

because it can help us make better predictions about how CRP acreage supply may be affected in the long run. Landowners may find the payment reduction to be unfavorable and in response to this change ask that restrictions on certain prohibited activities such as grazing or haying be weakened. Landowners might also demand a reduction in the amount of fees for early contract termination.

Literature Review

The literature available on the Conservation Reserve Program is extensive. Past research studies have focused on various aspects and issues within the program.

Effect of CRP on Land Values

A study by Wu & Lin, (2010) aimed to evaluate the effects of the CRP on prices of farmland and developed land by using both theoretical and empirical models. The results of the theoretical model suggested that the CRP increases agricultural returns but decreases growth premium and option value of farmland. The empirical model used cross-section data from 2,851 counties in the United States from 1997. The results suggested that the CRP increased average farmland value by 1.3% - 1.8% in the United States in 1997. These effects were the largest in the Moutain, Southern Plains, and Northern Plains regions where the CRP increased the farmland values by 5.2% to14.0%, 3.7% to 6.4%, and 2.7% to 5.3%, respectively. The results also showed that the CRP had a positive effect on developed land values.

A study by Schmitz & Shultz, (2008) aimed to quantify how CRP enrollments influence the price of cropland across North Dakota over the 2000 - 2004 period. The study utilized a hedonic price regression model to quantify the determinants of land values. In particular, the study specified the sale price per acre as a function of parcel size, land use, soil productivity measures, locational aspects, the year of the sale, and whether the land is enrolled in the CRP. Schmitz and Shultz (2008) noted that the primary factor influencing price differences between CRP acres and cropland values is the opportunity costs of having land enrolled in the program.

If CRP payments are lower than the profits that could be gained from crop production, then CRP acres should sell at a discount compared to similar non- enrolled acres. When CRP payments exceed the profits earned from crop production then CRP land should sell at a premium. Results of the study concluded that CRP sales were slightly lower in productivity value, cropland productivity measures, and sale values. The authors reasoned that the likely cause for buyers discounting the value of CRP land is that CRP rental rates did not account for changes in commodity prices. Because rental payments are fixed over the life of a CRP contract there are no adjustments to rental rates so that payment reflects an increase or decrease in commodity prices. Ultimately, the study concluded that landowners are less likely to re-enter their land into the CRP when their contracts expire under the same rental payment, especially during times when commodity prices are soaring.

Landowner Behavior Trends and CRP

In an article by Shoemaker (1989), Shoemaker observed the frequency of signups for CRP and the maximum bids the government was willing to accept. He believed that there was a chance that producers could earn economic rents if they could learn and understand what the bid caps were. The results of his research showed that producers who waited until later sign-up periods could receive higher premiums for lower quality land since at the time the government was mandated to enroll 40 million acres into the program. Shoemaker found that bidders in late sign-up periods with land of below average productivity were able to receive CRP rental rates that were available for producers with land of average productivity. He reasoned that these producers would experience “windfall profits” and that these windfall profits increase the farmers' incentive to participate in the program and could possibly contribute to changes in land values.

A paper by Kirwan, Lubowski, & Roberts (2005) analyzed the cost-effectiveness of the environmental benefits index (EBI). In the analysis, Kirwan et al. suggested that landowners with excellent EBI scores could possibly submit rental payment bids above the maximum amount imposed by the CRP and still have their land accepted into the program. Similarly to Shoemakers' study, these landowners were expected to experience premiums in the form of windfall profits for their enrolled acres. By analyzing data for CRP bids from general sign- ups conducted between 1997 and 2003, Kirwan et al. showed that landowners who understood they had land that was highly beneficial to the program and had greater EBI scores were more likely to submit bids to the CRP that requested a greater rental amount to retire their land.

Effect of Rental Rates on CRP Contract Renewals

An article written by Cooper & Osborn (1998) investigated how CRP participants may react to changes in existing rental rates, and how these changes could affect CRP contract renewal. They aimed to estimate a schedule of CRP acreage enrollment extensions as a function of the rental price. To perform the study survey data from over 8,000 CRP contract owners were used. CRP contract holders were questioned about their willingness to extend their CRP contracts under two scenarios. In the first scenario, they asked, "Would you accept [X] percent of your current annual CRP rental payment per acre to extend your CRP contract for an additional ten years if the contract extension did not allow haying or grazing?" The 2nd scenario, asked, "Would you accept [y] percent of your current annual CRP rental payment per acre to extend your CRP contract for an additional ten years if the contract did allow haying and/or grazing under certain conditions?" Cooper & Osborn (1998) developed a supply function that modeled total acreage enrolled as a function of the CRP rental payment. They used an ordered probit model to depict the range in rental rates over which landowners might consider renewing CRP contracts. Their results showed that up to 50% of CRP acreage could be renewed at less than the average

CRP payment cost per acre.

Data and Econometric Model

Our analysis focuses on determining a reduced-form supply function for CRP acreage. To investigate this, we utilize county-level CRP enrollment data (acreage and rent) over 1986-2017 compiled by the Farm Service Agency (FSA) under the United Sates Department of Agriculture (USDA). We deflate county- level CRP rent to real dollar values using 1986 as the base year. State-level crop price and production data for ten major field crops (Barley, Corn, Cotton, Oats, Peanuts, Rice, Rye, Sorghum, Soybeans, and Wheat) are used to calculate a crop price index. The prices are also deflated to 1986 prices. Data for county- level cropland acreage are used to examine how many acres of the ten major crops were planted per county. We choose to incorporate county-level weather data as well; we use the weather data to calculate six month county-level average temperature and precipitation for the months April through September; we do this to represent the climate over the average growing season for most crops. We also include the CRP enrollment cap and time trend in our regression analysis. Table 1 provides summary statistics for the data used in the analysis. For our analysis, we utilize the Arellano-Bond dynamic panel data estimation to develop our main research model as well as other model specifications. We also estimate a standard fixed effects model. The primary model that we specify is as follows:

$$\text{CRP\_Acreage}_{i,t} = \left(\sum_{j=1} \gamma_j \text{CRP\_Acreage}_{i,t-j} \right) + \beta_1 \text{CRP\_Rent}_{i,t-1} + \beta_2 \text{Crop\_Price}_{i,t-1} + \beta_3 \text{Crop\_Acre}_{i,t-1} + \beta_4 \text{CRP\_Cap}_{i,t-1} + \beta_5 \text{six-month average temperature}_{i,t-1} + \beta_6 \text{six-month average precipitation}_{i,t-1} + \beta_7 \text{year} + v_i + \epsilon_{i,t} \quad (1)$$

Where CRP_Acreage$_{i,t}$ is the CRP acreage in county *i* in year *t*; the summation represents the lagged dependent variable CRP_Acreage*i*,t-j, j=1,…,L. where L is the maximum lag of our dependent variable and γ are estimates of the

lags. CRP_ Rent *i*,t is the CRP average rent in county i in year t; Crop_Price$_{i,t-1}$ represents crop price index in county *i* and year *t-1*; Crop_Acre$_{i,t-1}$ is crop acreage in county *i* in year *t-1*; CRP_Cap *i*,*t*−1 the CRP enrollment cap in county i in year t-1; Six-month average temperature *i*,*t*−1 is average growing season temperature in county i in year t-1; Six-month average precipitation *i*,*t*−1 is average growing season precipitation in county i in year t-1; Year, represents the time trend; β_1, . .

., β_7 are parameters to be estimated, $\boldsymbol{v}_{i}$, is the unobserved fixed effect for county *i*, and $\epsilon_{i,t}$ is the error term.

Some econometric issues should be discussed before modeling equation (1). We consider average CRP rental payment in a county, state crop price index, county cropland acreage, the CRP enrollment cap to be key factors that should be included in the right-hand side of equation (1). Six month average temperature and precipitation along with year which represents a time trend are exogenous. Since CRP contracts typically lasts for 10 – 15 years we may need to consider a lagged dependent variable as an independent variable. With the CRP a landowner's willingness to enter or re-enter land into the program can be explained by two main factors. The first is the amount of rental payment they can receive for their land. Second is whether or not crop prices are high or low. We can observe the effect of these two factors on CRP acreage by calculating the elasticity of CRP acreage with respect to CRP rental payments and aggregated crop prices.

Landowners interested in enrolling acres into the program may observe the previous year's payment amount to determine a reasonable rental payment amount as well as the previous year's crop price. If people choose to enroll land into the program based on the rental payments and crop prices received from earlier years then this may impact CRP acreage supply. Landowner's decisions to enroll their acres into the program could be based on perceptions about the rental rates they could receive and what they believe future crop prices will be. For this reason, it is necessary to include the lagged dependent variable in the right-hand side of our equation. However, using a lagged dependent variable may lead to inconsistent parameter estimates (Wooldridge 2003). There could also be unobserved time- invariant variables that we do not consider. The CRP is focused on moving agricultural acres out of production in favor of improving environmental health through conservation practices. Fixed factors such as county soil quality may reflect the suitability of land to be used for conservation.

Counties with more fertile soil are likely to have land that would receive a higher EBI score than those counties with poorer quality allowing their acres to be accepted into the program more easily. A benefit of using the Arellano-Bond estimation approach is that the Arellano-Bond estimator controls for the endogeneity of the lagged dependent variable. We can remove any fixed effects that are present by taking the first difference. We then use further lags of the differenced lagged dependent variable to instrument the dependent variable. This approach uses the levels of the lagged endogenous variables as instruments for corresponding endogenous variables, additional instrumental variables can also be used for endogenous variables (Roodman 2009).

Our main results model is an Arellano-Bond dynamic panel data regression model that includes data which spans over a 32-year time frame (1986-2017). We compare our main results model to other models such as a fixed effects model as well as to different specifications of our main model. One specification we perform is running a model where we ignore endogeneity and assume that all variables other than our lagged dependent variable are exogenous. Another specification we test is a model in which we do not use additional instrumental variables such as lagged weather shocks for our endogenous variables. By performing different model specifications we can compare the results of each model and determine if certain model specifications significantly change the parameter estimates of the overall model. The results for the main results model and other model specifications are located in Table 2.

Based on the estimates we receive from our main results model we can then calculate the long-term effects of the 2018 farm bill policy change. The 2018 farm bill has implemented two major changes to the CRP. First, CRP rental payments will be reduced to 85 percent of county rental rates for general sign up and 90 percent of county rental rates for continuous signup. Second, the CRP will expand the maximum number of acres enrolled in the program from 24 million acres to 27 million acres. It is possible to estimate the effects these changes could have on CRP acreage supply by calculating the long term effects of CRP rental payments and the long term effects of the CRP enrollment cap. After developing parameter estimates from our main model, we should also perform a sensitivity analysis of our model to check the robustness of our results.

Results

Column (1) of Table 2 shows the results of the fixed effects model estimations of equation (1). The reason we obtain these results is that we are interested in what the fixed effects estimations would be if we chose not to utilize the Arellano-Bond estimations to address the fundamental econometric issues associated with equation (1). Using the Stata command "xtabond2," we obtained the Arellano-Bond estimations of equation (1), shown in columns (2) through (4) in Table 2. The table reports robust standard errors. The p-values from the Arellano-Bond first and second order autocorrelation test are also provided at the bottom of Table 2. All columns contain estimates with a maximum of 3 lags of the dependent variable.

Column (2) represents the model specification where we are ignoring endogeneity of the variables and are assuming that all the variables are exogenous except for the lagged dependent variable. Comparing the model from column (2) to the other model specifications we find that the parameter estimates for this model specification differ, but this is what one would expect given that the model does not account for the endogeneity amongst the variables.

In column (3) we have specified this model not to include additional instrumental variables for our endogenous variables i.e., lagged CRP acreage, one-year lagged deflated CRP average rent, one year lagged crop price index, and one year lagged county cropland acreage. However, the model specification for column (3) of Table 2 uses the lags of the endogenous variables as instrumental variables for the endogenous variables. The parameter estimates for this model specification are closer to that of our preferred model specification in column (4). Column (4) shows the main results of our preferred model specification with a maximum lag level of 3. The p-values from the Arellano-Bond first and second order autocorrelation test are the highest in the

main results model from column (4).

Our main results model includes 3 lags of our dependent variable CRP acreage while using the lags of the endogenous variables as instrumental variables for the endogenous variables as well as using additional instrument variables (i.e., 2 years lagged average 6- month temperature and precipitation) for the endogenous variables. Overall the parameter estimates for the model specifications were fairly consistent across models. The signs in front of each parameter estimate are as expected. From the estimates in column (4) in Table 2, we can infer that if CRP rent increases by $1/acre, then CRP acreage in a county will increase by on average 16.46 acres. If the CRP enrollment cap were to increase by 1 million acres then CRP acres in a county should increase by 57 acres on average per county. From the data set, we are able to estimate that the elasticity of CRP acreage with respect to CRP rent is about 0.18 and the elasticity of CRP acreage with respect to aggregated crop prices is around -0.07. These results suggest that when crop prices are high landowners are less likely to enroll their land into the CRP in favor of planting crops and that CRP acreage supply is inelastic.

Sensitivity & Robustness

We can check the sensitivity of our model by shortening the dataset to reflect different time frames. We focus on three different time frames one-time frame is from 1990-2014 another time frame we utilize is 1995-2010 and the final time frame we use is from 1996- 2017. These time periods are of interest because during these years, there were many policy changes that occurred in the CRP as a result of new farm bill legislation being passed as well as changes in crop prices and crop acreage. In Table 3 below we perform sensitivity analysis of our main results from column (4) in Table 2. To do this, we re-run our model from column (4) Table 2 reflecting different time periods. The results of our main model from Table 2 contains the full range of our data set a 32-year range from 1986 to 2017. By comparing the parameter estimates from our main model to those of different time periods, we will learn if the parameter estimates are consistent across different years.

From Table 3 we see that the parameter estimates across different time periods are somewhat consistent. But during certain time periods, some of our endogenous variables lose their significance. Our main model results from column (4) Table 2 include up to 3 year lags for our dependent variable CRP acreage for each model specification. We can perform more robustness measures by comparing the results of our main model to models that include even further lags of the dependent variable. At further lags of our dependent variable we find that some of our estimates become insignificant or differ significantly from our main results model, this is shown in Table 4. Table 4 gives us parameter estimates of models where we have taken 1, 2, 4, and 5 lags of our dependent variable. The models from Table 4 reflect the main model results in column (4) of Table 2 but in Table 4 we have specified the model to observe further lags of the dependent variable. From table 4 we can clearly see that at further lags our dependent variable becomes insignificant, but still, our estimates for CRP rent and CRP enrollment cap remain fairly consistent across different specifications.

Long-term Effects

Given that the results of our sensitivity test have shown that our parameter estimates are fairly robust we can now calculate the long-term effects of the 2018 farm bill policy changes using the estimates shown in column (4) of Table 2. Following Miao (2013) the long- term effect of CRP rental payments on CRP acreage supply can be calculated by the following equation.

$$\beta^{lr}_{CRP\_Rent} = \frac{\beta_{CRP\_Rent}}{1-\gamma_1-\gamma_2-\gamma_3} \quad (2)$$

If we plug the parameter estimates from column (4) Table 2 into equation (2), we can calculate the long-term effect of CRP rent on CRP acreage. The result is $\beta^{lr}_{CRP\_Rent}$ =

89.46. Given this ratio, we can now estimate what long-term effects of the 85% and 90% rental payment cap could possibly have on CRP acreage. From Table 1 we can see that the average CRP rental payment per county is $41/acre. For general signup, if CRP rental rates are reduced by 15%, then the average county CRP rental rate will fall by $6.15. Based on the long term effect estimate of CRP rent on CRP acreage we can conclude that under the general signup CRP acreage in the average county will fall by 550 acres.

Under the 2018 farm bill, the CRP expanded its acreage cap so that the maximum number of acres they will allow to enroll in the program is up to 27 million acres from the fiscal year 2019 to the fiscal year 2023. This is an increase of 3 million acres from the previous enrollment cap of 24 million acres. Using the same approach as equation (2), we can also calculate the long-term effect of the CRP enrollment cap on CRP acreage supply by equation (3) below.

$$\beta^{lr}_{CRP\_Cap} = \frac{\beta_{CRP\_Cap}}{1-\gamma_1-\gamma_2-\gamma_3} \quad (3)$$

The parameter estimate of CRP_Cap from column (4) of Table 2 is 56.62. Using this estimate we can infer that a 3 million acre increase in the CRP enrollment cap increases CRP acreage in a county by 168.96 acres on average. From equation (3) we estimate the long-term equation coefficient of CRP enrollment cap $\beta^{lr}_{CRP\_Rent} = 307.72$. We obtain this value by inserting the parameter coefficient estimates in column (4) Table 2 into equation (3). From the long-term estimate of CRP enrollment cap on CRP acreage, one way we could interpret this value is that if we multiplied the long-term estimate by the number of counties in our main model from column (4) of Table 2 then based on the long-run estimate of CRP acreage cap the expected increase in the number of acres is about 772,069 acres.

The overall results of our research indicate that over the next few years the CRP may enroll new acres into the program, however the number of acres that it will enroll will be well below the 3 million acre enrollment. With an average reduction in rental payment amount of around $6 per county, if future commodity prices rise then the chances of landowners

wanting to enroll acres or renew their expiring CRP contracts are less likely to occur.

Conclusions and Discussions

We developed an econometric model for analyzing CRP acreage supply by using Arellano-Bond dynamic panel estimation. The overall findings from our results appear to indicate that under the new farm bill regulations the CRP may not achieve its goal of enrolling 3 million acres into the program over fiscal years 2019 through 2023 everything else equal. Due to the rental payment cap imposed by the new bill, landowners will now receive less pay for their acres than what they received in prior years. During the mid-2000s and early 2010s crops such as corn and soybeans saw their prices rise greatly as the demand for corn for ethanol production and greater exports of soybeans increased. This change in crop prices might have driven landowners to forgo entering into or renewing a CRP contract in favor of using their acres for agricultural production.

After 2007 the CRP has seen a decade long decline in the number of acres enrolled in the program. While we cannot know for certain all the reasons behind the decline some likely explanations that one might offer could be strong crop prices and farm incomes, or landowner's receiving better rental offers from others who would like to grow crops on their land. It is possible that the acres of land in the program that receive lower EBI scores and thus receive lower rental payment offers are more likely to drop out from the program.

Due to the many significant environmental benefits that can be gained from CRP many landowners who are environmentalist may still be interested in enrolling acres into the program. There are many things that the models we estimated in this research paper could not account for such as county-level farm incomes and landowner age which may impact landowner reenrollment decisions. We were also unable to observe any non-pecuniary benefits that may impact individual landowner's willingness to enroll in the program. There are possibly many social benefits that landowners may gain from enrolling their acres into the CRP. If there are landowners who are keen on establishing habitats for wildlife and promoting biodiversity or are concerned with preserving the quality of the soil on their land, then CRP contracts may appear attractive to them.

From the perspective of a policymaker, the ultimate goal for the CRP is to get as many highly erodible lands out of agricultural production, establish effective long term conservation practices, provide income support for landowners, and also make the program cost-effective. These are difficult task to achieve however through research we are able to evaluate the effectiveness of the program, gain a better understanding of the mechanics of the program and how landowners will respond to new regulations in the CRP. It will be interesting to see how landowners will respond to the latest policy regulations imposed by the 2018 farm bill on the CRP.

One thing we might consider and suggest would be to conduct more general signups. If the program were to hold CRP general signups more frequently at various times throughout the year perhaps more people will enroll through general signup. Perhaps instead of reducing rental payment amounts the government could alter the payments to reflect changes in periods during which commodity prices are noticeably high or low. This type of change would require a significant increase to budget for the program.

With the data, we had available we were able to estimate a robust model of CRP acreage. If we had data available to us on factors such as county-level farm income, landowner age, as well as contract-level CRP data then both our analysis and model could have been more thorough. Future research that may help us understand the effectiveness of policy changes much clearer would involve CRP contract-level data. Through contract-level data we could provide better estimates of the quality of acres that fall out of the CRP and what potential environmental impacts would be lost or gained.

References

Carek, T. 1988. After the CRP contract expires. J. Soil and Water Conserv. 43:291-293

Claassen, R., 2014. Agricultural Act of 2014: Highlights and Implications-Conservation.

USDA Economic Research Service. United States Department of Agriculture, E.R.S.,

Washington, DC

Heimlich, R., 2003. Agricultural Resources and Environmental Indicators, 2003: Chapter6.2

Land Retirement. USDA Economic Research Service. United States Department of

Agriculture, E.R.S., Washington, DC

Joseph C. Cooper, C. Tim Osborn, The Effect of Rental Rates on the Extension of

Conservation Reserve Program Contracts, *American Journal of Agricultural Economics*,

Volume 80, Issue 1, February 1998, Pages 184–194

Kirwan, B., Lubowski, R., and M. Roberts. 2005. "How Cost-Effective are Land Retirement

Auctions? Estimating the Difference between Payments and Willingness to Accept in the

Conservation Reserve Program." *Amer. J. Agr. Econ*. 87 (Number 5): 1239–1247

Miao, R. (2013). Impact of Ethanol Plants on Local Land Use Change. *Agricultural*

and Resource Economics Review, 42(2), 291-309.

Osborn, Tim, 1997.Chapter6.3 Conservation Reserve Program, in Agricultural

Resources and Environmental Indicators, 1996-97. In: Margot Anderson, Richard

Magleby (Eds.).

Department of Agriculture, Economic Research Service Agricultural Handbook No.712, U.S

Ribaudo M. O., Hoag D. L., Smith M. E. and Heimlich R. (2001) Environmental indices and the politics of the Conservation Reserve Program. Ecological Indicators1, 11–20.

Roodman, D. 2009. "How to Do xtabond2: An Introduction to Difference and System GMM in Stata." *Stata Journal* 9(1): 86–136.

Schmitz, N. and S. Shultz. 2008. "The Impact of the Conservation Reserve Program on the Sale Price of Agricultural Land." *J. of Amer. Society of Farm Mangers and Rural Appraisers.* (2008): 51-59

Shoemaker, R. 1989. "Agricultural Land Values and Rents Under the Conservation Reserve Program." *Land Econ*. (May): 131-137

Stubbs, M. 2014. Conservation Reserve Program (CRP): Status and Issues. Washington, DC: Congressional Research Service

USDA FSA, 2007. Conservation Reserve Program Offer and Contract Processing. *FSA HANDBOOK. Page 212. United States Department of Agriculture F.S.A., Washington DC*

USDA FSA, 2007. Questions and Answers ABOUT CONSERVATION RESERVE PROGRAM CONTRACT RE-ENROLLMENTS AND EXTENSIONS (REX).United States Department of Agriculture F.S.A., Washington DC

USDA. 2008. “CONSERVATION RESERVE PROGRAM AND CONSERVATION RESERVE ENHANCEMENT PROGRAM.” *United States Department of Agriculture,* Washington, D.C.

USDA-FSA. 2017. “CRP Enrollment Rates and Rental Payments by County, 1986-2017”. *Farm* Service Agency, http://www.fsa.usda.gov/programs-and-services/conservation- programs/reportsand-statistics/conservation-reserve-program-statistics/index

USDA-NASS. 2018. “Quick Stats.” *National Agricultural Statistics Service,* http://quickstats.nass.usda.gov/

Wooldridge, J.M. 2002. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: The MIT Press. ———. 2003. *Introductory Econometrics: A Modern Approach* (2nd edition). Independence, KY: Cengage Learning / South-Western Thomson Learning.

Wu, J., and Lin, H. (2010), ‘The Effect of the Conservation Reserve Program on Land Values’, Land Economics, 86(1), 1–21.

Figure 1: Conservation Reserve Program Enrollment Fiscal Year 2017

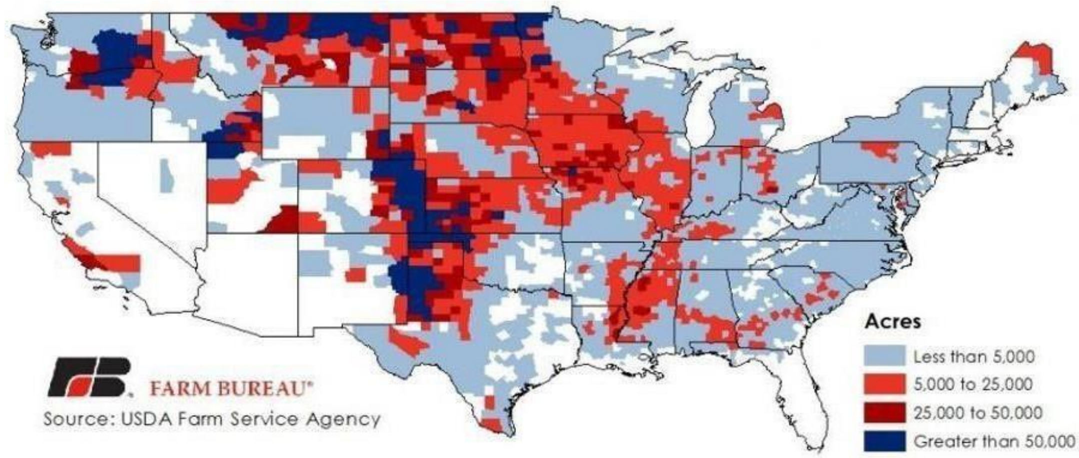

Figure 2: Conservation Reserve Program Rental Rates Fiscal Year 2017

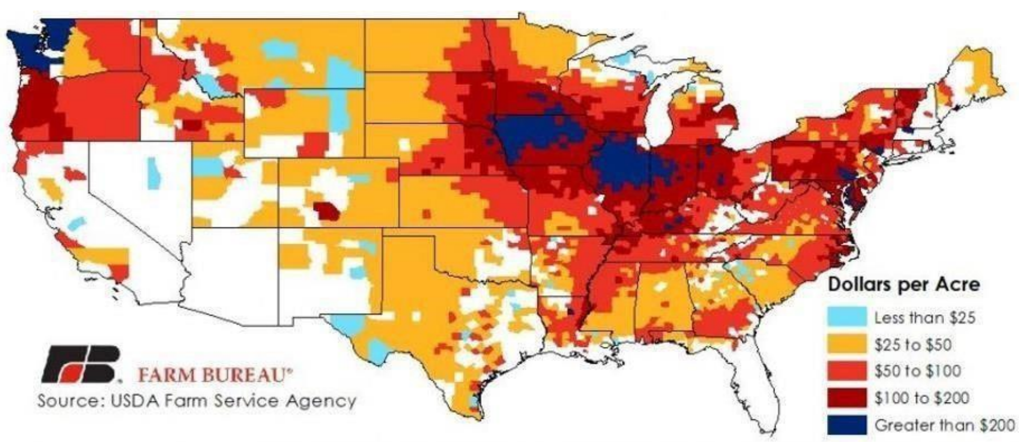

Figure 3: Total Acres Enrolled in CRP (1986-2017)

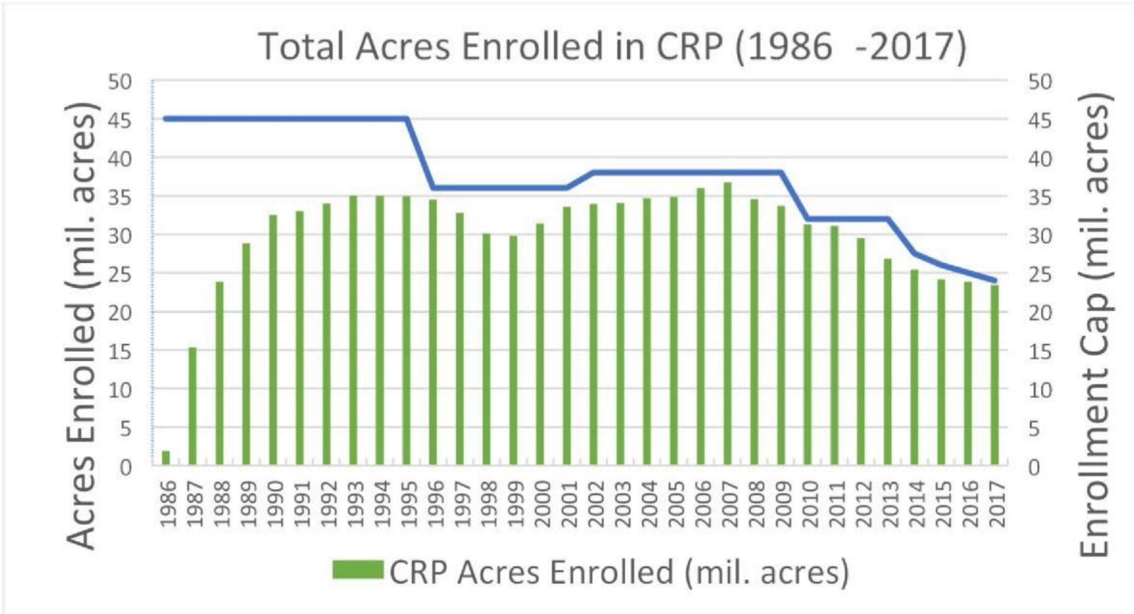

Table 1. Variables: Explanation and Summary Statistics

Variable	Explanation	Obs	Mean	Std. Dev.	Min	Max
CRP Acreage (Acres)	Number of CRP acres in a county	79,730	12,046	25,055	0.1	310,296
Deflated CRP Average Rent ($/Acre, in 1986 dollars)	Average CRP rental payment amount in a county	79,730	41	19.6	4.3	289.2
State Crop Price Index(10 crops, state level, 1986 = 1)	An indexof crop prices for each state (includes 10 major field crops)	78,110	1.2	0.3	0.5	2.4
County Crop Acreage (10 crops, state level, 1986 = 1)	Number of cropland acreage in a county (includes 10 major field crops)	68,695	103,821	111,159	60	947,400
Average Growing Season Temperature (Celsius)	Average county temperature for over a 6 month time period (April -Sept)	79,730	19.8	3.5	7.4	29.8
Average Growing Season Precipitation (MM/Month)	Average county precipitation for over a 6 month time period (April -Sept)	79,730	92.8	33.4	0.1	260.9
CRP Enrollment Cap	CRP enrollement cap is the maximum number of acres abled to be enrolled	79,730	37	6.3	24	45

Table 2. Estimation Results of Model (1): Dependent Variable CRP_Acreage

	Fixed Effects Estimation	Arellano-Bond Estimation		
Independent Variables	**(1)**	**(2)**	**(3)**	**(4)**
L.CRP_Acreage	1.175***	0.763***	1.028***	1.031***
	(0.0379)	(0.00395)	(0.0359)	(0.0352)
L2.CRP_Acreage	-0.214***	-0.119***	-0.186***	-0.188***
	(0.0374)	(0.00455)	(0.0239)	(0.0238)
L3.CRP_Acreage	-0.0580***	-0.0254***	-0.0277***	-0.0270***
	(0.00938)	(0.00240)	(0.00766)	(0.00764)
lag_DeflatedCRP_AverageRent	15.85***	-61.43***	16.17***	16.46***
	(1.825)	(2.597)	(3.940)	(4.200)
lag_PriceIndex	-853.3***	-1,460***	-805.9***	-828.9***
	(42.55)	(37.63)	(55.60)	(56.43)
lag_Crop_Acreage	0.00776***	0.0218***	0.00574***	0.00567***
	(0.00129)	(0.000467)	(0.00145)	(0.00145)
lag_AvgMeanTemperature6m	199.7***	220.0***	161.4***	149.0***
	(19.49)	(12.83)	(16.04)	(15.81)
lag_AvgPrecipitation6m	0.902**	0.596	-0.0546	0.112
	(0.358)	(0.455)	(0.364)	(0.307)
lag_CRP_Cap	40.75***	158.4***	56.68***	56.62***
	(4.621)	(4.187)	(5.392)	(5.415)
Year	10.70***	62.25***	27.04***	26.73***
	(2.567)	(3.487)	(3.598)	(3.692)
Observations	61,265	57,311	57,311	57,311
Number of Fips	2,544	2,509	2,509	2,509
R-squared	0.880	—	—	—
Arellano-Bond test for AR(1)	—	0.00	0.00	0.00
Arellano-Bond test for AR(2)	—	<0.49	<0.83	<0.87

Notes: Robust standard errors are reported in parentheses. For Arellano-Bond estimations (columns 2 through 3), the test for autocorrelation is an Arellano-Bond test for autocorrelation in first-differenced errors. In column 2 we estimate a model where we ignore endogeneity and we treat all variables other than the lagged dependent variable as exogenous. In column 3 we estimate a model where we do not use additional instrumental variables for our endogenous variables. In column 4 we have the main results model where we use 3 lags of our dependent variable and use lag 2 average precipitation and lag 2 temperature as instrumental variables for our endogenous variables.

Table 3. Different Time Period Sensitivity Tests of Model (1): Dependent Variable CRP_Acreage

	Arellano-Bond Estimations		
Independent Variables	**1990-2014**	**1995-2010**	**1996-2017**
L.CRP_acreage	1.003***	1.043***	1.050***
	(0.0370)	(0.0280)	(0.0369)
L2.CRP_acreage	-0.189***	-0.224***	-0.165***
	(0.0247)	(0.0300)	(0.0296)
L3.CRP_acreage	-0.0200**	0.0119	-0.000834
	(0.00786)	(0.0182)	(0.0158)
lag_DeflatedCRP_AverageRent	28.84***	5.810	4.752
	(7.236)	(8.864)	(4.378)
lag_PriceIndex	-925.4***	-1,231***	-872.4***
	(68.06)	(80.20)	(56.85)
lag_crop_acreage	0.00481***	0.00492***	0.00806***
	(0.00152)	(0.00178)	(0.00160)
lag_AvgMeanTemperature6m	144.6***	106.0***	142.0***
	(15.63)	(19.60)	(17.40)
lag_AvgPrecipitation6m	0.521*	-0.461	1.748***
	(0.314)	(0.411)	(0.356)
lag_CRP_Cap	50.82***	58.31***	39.51***
	(6.204)	(5.110)	(3.960)
Year	33.89***	39.09***	32.02***
	(4.150)	(4.026)	(3.725)
Observations	52,303	34,125	43,997

Number of Fips	2,505	2,445	2,447
Arellano-Bond test for AR(1)	0.00	0.00	0.00
Arellano-Bond test for AR(2)	<0.83	<0.67	<0.83

Notes: Robust standard errors are reported in parentheses. Arellano-Bond estimations in this table reflect the main results from Table 2 column 4 for this model. We use 3 lags of our dependent variable and use lag 2 average precipitation and lag 2 temperature as instrumental variables for our endogenous variables. The first column shows the results from time period 1990-2014 (24 years), the second column shows the results from 1995-2010 (15 years), and the last column shows a time period from 1996-2017` (21 years)

Table 4. Different number of lags as IV, 1 lag, 2 lags, 4lags, and 5 lags of Model (1): Dependent Variable CRP_Acreage(i,t)

	Arellano-Bond Estimations			
Independent Variables	**1 lag**	**2 Lags**	**4 Lags**	**5 Lags**
L.CRP_acreage	0.608***	0.972***	1.027***	1.032***
	(0.0221)	(0.0328)	(0.0349)	(0.0342)
L2.CRP_acreage	—	-0.211***	-0.149***	-0.153***
	—	(0.0188)	(0.0253)	(0.0262)
L3.CRP_acreage	—	—	-0.0369**	-0.0116
	—	—	(0.0160)	(0.0204)
L4.CRP_acreage	—	—	-0.00215	0.0200
	—	—	(0.00646)	(0.0127)
L5.CRP_acreage	—	—	—	-0.00221
	—	—	—	(0.00508)
lag_DeflatedCRP_AverageRent	44.13***	15.83***	14.25***	16.81***
	(8.967)	(4.995)	(4.273)	(4.135)
lag_PriceIndex	-787.3***	-806.6***	-917.1***	-1,053***
	(78.59)	(61.08)	(60.47)	(62.90)
lag_Crop_Acreage	0.0154***	0.00576***	0.00647***	0.00702***
	(0.00268)	(0.00165)	(0.00143)	(0.00146)
lag_AvgMeanTemperature6m	197.1***	159.1***	126.4***	148.3***
	(25.89)	(16.59)	(15.96)	(16.57)
lag_AvgPrecipitation6m	0.198	0.204	0.589*	0.989***
	(0.396)	(0.307)	(0.316)	(0.329)
lag_CRP_Cap	129.3***	70.89***	54.29***	55.13***
	(9.014)	(5.747)	(4.969)	(4.722)
Year	79.26***	31.48***	31.45***	34.81***
	(10.64)	(4.006)	(3.689)	(3.895)
Observations	62,403	59,845	54,781	52,270
Number of Fips	2,530	2,522	2,494	2,476
Arellano-Bond test for AR(1)	0.00	0.00	0.00	0.00
Arellano-Bond test for AR(2)	<0.01	<0.06	<0.19	<0.57

Notes: Robust standard errors are reported in parentheses. The first column shows the results from using up to 2-year lags of our dependent variable, the second column shows the results from using up to 4- year lags of our dependent variable, and the last column shows the results of using up to 5-year lags of our dependent variable