Stability and Resilience in U.S. Farm Income: The Role of Federal Farm Programs

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Abstract

This study examines the role of two key federal farm programs, the Conservation Reserve Program (CRP) and federal crop insurance, on the stability and resilience of regional farm income in the United States. Using county-level farm income data from 1969 to 2022, we calculate stability and resilience measures to assess the impact of these two programs. More than 50 years of anomaly in farm income are analyzed to study stability. In addition, six crucial shock years are identified within the data to evaluate resilience. Instrumental variable regressions with panel fixed effects and probit models are employed to analyze the impact of CRP and crop insurance payments on the measures of stability and resilience. Through this study, we make significant contributions to the existing literature. First, we show that CRP rental payments reduce both absolute and relative anomaly in market farm income, suggesting that CRP participation stabilizes farm income and mitigates volatility. Second, we reveal a contrasting effect of crop insurance program compared to CRP. Our results show that crop insurance payments increase both absolute and relative downward anomalies. This highlights the potential for unintended consequences of crop insurance programs in worsening income volatility. Third, we find a positive association between CRP payments and absolute resilience, indicating that CRP participation enhances farms' ability to withstand shocks. Finally, the study sheds light on potential moral hazard issues associated with crop insurance by demonstrating its negative impact on relative resilience. This finding of our study contributes to the ongoing debate on the overall effectiveness and potential downsides of crop insurance programs.

Keywords: *Stability, Resilience, CRP, Crop Insurance, Farm Income, Government Payment*

1 Introduction

One of the main objectives of the U.S. federal farm programs is to stabilize farm income. Moreover, with increasing number of internal and external shocks, resilience in farm income is attracting more attention of the policymakers. Thus, we investigate the role of conservation reserve program (CRP) rental payments and federal crop insurance subsidies in bringing stability and resilience in regional farm income in the United States (US). Exploring stability and resilience in farm income on a regional scale is important for several reasons. First, farm income is highly instable (variable) due to its exposure to not only regular fluctuations in crop yields and prices but also to a wide range of shocks. In fact, historical data reveals that U.S. farmers have consistently faced income instability (Mishra & Sandretto, 2002). Other research supports this by showing that farm income fluctuates far more than non-farm income (Beckman & Schimmelpfennig, 2015). Second, the level of instability in farm income differs across U.S. regions (Mishra et al., 2002). In fact, empirical studies illustrate that when one region thrives in a particular year, another may incur losses (Key et al., 2018). Finally, to enhance long-term sustainability in agriculture, exploring both these concepts— stability (steady flows of farm income) and resilience (the ability to deal with shocks)— are equally important and closely intertwined (Berardi et al., 2011; Volkov et al., 2022).

Why is it important to evaluate the role of federal farm programs such as conservation reserve program (CRP) and federal crop insurance on stability and resilience? There are several reasons. First, participation in the CRP program changes the land use dynamics in a region. For example, CRP enrollment yields less lands available for farming practices. We do not know how these land dynamics affect farm income. Moreover, Rosenberg & Pratt (2024) finds that land use dynamics of the rejected CRP offers vary across regions. Thus, it is important to investigate the impact of these land allocation decisions on regional farm income. Secondly, numerous empirical studies show that participation in the federal crop insurance raise moral hazard issues. For instance, Wu et al. (2020) finds that the likelihood of prevented planting claims, one of the crop insurance program payments, increases as the expected market price decreases or as fertilizer costs increase for corn and soybeans in the Prairie Pothole Region. It is still unknown how this moral hazard affects farm income. Finally, both the programs account for a significant outlay of government funds annually. Thus, evaluation of the effectiveness of these programs on bringing stability and resilience in farm income is of economic and policy importance.

We find a plethora of empirical studies on the stability and resilience of economic outcomes such as regional employment and production. These studies primarily focus on cities, a particular county, or different countries. However, we do not find any study on the stability and resilience of regional farm income, especially at the U.S. County level. To fill this research gap, we measure stability and resilience of the counties using farm income data from 1969 to 2022. We selected this timeframe for several reasons. First, U.S. farm income experiences greater variability during this period due to many reasons including climate change, changes in the agricultural markets (both domestic and global), and greater price volatility. Figure 2 shows the distribution in the U.S. farm income along with five-years moving average. We can easily observe that real farm income depicts higher variability compared to the five-years moving average. Secondly, U.S. agriculture also underwent many shocks which directly or indirectly affects the industry: credit crisis (farm debt crisis, 1980s), trade shock (North American Free Trade Agreement, 1994), economic shock (financial crisis, 2008), and pandemic shock (Covid-19, 2019). Finally, there were many policy changes during this period. For instance, CRP was introduced in 1987 which is within our data frame.

Our analysis involves several steps. First, we determine market farm income by removing all government payments from county-level farm income data. This separates income earned solely from agricultural production and marketing. Next, we assess stability in farm income by measuring variability of market farm income at the county level over time. Unlike prior studies using farm-level data, we focus on regional stability by utilizing county-level data. We define downward anomalies as deviations between observed income and expected income (based on 3, 4, and 5-year moving averages). This unique method captures trends and short-term fluctuations, crucial for understanding regional stability. We then assess resilience by identifying shock years (periods of significant decline in farm income followed by rebound) and quantifying both the absolute and relative resilience of U.S. counties. Finally, we estimate the impact of government programs (CRP and crop insurance) on stability and resilience using panel data models with instrumental variables to address potential endogeneity issues between CRP and crop insurance.

To conduct this analysis empirically, we collect data from publicly available sources, especially from various government agencies in the US. The county-level farm income data is obtained from the Bureau of Economic Analysis (BEA). We adjusted for inflation using the Producer Price Index (PPI) from the Bureau of Labor Statistics (BLS). We further complemented this data with information on CRP rental payments (Farm Services Agency) and crop insurance (Risk Management Agency). We collect population density (BEA and U.S. Census), and climate variables (PRISM Climate Group). This comprehensive dataset encompasses U.S. counties from 1969 to 2021. This long period of historical data allows us to investigate stability and resilience in U.S. farm income regionally and over time.

Through this study, we make significant contributions to the existing literature. First, we show that CRP rental payments reduce both absolute and relative anomaly in market farm income, suggesting that CRP participation stabilizes farm income and mitigates volatility. Second, we reveal a contrasting effect of crop insurance program compared to CRP. Our results show that crop insurance payments increase both absolute and relative downward anomalies. This highlights the potential for unintended consequences of crop insurance programs in worsening income volatility. Third, we find a positive association between CRP payments and absolute resilience, indicating that CRP participation enhances farms' ability to withstand shocks. Finally, the study sheds light on potential moral hazard issues associated with crop insurance by demonstrating its negative impact on relative resilience. This finding of our study contributes to the ongoing debate on the overall effectiveness and potential downsides of crop insurance programs.

2 Data

Table 1 in the appendix shows the list of variables used in this study and their descriptive statistics. We collect data from a variety of sources. All data for this analysis are sourced from publicly available databases. The main variable based on which all the stability and resilience measures are calculated is the county-level farm income data. We collect this detailed farm income data from the U.S. Bureau of Economic Analysis (BEA)[1]. The original data in nominal values (in thousands of dollars). Later, we transform these values into inflation-free dollars by

[1] The regional economic accounts published by BEA provides the geographical distribution of U.S. economic activities including farm income and expenses. Other notable estimates of BEA include gross domestic product by county and states, local area personal income, and employments. These data can be download from the following link: https://www.bea.gov/itable/regional-gdp-and-personal-income.

deflating these using the Producers Price Index (PPI)[2] from the U.S. Bureau of Labor Statistics. We also aggregate this county-level farm income data at the U.S. states and BEA regions[3] for further analysis.

Data on CRP rental payments is collected from the Farm Services Agency (FSA) of the U.S. Department of Agriculture[4]. We get the crop insurance data from the Risk Management Agency (RMA) website. Data on the harvested acres by counties in 1968 is downloaded from USDA NASS. Population data is collected from BEA county profiles. Data on county-level land area is retrieved from U.S. Census website to calculate population density. Finally, climate variables are sourced from the PRISM Climate Group. The unit of observations for this study is U.S. counties and the temporal framework is between is 1969-2021.

3 Method

Our analysis consists of several stages. We first determine the method to calculate the market farm income. We define market farm income, π, as the agricultural profit from production and sales of commodities on the market without any form of government payments. BEA calculates

[2] The PPI measures the average price change paid to domestic producers for their output, over time. We use PPI as the deflator because PPI measures the price change from the perspective of the producer or seller. In contrasts, another popular measure of price change, Consumer Price Index (CPI), measures price change from the purchaser's perspective. Since the focus of this study is the stability and resilience of agricultural producers, we use PPI instead of CPI.

[3] Bureau of Economic Analysis (BEA) has grouped the U.S. states into eight regions. States are classified primarily based on cross-sectional similarities in their socioeconomic characteristics. For more details on these regions, use the following url: http://www.mitpressjournals.org/doi/pdf/10.1162/003465305775098224.

[4] Historical data on CRP can be download from the following FSA website using the following url: https://www.fsa.usda.gov/programs-and-services/conservation-programs/reports-and-statistics/conservation-reserve-program-statistics/index

and publishes county-level farm income with government payments. We calculate county-level market farm income, π, by simply deducing all kinds of government payments to the producers[5].

3.1 Measuring Stability

We determine stability of farm income by measuring its variability, following similar methods used by Harkness et al. (2021). We define high stability as low variability in farm income and vice versa. However, contrary to Harkness et al. (2021) which uses farm-level data income data, we measure downward anomaly and variability using county-level aggregated market farm income to determine regional stability. We define downward anomaly as the deviation in market farm income from the expected market farm income when the former is less than the latter. We determine the expected market farm income by calculating the n-year moving average. We use n = 3, 4, and 5 years of moving average. The formula for these measures can be shown as follows:

$$\mathrm{ADA}_{\mathrm{it}} = \begin{cases} |\pi_{\mathrm{it}} - \overline{\pi}_i| & if \;\; \pi_{\mathrm{it}} < \overline{\pi}_i \\ 0 & if \;\; \pi_{\mathrm{it}} > \overline{\pi}_i \end{cases}$$

Where ADA stands for absolute downward anomaly and the subscripts i and t represents U.S. counties and year, respectively. $\overline{\pi}_i$ is the n-year moving average of the market farm income. The 3, 4, and 5 years of moving averages can be formulated as:

[5] We get the net income including corporate farms from BEA (Line code 310). Then, we deduct two items from this net income: (1) Government payments (Line code 130) and (2) Imputed and miscellaneous income received (Line code 140). We deduct imputed and miscellaneous income from the net income because it includes indemnity payments from crop insurance. It also includes income from home consumption and recreational activities. However, we cannot separate these incomes from the total imputed and miscellaneous income due to lack of additional data. Thus, we ignored it.

$$\overline{\pi}_{it} = \begin{cases} \frac{(\sum_{t-1}^{t+1} \pi_{\text{it}})}{n} & if\ n = 3 \\ \frac{(\sum_{t-2}^{t+1} \pi_{\text{it}})}{n} & if\ n = 4 \\ \frac{(\sum_{t-2}^{t+2} \pi_{\text{it}})}{n} & if\ n = 5 \end{cases}$$

Using moving averages has several advantages. First, it is relatively simple to understand and communicate. Second, taking both lagged and forward years to calculate the moving average ensures consideration of recent patterns such as gradual growth or decline in agricultural income. Finally, the moving average can smooth out any sudden rise or fall of farm income by short-term events. We do not use more than 5 years of moving averages for the following reasons. First, this can screen out recent changes in the agricultural industry which can be crucial for farmers making short-term decisions. For example, a recent drought or a shift in government policies might not be reflected in a 10 or 15-year average. Experts exert that farm income often exhibits cyclical patterns due to factors like commodity prices, weather events, and overall economic performance. Using a long moving average may result in smoothing out these cycles. For instance, a 3-year cycle in cattle prices would not be captured well by a 10-year average. Finally, agricultural industry can undergo structural changes over time, like technological advancements, new trade agreements, or economic sanctions. Using a long average might incorporate farm income trend from a period no longer relevant to current variability. For example, a major shift in consumer preferences for organic produce would not be reflected in data from 10 years prior.

The absolute measure of downward anomaly indicates the deviation of aggregate market farm income with absence of government payments for a particular year from the expected aggregate performance of farms in a county. We also calculate the relative measure of downward anomaly which can be formulated as follows:

$$RDA_{it} = \frac{ADA_{it}}{|\,\overline{\pi}_i|}$$

Where RDA stands for relative downward anomaly and $\overline{\pi}_i$ is the sample mean of the market farm income the county i. Since we measure the downward anomaly in absolute values, we also get the absolute value of the county-level means to avoid negative relative anomaly.

The last two measures of stability are widely used in the literature which are standard deviation (SD) and relative standard deviation. We measure the SD of the market farm income as follows:

$$SD_i \ = \sqrt{\frac{1}{4}\Sigma_{t-2}^{t+2}(\pi_{it} - \overline{\pi}_i)^2}$$

SD of a county indicates the amount of variation or dispersion around the mean of market farm income over time. Measuring the SD of market farm income at the county level enables assessment of differences in stability between individual counties, which is not possible when examining SD for a particular county. We also measure the relative standard deviation as follows:

$$RSD_i = \frac{SD_i}{|\,\overline{\pi}_i|}$$

Where RSD stands for relative standard deviation. $\overline{\pi}_i$ is the sample mean of the market farm income the county i.

3.2 Measuring Resilience

To measure resilience of U.S. counties, we first identify several shock years observing the trend in U.S. market farm income over the years. Figure 2 depicts the rise and fall of the U.S. market farm income and figure 4 represents the downward anomaly in market farm income over the years. We keep two aspects in mind while choosing shock years. First, there has to be a significant decline in farm income in that year compared to the previous year, Second, there has to be a significant rebound or improvement in farm income in the following year (next to the shock year). This is important because our resilience measure is based on the concepts of drop and rebound. Based on our criterion, we identified six shock years when farm income dropped dramatically and there were rebounds in the following years. Therefore, the shock years are: 1980, 1983, 1995, 1999, 2009, and 2020. Based on these six shock years, we quantify the degree of resilience of U.S. counties by measuring both absolute and relative resilience.

To measure the absolute resilience (AR) of counties, we follow similar methodology used by Han & Goetz (2015 and 2019). Following these studies, we first measure the changes in market farm income in the drop year and rebound year. A drop year represents the year when farm income declines due to negative impact of the shock and rebound year represents when farm income bounces back after the shock is over or negative impact becomes lesser. Figure 1 illustrates the concept of drop and rebound.

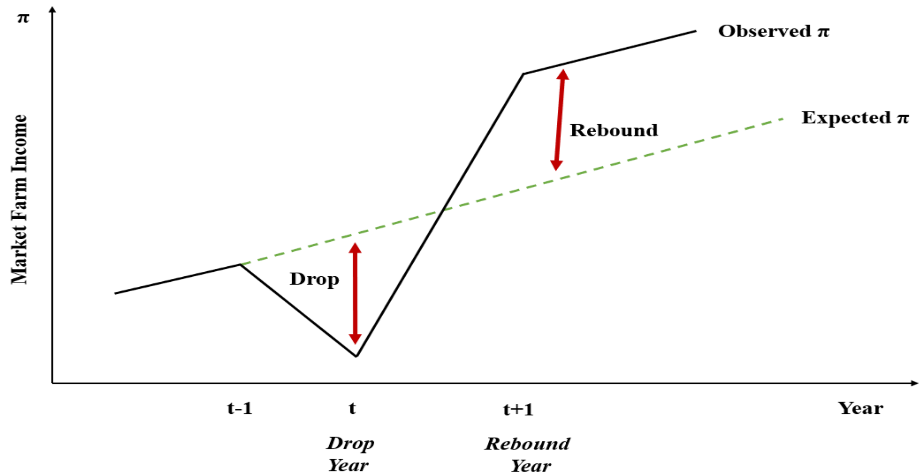

Figure 1. Concept of drop and rebound in resilience calculation.
(Note: Drop and rebound represent the difference between the expected and observed market farm income of a county. In this study, drop years, t, are 1980, 1983, 1995, 1999, 2009, and 2020).

We formularize "drop" in the following way:

$$Drop_{it} = \begin{cases} \left(\dfrac{\pi_{expected} - \pi_{observed}}{\pi_{expected}}\right) * 100 & if \quad \pi_{expected} > \pi_{observed} \\ 0 & if \quad \pi_{expected} < \pi_{observed} \end{cases}$$

A larger drop represents a less resilient county. We calculate the expected market farm income for a particular county and year using the compound annual growth rate (CAGR). We assume that the expected market farm income of a county follows a long-run growth path in the absence of any shock. Thus, we calculate this path for each county at the year t-1 using a Compound Annual Growth Rate (CAGR).

$$CAGR = \left[\left(\frac{Ending\ Value}{Beginning\ Value}\right)^{\frac{1}{Number\ of\ years}} - 1\right] * 100\%$$

Let's assume that the CAGR in the market farm income for county i at pre-shock year is "θ_{it-1}", given that the drop in market farm income takes place in the year t. Then the compound annual growth rate, θ_i, at the year t-1 is calculated as follows:

$$\theta_{it-1} = \left(\frac{\pi_{t-1}}{\pi_{t-4}}\right)^{\frac{1}{3}} - 1$$

Using the CAGR, we compute the expected farm income for county i at time t and t+1 as follows:

$$\widehat{\pi_t} = \pi_{t-1}(1 + \theta_{it-1})$$

$$\widehat{\pi_{t+1}} = \pi_t (1 + \theta_{it-1})^2$$

Then, we measure the "rebound" in market farm income. A rebound is the ability of a county to bounce back after the shock years is over.

$$Rebound_{it+1} = \begin{cases} \left(\frac{\pi_{observed} - \pi_{expected}}{\pi_{expected}}\right) * 100 & if \quad \pi_{observed} > \pi_{expected} \\ 0 & if \quad \pi_{observed} < \pi_{expected} \end{cases}$$

Absolute resilience (AR) is the ratio of the above two measures: drop and rebound. measured through the following formula:

$$AR_{it} = log\left[\frac{Rebound_{it+1} - min(Rebound_i) + 1}{Drop_{it} - min(Drop_i) + 1}\right]$$

If a county experiences a smaller drop and more rebound in the same shock year, that county is more resilient than others.

To measure relative resilience (RR) of a county, we calculate a sensitivity index, following Faggian et al. (2018). This sensitivity index compares how much a county bounces back compared to other counties within the same state or region. To compute this sensitivity index, we only focus on recovery phase. First, we calculate the change in market farm income at the county, state, and regional level in the following way:

$$\Delta \pi_{ct+1} = \frac{\pi_{it+1} - \pi_{it}}{|\pi_{it}|}$$

$$\Delta \pi_{st+1} = \frac{\pi_{st+1} - \pi_{st}}{|\pi_{st}|}$$

$$\Delta \pi_{rt+1} = \frac{\pi_{rt+1} - \pi_{rt}}{|\pi_{rt}|}$$

Where $\Delta \pi_{ct+1}$, $\Delta \pi_{st+1}$, and $\Delta \pi_{rt+1}$ represents percentage change in market farm income in the rebound year for each county c, state s, and region r. We calculate the relative resilience (RR) by the following formula:

$$RR_{is} = \frac{\Delta \pi_{ct+1} - \Delta \pi_{st+1}}{|\Delta \pi_{st+1}|}$$

$$RR_{ir} = \frac{\Delta \pi_{ct+1} - \Delta \pi_{rt+1}}{|\Delta \pi_{rt+1}|}$$

Where RR_{is} and RR_{ir} represents relative resilience of county i compared with state s or region r.

3.3 Model Specification

To estimate the impact of CRP rental payments and crop insurance payments on stability and resilience of market farm income the following two equations have been estimated using county-level panel data with fixed effect to account for unobserved heterogeneity across counties. Estimation of the model parameters is carried out using the two-stage least squares (2SLS) method to address endogeneity concerns.

The econometric model for stability is specified as follows:

$$Stability_{it} = \beta_0 + \beta_1 * CrpRental_{it} + \beta_2 * PSPDL_{it} + \beta_3 * TimeTrend_{it} + \beta_4 * TimeTrendSquared_{it} + \beta_5 * PopDensity_{it} + \beta_6 * Precipitation_{it} + \beta_7 * Temperature_{it} + \varepsilon_{it} \quad (1)$$

The econometric model for resilience is specified as follows:

$$Resilience_{it} = \beta_0 + \beta_1 * CrpRental_{it} + \beta_2 * PSPDL_{it} + \beta_3 * TimeTrend_{it} + \beta_4 * PopDensity_{it} + \beta_5 * Precipitation_{it} + \beta_6 * Temperature_{it} + \varepsilon_{it} \quad (2)$$

Where the stability and resilience measures are the outcome variables and *CrpRental* and *PSPDL* are key explanatory variables of interest. *CrpRental* is the total rental payments for CRP by county and *PSPDL* is used to represents crop insurance demand by county. *PSPDL* stands for premium subsidy per dollar of liability and calculated as follows:

$$PSPDL = \frac{Total\ subsidy\ by\ county}{Total\ liability\ by\ county}$$

The other explanatory variables in the equation (1) and (2) represent control variables for these two econometric models. First, the $TimeTrend$ and $TimeTrendSquared$ represents control for time, in this case year. Second, $PopDensity$ represents the population density by county. Finally, $Precipitation$ and $Temperature$ represent weather variables.

To address potential endogeneity issues between CRP and crop insurance as mentioned by (DeLay, 2019) , instrumental variables are employed for the endogenous variables CRP and

PSPDL. For CROP rental payments, we use total cropland are by county as an instrumental variable. The IV has been calculated as follows:

$$CropLandArea = AcresHarvested_{1968} * (0.25 * CRP\_CAP)$$

Where $AcresHarvested$ represents total crop acreage harvested in the year 1968 and CRP_CAP represents conservation reserve program CAP. We use total crop acreage harvested in the year 1968 because it is outside of our data frame of this study, showing the exogeneity of these quantities. We also use CRP_CAP because it is determined by the federal legislature.

To generate an instrument for crop insurance or $PSPDL$, we use the product of insured acreage in 1994 and subsidy rate for crops by county.

$$CropSubsidy = \Delta\, InsuredAcreage_{1994} * SubsidyRate$$

To calculate the change in insured acres in 1994, we use the following formula:

$$\Delta\, InsuredAcreage_{1994} = \frac{InsuredAcreage_{1995} - InsuredAcreage_{1994}}{InsuredAcreage_{1994}}$$

We also calculate the subsidy rate as follows:

$$SubsidyRate_{it} = \frac{TotalSubsidy_{it}}{TotalPremium_{it}}$$

Finally, we estimate the model parameters using the two-stage least squares (2SLS) method to address endogeneity concerns.

4. Results

Table 2 and 3 illustrate the regression results on the absolute and relative downward anomaly. Results show that CRP rental payments reduce both absolute and relative downward anomaly in market farm income. According to our preferred model 5, with a 1% increase in CRP rental payments, the absolute downward anomaly decreases by 0.57% and relative downward anomaly decreases by 0.055%. On the other hand, crop insurance represented by PSPDL increases both absolute and relative downward anomaly in market farm income. In fact, the magnitude of impact increases when we consider longer periods for moving average (5 years). According to our preferred model 5, with a 1% increase in PSPDL, the absolute downward anomaly increases by 4.58% and the relative downward anomaly increases by 0.31%.

Table 4 and 5 demonstrate the regression results on the absolute and relative variability measured by standard deviations. Results show that CRP rental payments reduce absolute variability. According to our preferred model 5, with a 1% increase in CRP rental payments, the absolute variability decreases by 0.038%. However, for relative variability in market farm income, the impact of CRP is not statistically significant when we use a 5-year moving average. On the other hand, crop insurance represented by PSPDL increases absolute variability in market farm income. In fact, the magnitude of impact increases when we consider longer periods for moving average (5 years). According to our preferred model 5, with a 1% increase in PSPDL, the absolute variability increases by 0.31%. We do not find statistically significant impact of crop insurance on relative variability.

Table 6 presents regression results on the impact of CRP and crop insurance on absolute resilience in market farm income. Results show that CRP rental payments increase absolute resilience. In fact, with a 1% increase in CRP rental payments, the absolute resilience increases by 0.97%. On the other hand, we do not find any statistically significant evidence that crop insurance has any impact on absolute resilience.

Table 7 presents regression results on the impact of CRP and crop insurance on relative resilience in market farm income. We do not find any statistically significant evidence that CRP rental payments have any impact on relative resilience. However, we find that crop insurance reduces relative resilience in market farm income. One possible explanation of this relationship is that many studies have found moral hazard issues with crop insurance adoption. In other words, farmers become less efficient after adopting crop insurance.

4 Conclusion

We investigate the role of two key federal farm programs: conservation reserve program (CRP) and federal crop insurance program in bringing stability and resilience in regional farm income in the US. To determine the impact of these payments, we first measure the market farm income by county by deducting all kinds of government payments from aggregate farm income from 1969 to 2022. Second, using this regional market farm income data, we calculate four measures of stability and two measures of resilience. To measure resilience, we identify six shock years within our data framework when market farm income dropped significantly. Finally, we regress these stability and resilience measures with our key variables of interest (government payment for CRP and Crop insurance) using instrumental variables, along with other control variables such as population density and climate variables. Panel fixed effects and probit models with two stage estimation have been utilized to estimate the impact CRP and Crop insurance on the stability and resilience measures.

Through this study, we make several significant contributions to the existing literature. First, we show the beneficial impact of CRP rental payments on reducing both absolute and relative downward anomalies in market farm income at the county-level. This suggests that policies promoting CRP participation can contribute to stabilizing farm income and mitigating farm income volatility. Second, contrary to CRP, our findings reveal that crop insurance, as represented by PSPDL, increases both absolute and relative downward anomalies in market farm income. This finding underscores the importance of considering the unintended consequences of crop insurance programs, particularly in terms of intensifying farm income volatility. Third, we contribute to the existing literature by uncovering a positive association between CRP rental payments and absolute resilience. This suggests that CRP participation enhances the ability of farm income to withstand shocks and fluctuations. Finally, we shed light on the potential moral hazard issues associated with crop insurance adoption by showing the negative impact of crop insurance on the relative resilience in market farm income. This finding contributes to the ongoing debate surrounding the efficacy and unintended consequences of crop insurance programs.

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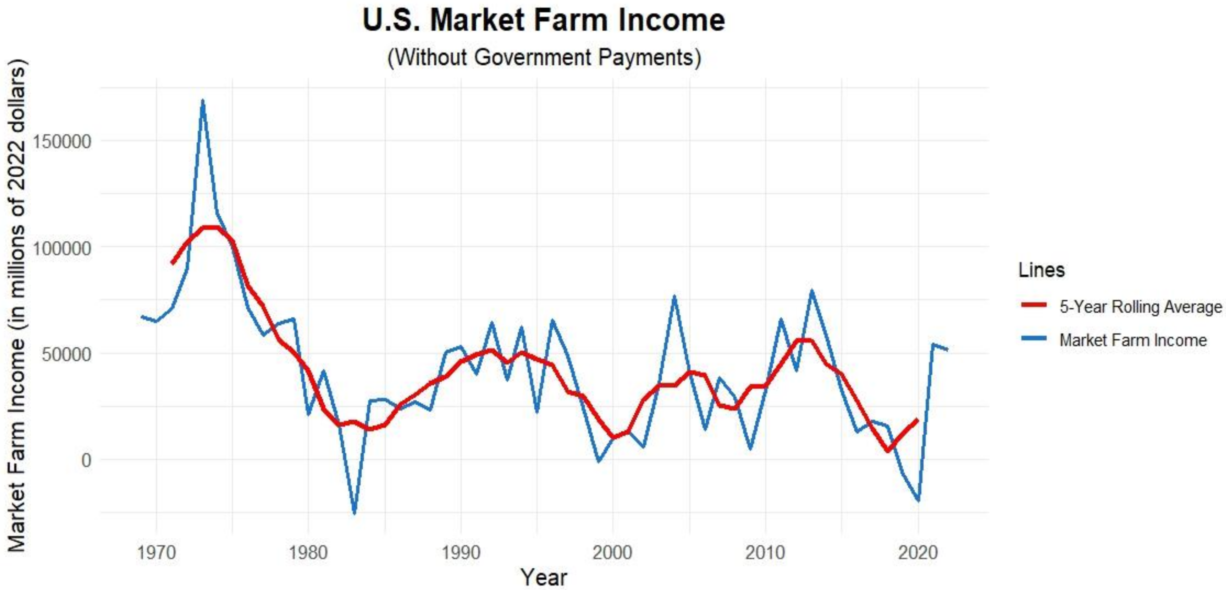

Figure 2. Distribution of U.S. market farm income from 1969 to 2022.

Notes: (1) Market farm income is calculated by deducting all types of government payments to producers including payments from CRP and crop insurance. (2) Producer price index (PPI) has been used to deflate the nominal farm income. (3) The unit of market farm income is in millions of 2022 dollars. (4) The five- year rolling average has been calculated by summing up market farm income of current year, 2 previous years, and 2 forward years and then dividing by 5.

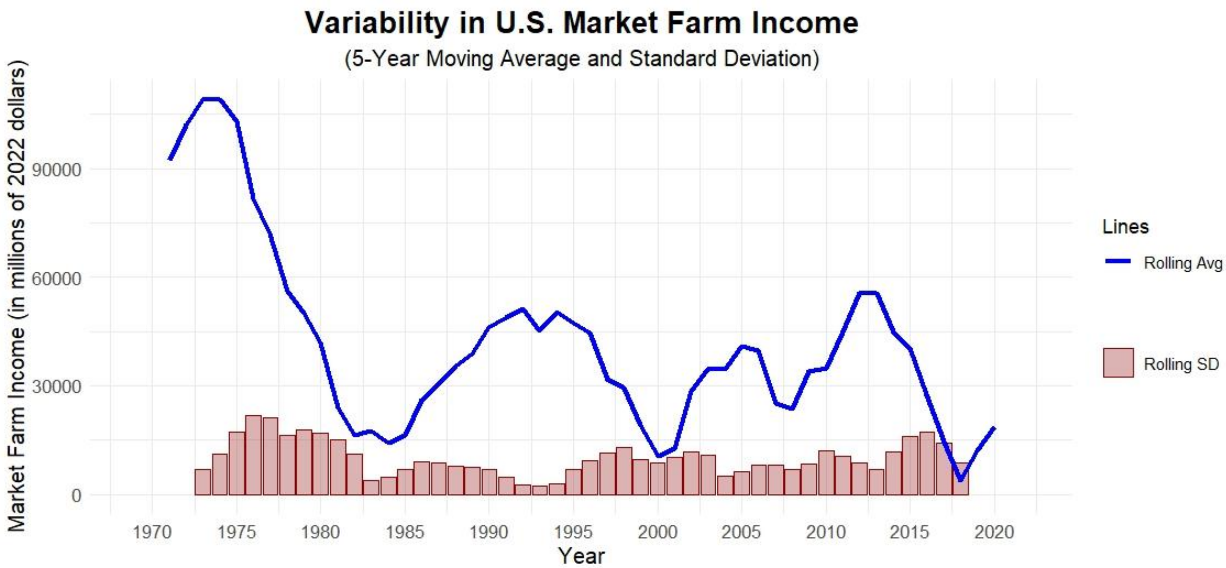

Figure 3. Distribution of five- year rolling average and standard deviation (SD) of the U.S. market farm income from 1969 to 2022.

Notes: (1) The five- year rolling average has been calculated by summing up market farm income of current year, 2 previous years, and 2 forward years and then dividing by 5. (2) The five- year rolling SD has been calculated by summing up squared mean deviation (difference between farm income and five-year rolling average) in market farm income of current year, 2 previous years, and 2 forward years and then dividing by 5. (3) Market farm income is calculated by deducting all types of government payments to producers including payments from CRP and crop insurance. (4) Producer price index (PPI) has been used to deflate the nominal farm income. (5) The unit of market farm income is in millions of 2022 dollars.

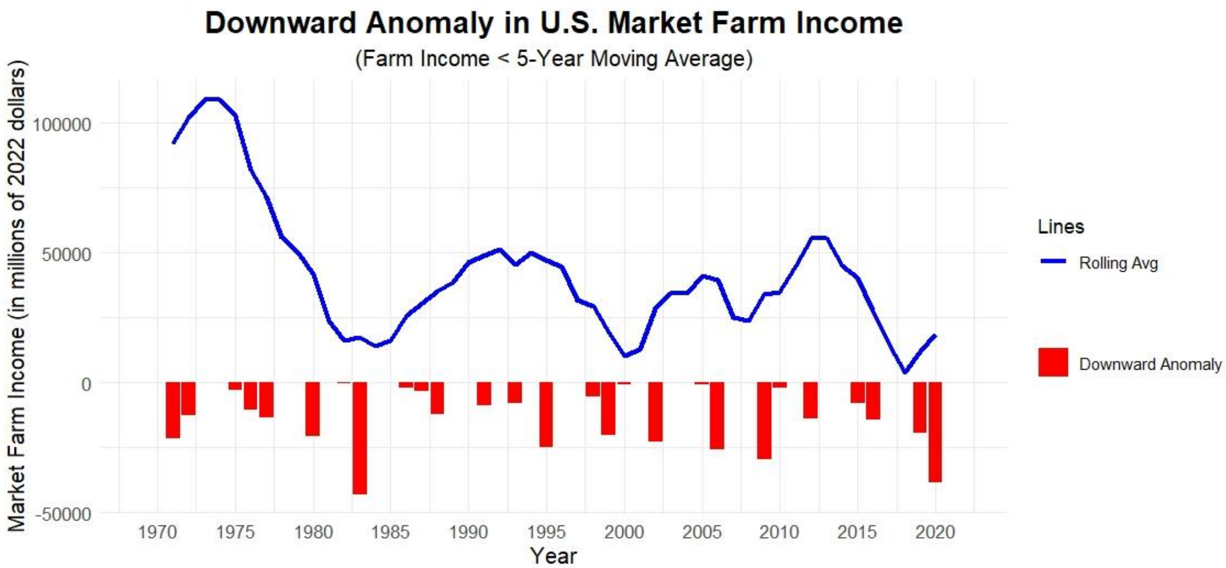

Figure 4. Distribution of five- year rolling average and downward anomaly of the U.S. market farm income from 1969 to 2022.

Notes: (1) The five- year rolling average has been calculated by summing up market farm income of current year, 2 previous years, and 2 forward years and then dividing by 5. (2) Downward anomaly by year is the absolute mean deviation (absolute value of the difference between farm income and five-year rolling average) in market farm income. (3) Market farm income is calculated by deducting all types of government payments to producers including payments from CRP and crop insurance. (4) Producer price index (PPI) has been used to deflate the nominal farm income. (5) The unit of market farm income is in millions of 2022 dollars.

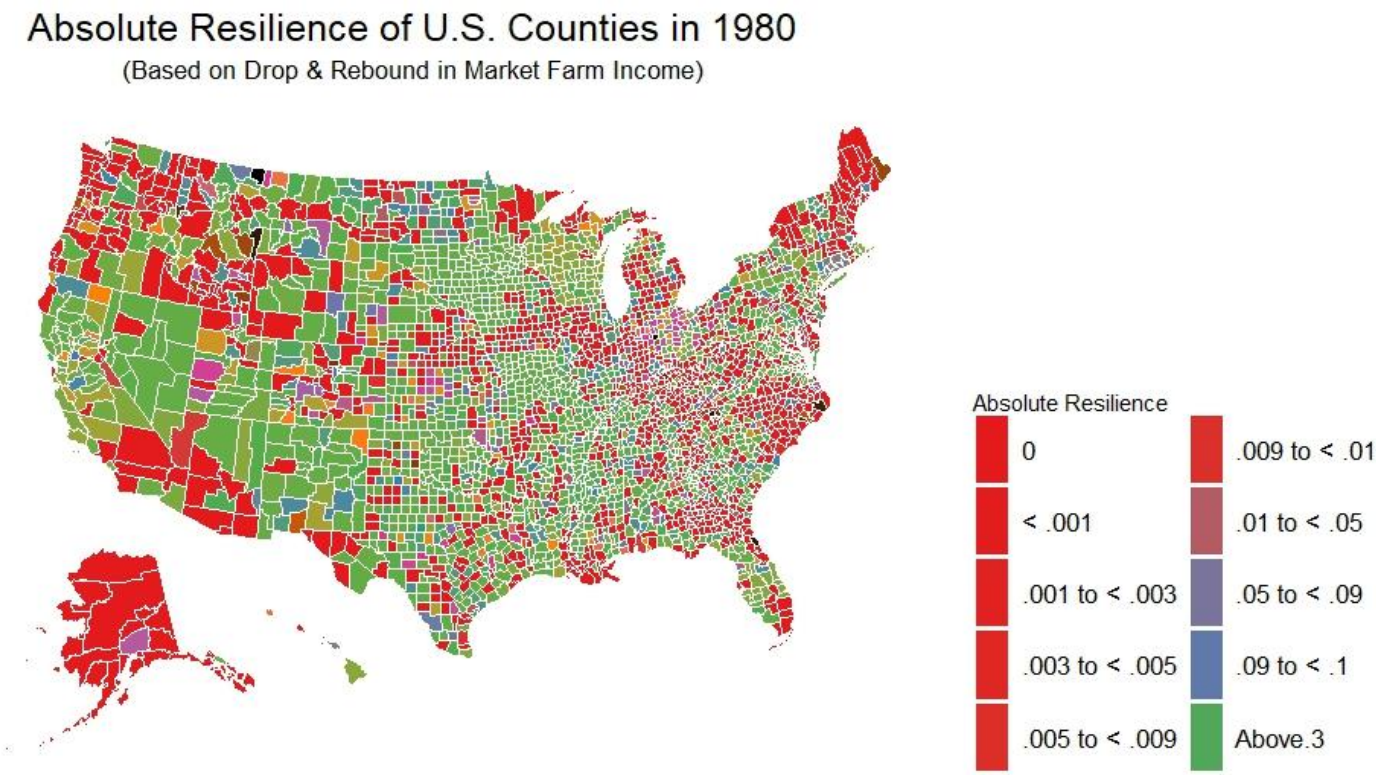

Figure 5. Distribution of absolute resilience of U.S. counties in 1980.

Notes: (1) Absolute Resilience (AR) of counties is calculated based on the changes in market farm income in the drop year and rebound year. (2) Drop year represents the year when farm income declines due to negative impact of the shock. (3) Rebound year represents when farm income bounces back after the shock is over or negative impact becomes lesser. (4) "Drop" and "Rebound" represent the difference between the expected and observed values in market farm income in drop and rebound year. (5) Absolute Resilience (AR) is the ratio of "Drop" and "Rebound" in market farm income. (6) Market farm income is calculated by deducting all types of government payments to producers including payments from CRP and crop insurance.

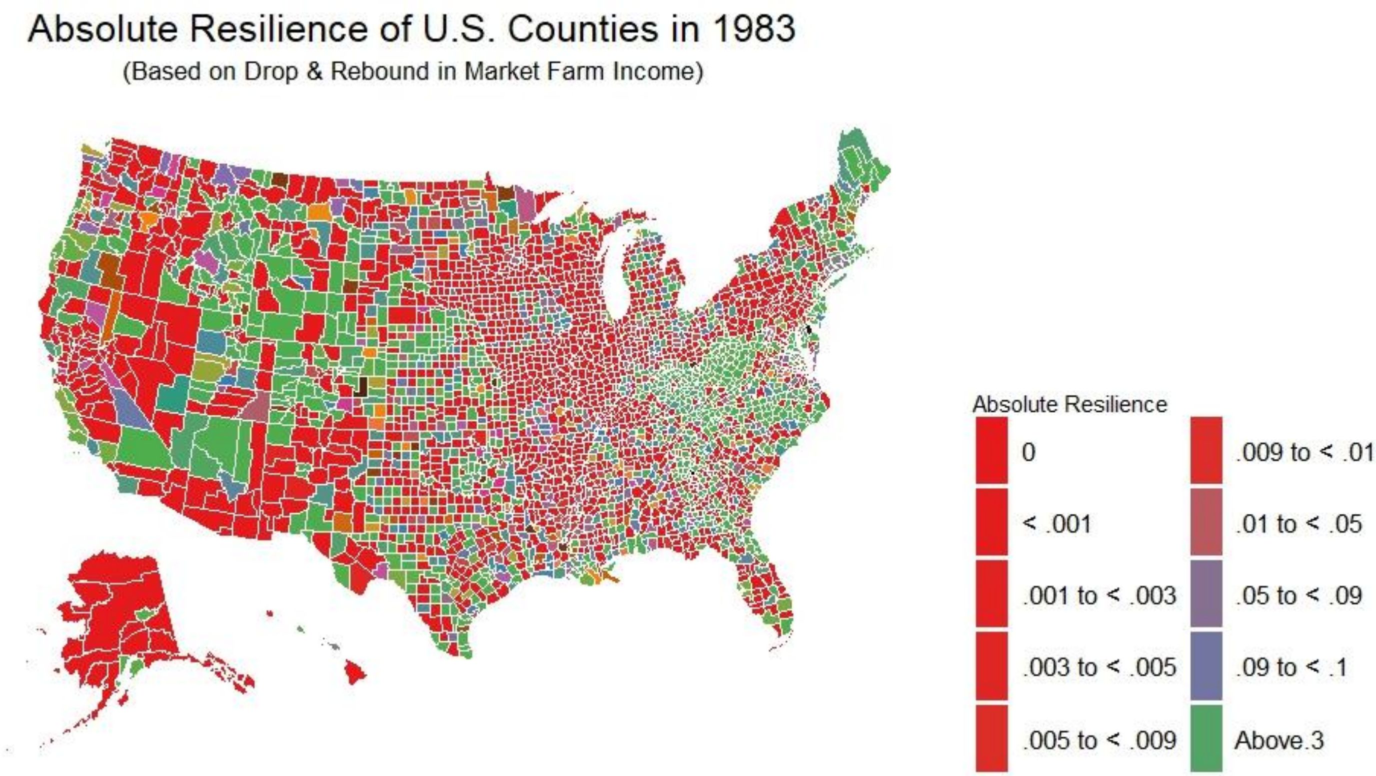

Figure 6. Distribution of absolute resilience of U.S. counties in 1983.

Notes: (1) Absolute Resilience (AR) of counties is calculated based on the changes in market farm income in the drop year and rebound year. (2) Drop year represents the year when farm income declines due to negative impact of the shock. (3) Rebound year represents when farm income bounces back after the shock is over or negative impact becomes lesser. (4) "Drop" and "Rebound" represent the difference between the expected and observed values in market farm income in drop and rebound year. (5) Absolute Resilience (AR) is the ratio of "Drop" and "Rebound" in market farm income. (6) Market farm income is calculated by deducting all types of government payments to producers including payments from CRP and crop insurance.

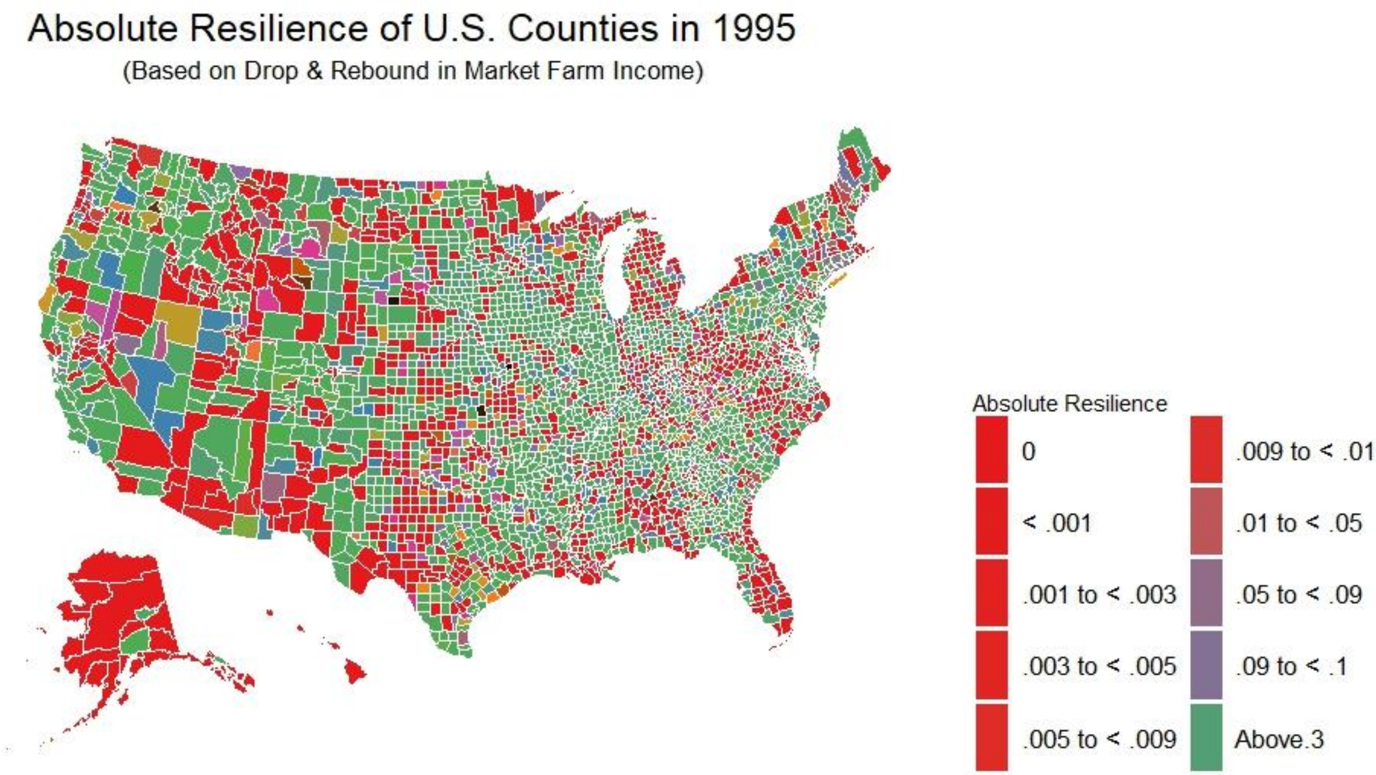

Figure 7. Distribution of absolute resilience of U.S. counties in 1995.

Notes: (1) Absolute Resilience (AR) of counties is calculated based on the changes in market farm income in the drop year and rebound year. (2) Drop year represents the year when farm income declines due to negative impact of the shock. (3) Rebound year represents when farm income bounces back after the shock is over or negative impact becomes lesser. (4) "Drop" and "Rebound" represent the difference between the expected and observed values in market farm income in drop and rebound year. (5) Absolute Resilience (AR) is the ratio of "Drop" and "Rebound" in market farm income. (6) Market farm income is calculated by deducting all types of government payments to producers including payments from CRP and crop insurance.

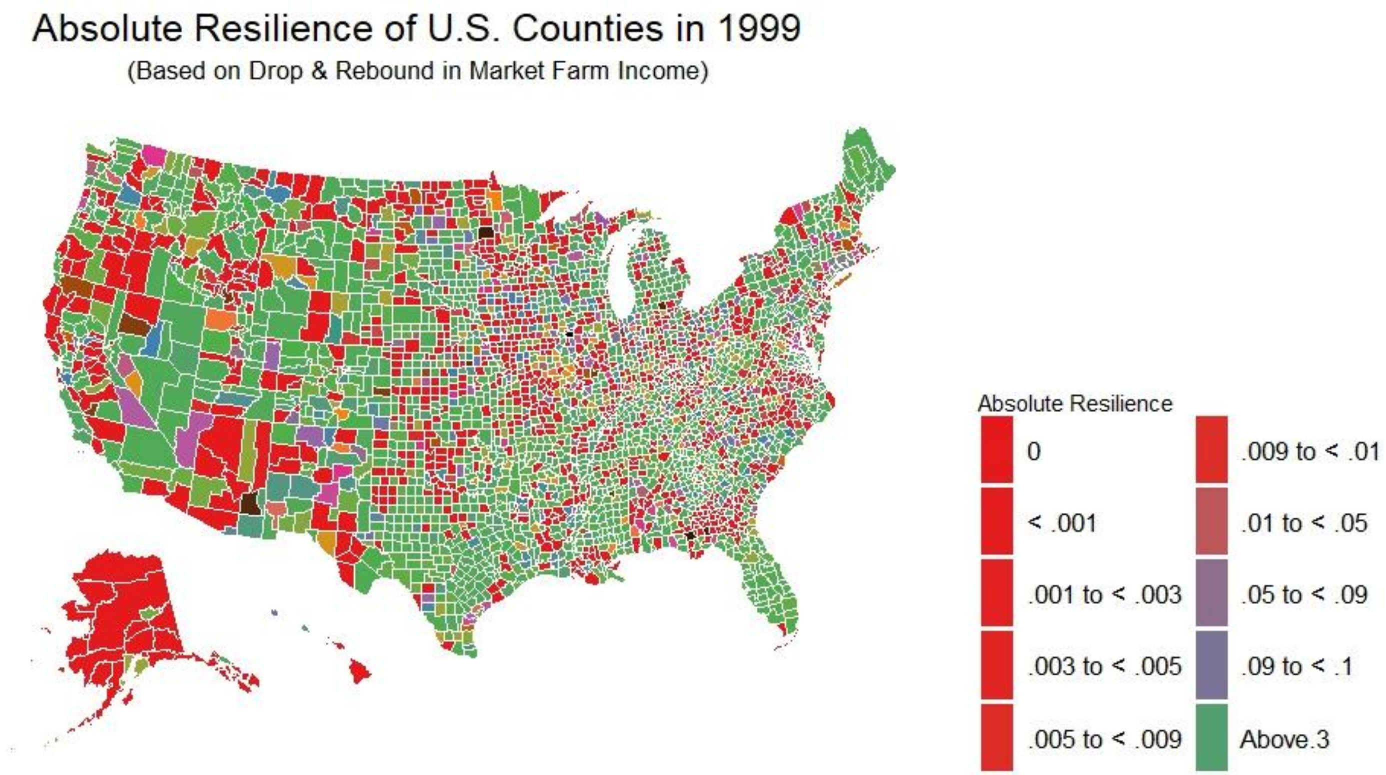

Figure 8. Distribution of absolute resilience of U.S. counties in 1999.

Notes: (1) Absolute Resilience (AR) of counties is calculated based on the changes in market farm income in the drop year and rebound year. (2) Drop year represents the year when farm income declines due to negative impact of the shock. (3) Rebound year represents when farm income bounces back after the shock is over or negative impact becomes lesser. (4) "Drop" and "Rebound" represent the difference between the expected and observed values in market farm income in drop and rebound year. (5) Absolute Resilience (AR) is the ratio of "Drop" and "Rebound" in market farm income. (6) Market farm income is calculated by deducting all types of government payments to producers including payments from CRP and crop insurance.

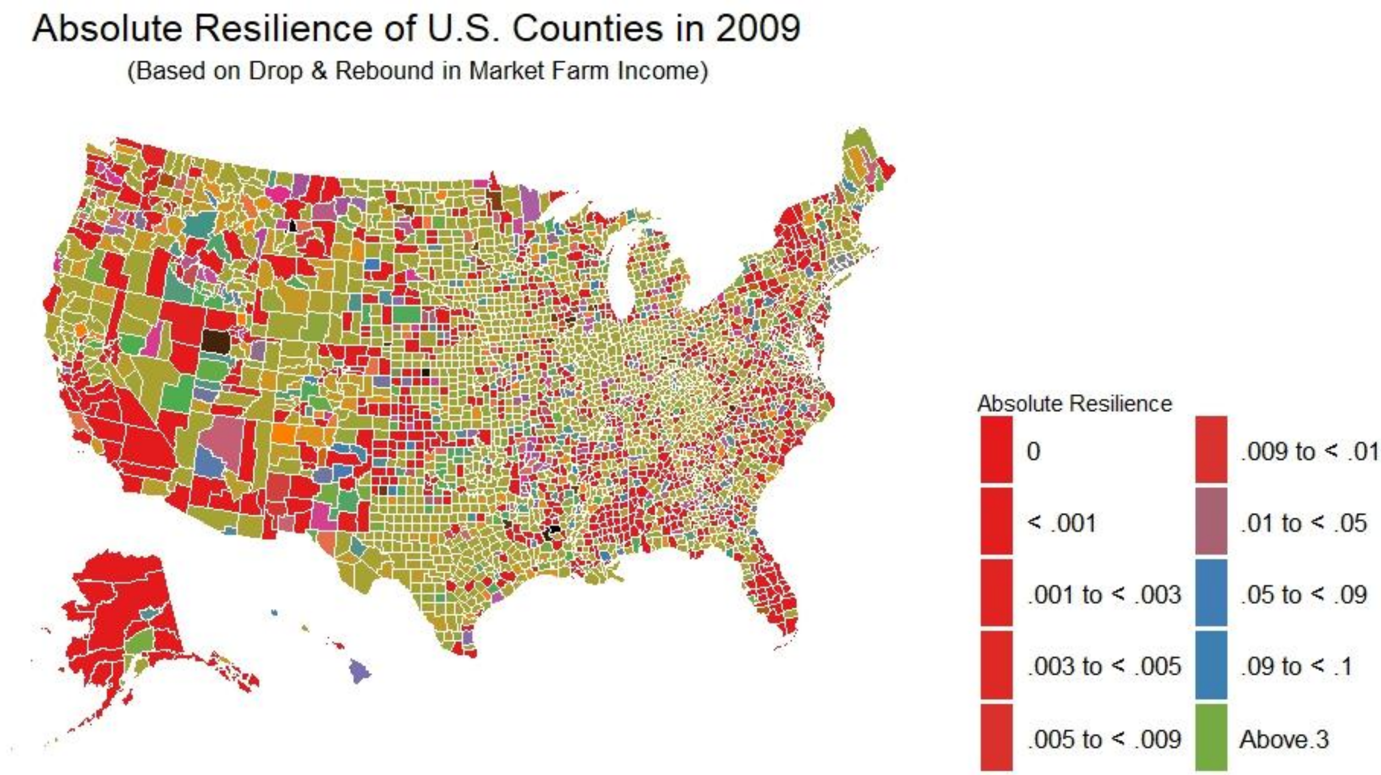

Figure 9. Distribution of absolute resilience of U.S. counties in 2009.

Notes: (1) Absolute Resilience (AR) of counties is calculated based on the changes in market farm income in the drop year and rebound year. (2) Drop year represents the year when farm income declines due to negative impact of the shock. (3) Rebound year represents when farm income bounces back after the shock is over or negative impact becomes lesser. (4) "Drop" and "Rebound" represent the difference between the expected and observed values in market farm income in drop and rebound year. (5) Absolute Resilience (AR) is the ratio of "Drop" and "Rebound" in market farm income. (6) Market farm income is calculated by deducting all types of government payments to producers including payments from CRP and crop insurance.

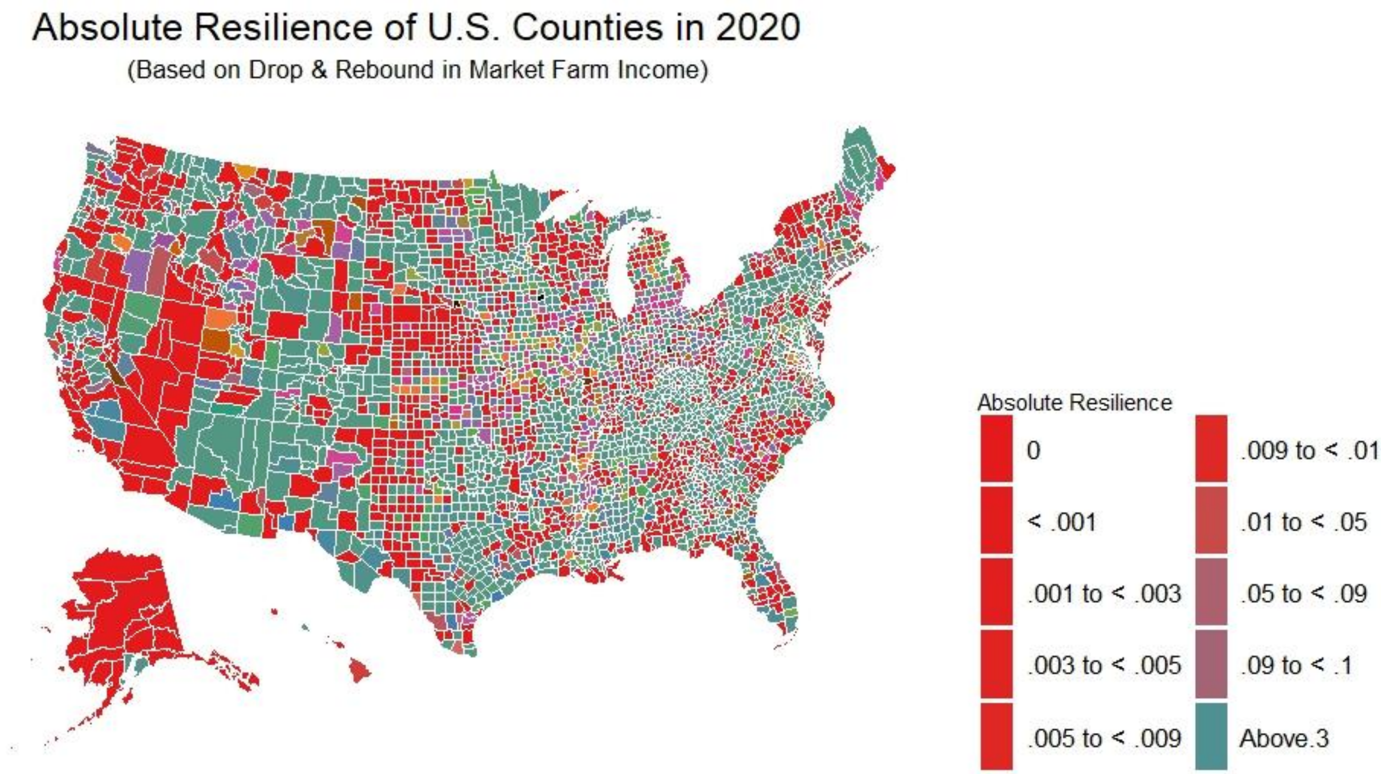

Figure 10. Distribution of absolute resilience of U.S. counties in 2020.

Notes: (1) Absolute Resilience (AR) of counties is calculated based on the changes in market farm income in the drop year and rebound year. (2) Drop year represents the year when farm income declines due to negative impact of the shock. (3) Rebound year represents when farm income bounces back after the shock is over or negative impact becomes lesser. (4) "Drop" and "Rebound" represent the difference between the expected and observed values in market farm income in drop and rebound year. (5) Absolute Resilience (AR) is the ratio of "Drop" and "Rebound" in market farm income. (6) Market farm income is calculated by deducting all types of government payments to producers including payments from CRP and crop insurance.

Table 1. Summary Statistics

Variable	Observation	Mean	Std. dev.	Min	Max
Market Farm Income by Counties	167,919	13631.89	66064	-338193.6	2849725
Market Farm Income by States	169,560	1041050	2270870	-5868487	2.19e+07
Market Farm Income by BEA Regions	169,560	7177041	9034797	-1.49e+07	5.84e+07
Total Rental Payment of Conservation Reserve Program (CRP)	174,112	559.1458	1497.424	0	24321.49
Crop Insurance: Premium Subsidy Per Dollar of Liability (PSPDL)	144,723	.0536979	.0420917	0	.7880031
Instrumental Variable for CRP	148,285	1.11e+08	1.98e+08	0	2.82e+09
Instrumental Variable for Crop Insurance (PSPDL)	129,534	7.818241	29.44159	-7.430981	1483.156
Population Density	163,008	180.8992	1182.925	.0331769	50561.07
Annual Precipitation (sum)	167,454	1005.351	409.723	12.73195	4306.115
Annual Temperature (mean)	167,616	12.49371	4.580648	-.913638	26.0148

Table 2. Determinants of Absolute Downward Anomaly (ADA): Two-Stage Least Squares Using Instrumental Variables (IVs)

Dependent Variable: Absolute Downward Anomaly (ADA)	**Model 1** *(Using 3-years Moving Average)*	**Model 2** *(Using 4-years Moving Average)*	**Model 3** *(Using 5-years Moving Average)*
Independent Variables:			
Log of CRP Total Rental Payment	-0.685*** (0.109)	-0.278* (0.113)	-0.574*** (0.114)
Log of Premium Subsidy Per Dollar of Liability (PSPDL)	2.174*** (0.518)	4.381*** (0.540)	4.577*** (0.543)
Time Trend	-5.954 (4.335)	-28.18*** (4.518)	-28.05*** (4.548)
Time Trend Squared	0.00146 (0.00108)	0.00699*** (0.00112)	0.00695*** (0.00113)
Population Density	-0.000960 (0.000736)	0.000866 (0.000767)	0.000270 (0.000772)
Annual Precipitation (sum)	0.00183*** (0.0000924)	0.00147*** (0.0000963)	0.00199*** (0.0000969)
Annual Temperature (mean)	-0.0476* (0.0238)	0.0770** (0.0248)	0.0601* (0.0250)
Number of Observations	73526	73526	73526

*Notes: Asterisks indicate the following p-values: * p < 0.05, ** p < 0.01, *** p < 0.001. Standard errors in parentheses.*

Table 3. Determinants of Relative Downward Anomaly (RDA): Two-Stage Least Squares Using Instrumental Variables (IVs)

Dependent Variable:	**Model 1**	**Model 2**	**Model 3**
Relative Downward Anomaly (RDA)	*(Using 3-years Moving Average)*	*(Using 4-years Moving Average)*	*(Using 5-years Moving Average)*
Independent Variables:			
Log of CRP Total Rental Payment	-0.215*** (0.0261)	-0.0687** (0.0253)	-0.0553* (0.0251)
Log of Premium Subsidy Per Dollar of Liability (PSPDL)	-0.00776 (0.124)	0.232 (0.120)	0.272* (0.119)
Time Trend	3.034** (1.041)	-0.442 (1.008)	-1.281 (1.000)
Time Trend Squared	-0.000757** (0.000259)	0.000109 (0.000250)	0.000318 (0.000248)
Population Density	-0.000800*** (0.000177)	-0.000689*** (0.000171)	-0.000518** (0.000170)
Annual Precipitation (sum)	0.0000725** (0.0000222)	0.000000987 (0.0000215)	0.0000125 (0.0000213)
Annual Temperature (mean)	-0.0191*** (0.00572)	-0.0176** (0.00554)	-0.0222*** (0.00549)
Number of Observations	73526	73526	73526

*Notes: Asterisks indicate the following p-values: * p < 0.05, ** p < 0.01, *** p < 0.001. Standard errors in parentheses.*

Table 4. Determinants of Absolute Variability: Two-Stage Least Squares Using Instrumental Variables (IVs)

Dependent Variable:	**Model 1**	**Model 2**	**Model 3**
Standard Deviation (SD)	*(Using 3-years Moving Average)*	*(Using 4-years Moving Average)*	*(Using 5-years Moving Average)*
<u>Independent Variables:</u>			
Log of CRP Total Rental Payment	-0.0669*** (0.0147)	-0.0779*** (0.0145)	-0.0376** (0.0126)
Log of Premium Subsidy Per Dollar of Liability (PSPDL)	0.242*** (0.0701)	0.254*** (0.0691)	0.310*** (0.0585)
Time Trend	1.356* (0.587)	1.286* (0.578)	0.775 (0.505)
Time Trend Squared	-0.000339* (0.000146)	-0.000321* (0.000144)	-0.000195 (0.000126)
Population Density	-0.000835*** (0.0000996)	-0.000889*** (0.0000981)	-0.000781*** (0.0000846)
Annual Precipitation (sum)	-0.000109*** (0.0000125)	-0.000131*** (0.0000123)	-0.0000425*** (0.0000106)
Annual Temperature (mean)	-0.0758*** (0.00322)	-0.0775*** (0.00318)	-0.0776*** (0.00268)
Number of Observations	73524	73524	71460

*Notes: Asterisks indicate the following p-values: * p < 0.05, ** p < 0.01, *** p < 0.001. Standard errors in parentheses.*

Table 5. Determinants of Relative Variability: Two-Stage Least Squares Using Instrumental Variables (IVs)

Dependent Variable:	**Model 1**	**Model 2**	**Model 3**
Standard Deviation (SD)	*(Using 3-years Moving Average)*	*(Using 4-years Moving Average)*	*(Using 5-years Moving Average)*
Independent Variables:			
Log of CRP Total Rental Payment	-0.0651^{*}	-0.149^{***}	-0.0381
	(0.0289)	(0.0291)	(0.0287)
Log of Premium Subsidy Per Dollar of Liability (PSPDL)	-0.0900	0.0542	0.244
	(0.138)	(0.139)	(0.133)
Time Trend	4.262^{***}	3.826^{***}	1.786
	(1.152)	(1.160)	(1.150)
Time Trend Squared	-0.00107^{***}	-0.000958^{***}	-0.000451
	(0.000286)	(0.000288)	(0.000286)
Population Density	-0.000791^{***}	-0.000938^{***}	-0.000427^{*}
	(0.000195)	(0.000197)	(0.000192)
Annual Precipitation (sum)	-0.0000278	-0.0000369	0.0000465
	(0.0000245)	(0.0000247)	(0.0000242)
Annual Temperature (mean)	-0.0863^{***}	-0.0932^{***}	-0.0882^{***}
	(0.00633)	(0.00637)	(0.00609)
Number of Observations	73524	73524	71460

*Notes: Asterisks indicate the following p-values: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Standard errors in parentheses.*

Table 6. Determinants of Absolute Resilience (AR): Two-Stage Least Squares Using Instrumental Variables (IVs)

Dependent Variable: Absolute Resilience (AR)	Coefficient	Standard Error	z	P > |z|	95% Confidence Interval	
<u>Independent Variables:</u>						
Log of CRP Total Rental Payment	1.109144	0.294311	3.77	0.000	.5323063	1.685982
Log of Premium Subsidy Per Dollar of Liability (PSPDL)	-0.4020554	1.450445	-0.28	0.782	-3.244876	2.440765
Time Trend	0.0758287	0.022208	3.41	0.001	.0323019	.1193556
Population Density	0.0008673	0.0016649	0.52	0.602	-.0023959	.0041305
Annual Precipitation (sum)	-0.0002408	0.0003452	-0.70	0.485	-.0009174	.0004357
Annual Temperature (mean)	0.1942769	0.2441134	0.80	0.426	-.2841766	.6727305
Number of Observations	*8378*					
Model F(6, 6196)	*16.33*					
Prob > F	*0.0000*					

Table 7. Determinants of Relative Resilience (RR) to State Performance: Probit Model Using Instrumental Variables (IVs)

Dependent Variable: Relative Resilience (RR)	Coefficient	Standard Error	z	P > |z|	95% Confidence Interval	
<u>**Independent Variables:**</u>						
Log of CRP Total Rental Payment	-0.0804729	0.0523499	-1.54	0.124	-.1830769	.0221311
Log of Premium Subsidy Per Dollar of Liability (PSPDL)	-0.4821997	0.257563	-1.87	0.061	-.9870139	.0226144
Time Trend	-0.0033344	0.005136	-0.65	0.516	-.0134008	.006732
Population Density	-0.0006561	0.0002209	-2.97	0.003	-.0010891	-.0002231
Annual Precipitation (sum)	-0.0001708	0.0001086	-1.57	0.116	-.0003837	.0000422
Annual Temperature (mean)	0.0240778	0.0051582	4.67	0.000	.0139679	.0341877
Number of Observations	*8,442*					
Wald chi2(6)	*134.44*					
Prob > chi2	*0.0000*					

Table 8. Determinants of Relative Resilience (RR) to Regional Performance: Probit Model Using Instrumental Variables (IVs)

Dependent Variable: Relative Resilience (RR)	Coefficient	Standard Error	z	P > |z|	95% Confidence Interval	
Independent Variables:						
Log of CRP Total Rental Payment	- 0.1391355	.0416685	-3.34	0.001	-.2208042	-.0574668
Log of Premium Subsidy Per Dollar of Liability (PSPDL)	-1.073319	.1703214	-6.30	0.000	-1.407143	-.7394957
Time Trend	0.0078031	.0040522	1.93	0.054	-.0001391	.0157453
Population Density	-0.001092	.0001518	-7.19	0.000	-.0013896	-.0007945
Annual Precipitation (sum)	-0.0004185	.0000767	-5.46	0.000	-.0005688	-.0002682
Annual Temperature (mean)	0.0653256	.0042569	15.35	0.000	.0569823	.0736689
Number of Observations	*8,442*					
Wald chi2(6)	*668.79*					
Prob > chi2	*0.0000*					