HARVESTING DATA: A METHODOLOGY FOR ANALYZING INNOVATIONS IN AGRICULTURAL POLICY

BY

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THESIS

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ABSTRACT

The use of economic modeling, data analysis, and spatial visualization has great potential application in agricultural policymaking. Agricultural production is deeply connected to geographic factors, such as climate, soil composition, and water availability. Policymakers would greatly benefit from the availability of data-driven models that allow visualization of policy outcomes to make more informed decisions. Spatial models and regional specific data offer unique insights into how different policies might impact payment outcomes for agricultural subsidy programs as well as the economic viability of these programs across regions. By leveraging these tools, policymakers can adapt their political strategies and opinions to the outcomes of these policies in the context of the agricultural landscapes they represent. This method of policymaking will ensure that their decisions are grounded in comprehensive data but also are linked to the specific needs of their region's agricultural sector. This approach has the potential to pave the way for developing a variety of p(olicies that effectively address the challenges facing agriculture, and this paper will provide a case study using two fictional but realistic policy changes to existing farm programs.

Congress reauthorizes federal agricultural policy approximately every five years in legislation commonly referred to as the Farm Bill. This paper delves into the specifics of one income support program for farmers, the Agriculture Risk Coverage (ARC) program, and presents a methodology for using data to analyze two enhancements specifically tailored to the Midwest's agricultural landscape as specific case studies. By examining the program's provisions, this thesis demonstrates a method for analyzing concrete programmatic changes aimed at improving payout structures and risk coverage. Furthermore, I explore the potential of integrating conservation incentives, specifically cover crops, into ARC, thereby not only

elevating the program's economic outcomes but also fostering environmental stewardship of agricultural land. This approach seeks to explore policy that combines economic and natural resource outcomes that could align the ARC program with broader environmental objectives. Each of the case studies is found to increase payments as compared to the current ARC-County (ARC-CO) program. Under a few assumptions, this increase in payments is hypothesized to drive an increase in enrollment in the altered ARC-CO programs, creating a better suite of options for the midwestern grower as they engage in risk management for their farms.

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CHAPTER 1: THE FARM BILL, COMMODITIES, AND AGRICULTURAL POLICY

1.1 OVERVIEW OF THE FARM BILL

Every five years, absent extensions or delays, the United States Congress reauthorizes what is colloquially known as the Farm Bill. The Farm Bill, which has a different statutory name each time it is authorized, is an omnibus legislative package that sets five years of agricultural and nutrition policy. It is largely under-recognized by the public, despite the sprawling impact it has across industries (Graddy-Lovelace et al., 2020). While it is often directly tied to farm and nutritional assistance programs, it has impacts on university research, international trade programs, market development, animal health and welfare, and more. There are traditionally twelve titles in a farm bill, each with a different purpose. A goal each time a farm bill is reauthorized is to alter it to meet the needs of the time. These changes reflect shifts in farmer attitudes, climate change, market distortions, and other such items that evolve from one farm bill to the next. Ultimately, the reauthorization of the Farm Bill represents an opportunity to adapt agricultural policy to the current landscape, responding to evolving challenges and the diverse needs of the agricultural sector, with the potential to shape far-reaching implications for food security, environmental conservation, and the economic viability of the farming industry.

While the general public may have a lack of awareness about the Farm Bill and its effects, different interest groups take great interest in the process of farm policymaking. Due to the broad nature of this omnibus legislation, lobbying organizations of varying interests and viewpoints advocate for priorities. From crop organizations to nutrition relief supporters to bioenergy advocates, there is a wide range of groups that have a voice in the Farm Bill process (CRS 2023). These groups often have competing agendas, and, even when their agendas are unrelated, they are competing for funding. This leads to a complex set of negotiations, both

within and between the two chambers of Congress. The contentious nature of farm bill negotiations often hinges on complex farm income support or commodity policies that, while representing only a fraction of agricultural legislation, disproportionately influence political dynamics. This disproportionate impact underscores the necessity for inventive policy frameworks that can address the needs of a variety of stakeholders and farmers.

1.2 THE FARM SAFETY NET

There are a variety of aspects of the Farm Bill that go to provide support for farmers in the event of disaster or market failure that are collectively known as the farm safety net. The farm safety net is largely comprised of crop insurance and commodity support. Crop insurance functions like most insurance programs in that farmers pay into the program and receive indemnities when they have approved losses, but it is heavily subsidized by the federal government (unlike many other insurance programs). It was first developed in 1938 and the most recent overhaul of the program took place in 2000 and is now considered the primary form of loss assistance for farmers (Glauber et al., 2002). The federal crop insurance pricing and coverage scheme is complicated; it is regulated by the United States Department of Agriculture Risk Management Agency (USDA RMA) and administered by private insurers. It is the largest and costliest agricultural policy mechanism in the United States, and major modifications to the program could significantly influence government spending, program participation, and production choices. Because crop insurance is not frequently overhauled in farm bill reauthorizations, I do not explore it further in this thesis but rather focus on a different part of the farm safety net with a methodology that could arguably be adapted to crop insurance and other agricultural policy mechanisms as well.

1.3 STATUTORY BACKGROUND OF THE COMMODITY TITLE

Farm income or commodity support is authorized in a different title and is operated by a different agency than crop insurance. These programs are generally administered as subsidy payments directly from the USDA Farm Service Agency (FSA). In the realm of agricultural policy, there is a myriad of interest groups, each with its own perspective on the role of commodity support within the Farm Bill framework, reflecting a landscape of diverse and often competing priorities rather than a clear consensus. These stakeholders, including farmers, policymakers, and industry experts, widely acknowledge the vital role commodity support plays in ensuring the stability and sustainability of the agricultural sector. However, despite widespread agreement on its importance, the divergent opinions within this collective group become apparent when it comes to crafting the specifics of commodity policy.

The Agricultural Act of 2014, hereafter referred to as the 2014 Farm Bill, authorized a significant update to the historical first title of past farm bills. The 2014 Farm Bill saw a removal of the Direct and Counter Cyclical Program, the Supplemental Revenue Assistance Payments Program, and the Average Crop Revenue Election Program and combined parts of each along with new provisions into two new programs. The Agricultural Risk Coverage program (ARC) is a risk-based commodity payment program that uses historical crop data and market data to provide market support for farmers of eligible commodities in the event of market or crop failure. ARC itself is comprised of two subprograms – ARC-County (ARC-CO), the much more commonly used subprogram, and ARC-Individual Coverage (ARC-IC), a farm-level subprogram that is relatively unpopular. Because of this, ARC and ARC-CO are used interchangeably by policymakers and researchers and will also be used interchangeably in this paper. The Price Loss

Coverage program (PLC) is a price-based commodity payment program that uses historical reference prices of eligible commodities when there is a price crash for a certain commodity (Farm Service Agency, 2014). In general, farmers with approved cropping histories with FSA have a choice to enroll those acres in either ARC or PLC.

The Agriculture Improvement Act of 2018, hereafter referred to as the 2018 Farm Bill, provided several updates to the ARC/PLC program while maintaining in general the programmatic structure of both. The 2018 Farm Bill revised some calculations for final payments. As reauthorized in 2018, ARC and PLC payments are for a defined list of a total of 22 eligible crops: wheat, oats, barley, corn, grain sorghum, long grain rice, medium/short grain rice, temperate japonica rice, seed cotton, dry peas, lentils, large and small chickpeas, soybeans, peanuts, sunflower seed, canola, flaxseed, mustard seed, rapeseed, safflower, crambe, and sesame seed. Farmers must make enrollment decisions for each crop they wish to enroll in either ARC or PLC, meaning that farmers can enroll different crops in different programs. However, a crop cannot be enrolled in both programs (Farm Service Agency, 2018). Additionally, the 2018 Farm Bill allowed farmers to change enrollment between ARC and PLC each year. In the 2014 design of ARC/PLC, farmers made a program enrollment decision in 2014 that remained for the program's lifespan through 2018 (Congressional Research Service, 2022).

In summary form, the key difference between PLC and ARC is that PLC provides payments using a fixed price-based mechanism to safeguard farmers' income, and ARC uses revenue-based (prices multiplied by yields) calculations. One argument for ARC is that it aims to provide a safety net that adapts to the dynamic nature of the agricultural economy. Because of these competing viewpoints, ARC and PLC employ different goals. PLC is, in essence, an nth iteration of price support that the USDA has offered in different forms since the Great

Depression, but it has appeared similarly to its current form since the 1970s. While program design has changed over time, USDA has offered different forms of price support for nearly a century. ARC exists to provide income support as well, of course, but it uniquely offers support based on historical market conditions. This helps farmers in situations based on farm revenue on a crop-by-crop basis rather than solely providing assistance in the situation of a price crash (Zulauf et al., 2022). The decoupled design of ARC-CO and PLC programs, which was created to serve as a part of the farm safety net, raises ongoing debates about their effectiveness, with critics suggesting that they may function more as transfer payments rather than as robust protective measures for farmers facing market uncertainties.

1.4 COMMODITY SUPPORT IN THE MIDWEST

In the midwestern United States, corn and soybeans are the dominant crops. Therefore, the ARC/PLC enrollment behavior of corn and soybean farmers is important to understand for the midwestern policymaker. From 2019-2022, soybean farmers resoundingly preferred to enroll their acres in ARC-CO. In 2019 and 2020, 80% of soybean program acres enrolled in a commodity program were enrolled in ARC, and that number rose to 85% and 86% in 2021 and 2022, respectively. Since the inception of ARC/PLC in 2014, soybeans have received no payment from PLC because the statutory reference prices are too low relative to actual crop prices. As such, most farmers do not view PLC to be a viable program for soybeans. When farmers do enroll soybean base in PLC, it is likely because that option also permits them to purchase a crop insurance add-on that they view as beneficial, or more beneficial than ARC (Schnitkey et al., 2023a).

Corn base acre enrollment is slightly different to that of soybeans. PLC enrollment for corn acres yielded payment a bit over half of the time since 2014. Over the past few years, however, corn program acres have trended toward a preference for ARC. Income stress on the farm is more accurately indicated by low revenues than low prices, namely because yields are increasing for corn. ARC's reliance on contemporary market conditions and actual yield data enables it to provide support that aligns with current high revenue and price scenarios. This is different than PLC's reliance on fixed statutory price triggers, which can easily become outdated or otherwise fail to reflect the state of the market. In 2019 and 2020, the first two years of the 2018 ARC changes, only 19% of corn program acres enrolled in ARC-CO. In 2021, that increased to 48% enrollment in ARC-CO and to 60% enrollment in 2022. This has largely been driven by a decrease in PLC payments relative to ARC-CO payments due to changes in crop prices (Schnitkey, 2023b).

PLC is predicated on the assumption that Congress can establish a static price trigger that remains relevant over a given five-year period, which can see multiple market shocks and other major events that alter the economics of farming. While PLC may function effectively for certain crops in other regions, enrollment decisions by farmers indicate that it is not preferred for large-acreage midwestern crops like corn and soybeans. This study selects ARC for investigation due to its inherent flexibility in design and the greater relevance of its market orientation to the crops and farmers of the Midwest. The core objective of this paper is to exhibit the utility of modeling as a tool for analyzing the design of commodity policy, particularly for midwestern row crops. The analysis seeks to offer mechanisms through which policy redesign, supported by economic analysis, can enhance the efficacy of agricultural support programs. As such, this paper will explore two scenarios of improvement to ARC; the first will be a modification to certain steps of

the ARC calculation while the second will incorporate an incentive for cover crop adoption. A background of cover crops is also necessary to understand why this secondary proposal is being made.

1.5 COVER CROPS AND CONSERVATION POLICY

Cover crops have been a topic of farm management for many years, but they have more recently become a focus for policy and have seen increasing rates of adoption. Cover crops are plants, typically grass or legume, grown on fields between cash cropping seasons, and they are not harvested for sale. While cover crops do not provide direct cash benefit to the farmer, they provide indirect benefits through their improvements to soil and water quality (Adetunji et al., 2020). Using cover crops can yield many other on-field advantages, notably the enhancement of soil properties such as stability, microbial activity, and organic matter content. These improvements can lead to weed suppression, nutrient loss reduction, increased water infiltration, and heightened drought resilience. However, the benefits and subsequent on-farm impacts are highly contingent on local soil, climate conditions, and management practices, underscoring their variable and complex nature. Public benefits, such as improved water quality, are also noted. While cover crops are increasingly recognized for their substantial contributions to soil health and broader ecological benefits, their implementation is nuanced, with inherent complexities in management practices, costs, and regulatory frameworks (Wallander et al., 2021).

In recent years, there has been a significant surge in policy initiatives both at the state and federal levels aimed at mitigating nutrient loss and promoting sustainable soil management practices. Recognizing the role of agriculture in the nation's economy and environmental health, policymakers have intensified their efforts to develop comprehensive strategies addressing

nutrient runoff, soil erosion, and water quality degradation. In Illinois, for example, there is a Nutrient Loss Reduction Strategy with the goal to incentivize avoiding nutrient loss from agricultural fields as well as point source pollution reduction. However, a study conducted via interviews with Illinois farmers and found that while they are concerned about nutrient loss and are adjusting their practices accordingly, many are not familiar with the specifics of the Illinois Nutrient Loss Reduction Strategy (NLRS). The farmers are predominantly engaged in corn-soybean farming, and they often rely on economic considerations and trusted sources like university research or input from local suppliers when making decisions about nutrient management. Despite the lack of widespread knowledge about the NLRS, the interviewed farmers are taking steps such as using nitrification inhibitors and cover crops to address nutrient loss. Encouraging further adoption of Best Management Practices (BMPs) is crucial for meeting the NLRS goals, which include significant reductions in nitrate-nitrogen and phosphorus runoff to the Mississippi River (Marks et al., 2019).

The costs associated with cover crops can to some degree be addressed by programs such as these. However, incentivizing adoption of conservation practices even through farm subsidies is difficult. Farmers are historically hesitant to integrate major changes into their cropping systems. One major reason for this is the cost of practice change. Farmers looking to adopt cover crops have to consider the cost of seed, labor, and equipment, not to mention the cost of time for both planting and learning about cover cropping (Bergtold et al., 2019). For many, this may not seem like a worthwhile investment. The adoption of cover crops presents a complex challenge within systems dominated by annual cash rents and the immediate financial pressures faced by farmers. These economic constraints, coupled with the risk of delayed planting for subsequent cash crops, often overshadow the long-term benefits of cover cropping. Since many advantages,

such as soil health improvement and ecosystem services, accrue over time and extend beyond individual farm boundaries, the immediate costs and risks can deter adoption. The temporal disconnect between the investment in cover crops and the realization of their benefits, particularly in the context of externalities, creates a barrier to widespread integration of cover cropping into common farm practice. This is why conservation programs in the United States are completely voluntary by design, and the voluntary nature of conservation has remained steadfast for several farm bills. In addition to uptake concerns, access to these conservation subsidy payments is notoriously difficult. The Natural Resources Conservation Service (NRCS) of the USDA is responsible for administering conservation payments to eligible farmers. Since 2017, the NRCS has been able to fund barely half of all eligible applicants for one of its programs, for example. This is largely due to arbitrary funding caps that were created as political bargaining chips in the 2018 Farm Bill (Coppess, 2023).

Even through federal and state level conservation programs exist, the concerns surrounding farmer adoption of conservation practices. Nutrient loss mitigation often intersects with, and is at times at odds with, the economic and risk considerations of farmers. Current policies have approached these issues in a piecemeal manner. The discrepancy between availability of environmental programs and use of these programs underscores the need for a more cohesive policy approach. Conservation policy has historically been constrained by inexplicable limitations, which is typically seen as these funding caps. This disparity is particularly evident when compared with the more robust support allocated to commodity programs, which is demonstrative of an easier political pathway for commodity support. One proposed solution to this is to integrate conservation incentives into commodity support structure. This is where ARC can be used as a policy mechanism to achieve increased cover crop

adoption as well as to reward those farmers already engaging in cover cropping. Both sides of the aisle, across the country, recognize commodity support as an important part of the farm safety net. This is why commodity support can be used to incentivize conservation. To understand how cover crops can be incorporated into ARC, it is first critical to understand how ARC payments are calculated.

CHAPTER 2: CALCULATING AND RECALCULATING ARC

2.1 THE ARC CALCULATION

The process of determining the subsidy owed to a grower using the ARC-CO program involves several intermediary calculations. These are performed by the United States Department of Agriculture Farm Service Agency and paid to the farmer following the crop year in which they enrolled in the program. All payments for ARC-CO are calculated using the county level average yields and national average (twelve-month marketing) prices; therefore, the calculations for the payments require county level data. Payments are specific to each crop for each county.

For a given crop in a given county in a given year, the first component of the calculation is what is called the benchmark yield, measured in bushels per acre. The benchmark yield is calculated by taking a five-year Olympic moving average of historical county average yields for the crop. An Olympic moving average is calculated by taking the average of the previous 5 years' yields for the crop and removing the highest and lowest yield from the average – so, it is the average of the middle three yields.

The next component is the benchmark price. The benchmark price is similarly calculated by taking a five-year Olympic moving average of historical average prices for the crop. The benchmark price is not county specific as the USDA sets a national price for the crop. Again, when calculating the benchmark price, the highest and lowest prices for the crop from each of the last 5 years are omitted. The calculation of the benchmark yield and the benchmark price are traditionally not included as part of the calculation of ARC-CO as they rely on historical numbers.

Once the benchmark yield and the benchmark price are calculated, the process to calculate the payment owed to ARC-CO enrollees in a county begins. For any year, the first step is to calculate the benchmark revenue for a given crop in a given county.

$$B = MA_{Y,5} * MA_{P,5} \quad (1)$$

Where B is the benchmark revenue, $MA_{Y,5}$ is the benchmark yield, and $MA_{P,5}$ is the benchmark price. The calculation of the benchmark revenue is done by multiplying the benchmark yield by the benchmark price.

The next step of the ARC-CO payment calculation is to calculate the guarantee revenue.

$$G = B * 0.86 \quad (2)$$

Where G is the guarantee revenue. The guarantee revenue is calculated by taking 86% of the benchmark revenue.

For each crop and county, there is a maximum payment rate.

$$P_{max} = B * 0.10 \quad (3)$$

Where P_{max} is the maximum payment rate, calculated by taking 10% of the guarantee revenue.

All of the above calculations can be performed ahead of a crop year. The only input data being the benchmark yield and the benchmark revenue means that there is no reliance on a crop year's data to find the benchmark revenue, guarantee revenue, or maximum payment rate. At the end of a crop year, county average yields and the national price are used for the succeeding calculations. The county average yield is referred to as the actual yield. The next step is to calculate actual revenue.

$$R_{actual} = Y_{actual} * P_{nat} \quad (4)$$

Where R_{actual} is actual revenue, Y_{actual} is the actual yield and P_{nat} is the national price set by the USDA.

The penultimate calculation is to subtract the actual revenue from the guarantee revenue to give the formula payment rate, but the value cannot be less than zero.

$$F = \max(G - R_{actual}, 0) \quad (5)$$

Where F is the formula payment rate.

The formula payment rate is then used to calculate the payment for the given crop in the given county.

$$P_{ARC\text{-}CO} = \min(F, P_{max}) \quad (6)$$

Where $P_{ARC\text{-}CO}$ is the payment received for ARC-CO enrolled farmers. Each of equations (1) through (6) as well as the benchmark yield and benchmark price calculations are performed for each eligible crop in each county in each year. The ARC-CO payment is made the October following the crop year. This means that if a farmer enrolled a crop in 2023, they will receive any potential payment beginning in October of 2024 (Farm Service Agency, 2014).

2.2 A CHANGING ARC

The many criticisms of farm policy, the risk management toolkit, and incentivization for conservation are notoriously difficult to address. This is why there are frequent programmatic changes, geographical and partisan disagreements, and wide-ranging policy proposals in any given farm bill reauthorization year. The commodity title, and recently ARC-CO in particular, is a frequent target of policy change. Options to improve ARC-CO will be explored as it is the most popular program in terms of historic enrollment for midwestern farmers.

2.3 ENHANCED ARC-CO (EARC-CO)

The first case study for potential policy changes to ARC-CO is to change the guarantee and maximum payment rate calculations, called Enhanced ARC-CO, or EARC-CO. All steps of

the ARC-CO calculations would stay the same, including the preliminary calculations to find the benchmark and the benchmark price, but the guarantee revenue is calculated by taking 90% of the benchmark revenue and the maximum payment rate by taking 15% of the guarantee revenue. This effectively creates a situation in which a) the formula payment rate for EARC-CO, F_E has the potential to be higher than the current formula payment rate, F and b) the maximum payment rate for EARC-CO, $P_{max, E}$ is higher than the current P_{max}. This implies that payments will often be higher under EARC-CO than ARC-CO. The calculations are as follows, again performed each year for a given crop in a given county, starting after Equation (1):

$$G_E = B * 0.90 \quad (7)$$

$$P_{max,E} = B * 0.15 \quad (8)$$

$$R_{actual, E} = Y_{actual} * P_{nat} \quad (9)$$

$$F_E = \max(G_E - R_{actual, E}, 0) \quad (10)$$

$$P_{EARC-CO} = \min(F_E, P_{max, E}) \quad (11)$$

Where the subscript "E" indicates the values of the calculations under the program shift to EARC-CO. By modeling past payment schemes to this proposed change in the ARC calculation, this study aims to illustrate the potential impact of these adjustments on payment structures, offering a data-driven perspective on how such policy shifts can improve risk management for midwestern row crop farmers.

2.4 ARC-CO ADJUSTMENT (ARC-CA)

The second case study for changes to ARC-CO introduces a $50 conservation incentive to the Agriculture Risk Coverage (ARC) program. This adjustment is specifically designed to address the costs associated with adopting cover crops, operating under the assumption that these

costs amount to $50 per acre. There is not a consensus on the actual exact cost of cover crop implementation, with some estimating the cost to be more like $55 per acre (Christianson et al., 2013). This paper uses the low end of the NRCS estimate for cover crop per acre costs of $50 (Myers et al., 2019). By modifying the ARC calculations to create a fiscal incentive for cover cropping, this policy change is able to incentivize conservation practices while providing risk management support through a commodity program that farmers are already using. This program would be called Agricultural Risk Coverage Conservation Adjustment, or ARC-CA. Like ARC-CO, ARC-CA would be calculated on a by-county, by-crop basis each year. ARC-CA would be added as an additional program option under the ARC/PLC umbrella, meaning farmers would be able to choose to enroll in ARC-CO, ARC-IC, ARC-CA, or PLC.

ARC-CA would also address the concerns associated with conservation practice adoption as well as payment for adoption. ARC-CA encourages adoption by offering it outside of the traditional setting. When afforded the opportunity for a better deal for a program in which a farmer is already enrolling, that farmer may be more likely to plant a cover crop. It also circumvents the concerns associated with caps on farm bill Title II funding. For those already planting cover crops, they will have enhanced access to payment for it. ARC-CA calculations pick up after equation (3), with a changed calculation of actual revenue. Steps (1) through (3) will be unchanged, as will the benchmark and benchmark price calculations.

$$R_{actual,adj} = Y_{actual} * P_{nat} - 50 \quad (12)$$

Where $R_{actual,adj}$ is the adjusted actual revenue under ARC-CA. The subtraction of $50 from the actual revenue calculation means that, when calculating the formula payment rate in the next step, a lower actual revenue is being subtracted from the guarantee, leaving a higher potential maximum under the formula payment rate adjustment:

$$F_{adj} = \max(G - R_{actual,adj}, 0) \quad (13)$$

Where F_{adj} is the adjusted formula payment rate, found through the same process as F under ARC-CO.

$$P_{ARC\text{-}CA} = \min(F_{adj}, P_{max}) \quad (14)$$

Where $P_{ARC\text{-}CA}$ is the expected payment rate each year for a given crop in a given county where cover crops are planted under ARC-CA.

This approach to ARC, calculated annually on a by-county, by-crop basis, offers a flexible and responsive mechanism for farmers who are looking to integrate conservation into their farming strategies, while offering them the familiar structure and risk management support of ARC. The addition of ARC-CA as an option alongside ARC-CO, ARC-IC, and PLC empowers farmers with more choices in their safety net while also addressing environmental concerns in a more pragmatic manner.

CHAPTER 3: A CASE STUDY FOR ENHANCED ARC-CO AND ARC-CA

3.1 OVERVIEW OF A CASE STUDY FOR CHANGING ARC

For the purposes of better understanding how and why these two proposals function better for midwestern farmers than the currently available ARC-CO, one county in Illinois and one county in Iowa will be used as a case study for payments in each scenario for both corn and soybeans. The counties chosen are McLean County, Illinois and Iowa County, Iowa. Illinois is the largest soybean producing state in the United States whereas Iowa is the largest corn producing state, and Illinois ranks second in corn and Iowa second in soybeans. These two states are largely representative of agriculture in the Midwest; it is critical to acknowledge the importance of corn and soybeans to the U.S. economy, and these counties provide a look at how support for these commodities would be improved under different programs. The payments in each scenario below were created using publicly available data from the USDA Farm Service Agency (FSA). FSA provides ARC-CO payment data as well as the intermediate calculations, allowing me to calculate EARC-CO and ARC-CA using the methodology described in the previous section.

McLean County, Illinois was home to nearly 300,000 acres each of corn and soybeans in the most recent National Agricultural Statistics Service (NASS) Census of Agriculture in 2017. Other crops reported are less than 0.01% of total crop acreage in the county, demonstrating that corn and soybeans are by far the top commodities grown or produced in the county (2017b). Iowa County, Iowa was home to just shy of 130,000 acres of corn and just above 100,000 soybean acres as of 2017, according to the National Agricultural Statistics Service (NASS) in their most recently published Census of Agriculture. Corn and soybeans, as expected, are the most popular crops in the county (2017a).

The analysis provided below relies on a few key assumptions. The first is that an improved payment scheme drives higher enrollment for growers in agricultural programs. This is a common-sense assumption of a rational firm; farmers choose to enroll in programs that provide them with some economic benefit. So, if the economic benefit (which appears here as a payment increase) of a program increases, so should enrollment in that program as rational farmers are seeking to maximize their utility and/or profit when enrolling in a commodity program. The second assumption is aggregation of behavior. Representative agents, specifically counties and crops of interest for this situation, are being used as a single representative agent to simplify analysis of the proposed ARC-CO changes. These counties represent the typical farmer in the Midwest and are treated then as an aggregate; the assumption is that what is true for these counties is true for all similar counties.

3.2 ENHANCED ARC-CO

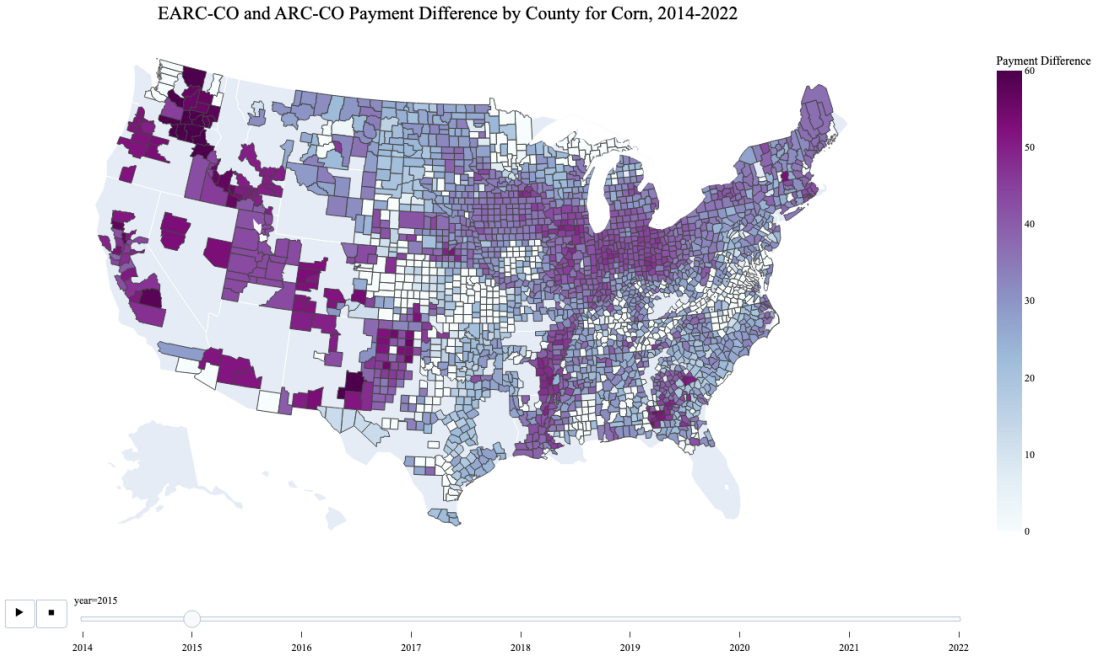
The Google Drive accompanying this work includes data for all ARC-CO payments and their intermediary calculations for every (non-irrigated) ARC eligible crop, for each county, from 2014 to 2022. In addition to ARC-CO Payments, the data is also used to model what EARC-CO and ARC-CA payments would have looked like over that time frame. This retrospective analysis demonstrates what the implementation of EARC-CO and ARC-CA policies from 2014 to 2022 would have yielded in terms of payment, providing a hypothetical scenario to understand how these proposed programs would have impacted commodity payment outcomes. In the Google CoLab file, animations for corn and soybeans specifically are offered. The animations demonstrate each of these scenarios over the time period. The data in the CoLab file could be used for any crop, and user experience is currently being improved to allow a user to select a

crop from a dropdown menu which would display animations for the selected crop. Given the extensive nature of that data and the focus of this paper only on midwestern states, the focus of this section will be narrowed to the aforementioned corn and soybeans.

3.2.1 Enhanced ARC-CO for Corn

The map below provides a snapshot of the available data. This shows a comparison of ARC-CO payments at the county level that went out for corn across the country in 2015 to what payments would have looked like for EARC-CO. The map illustrates increased payments from the enhanced calculations with dark purple counties experiencing around a $60 increase per acre. As mentioned in Section 2.3, the expectation is that EARC-CO yields higher and more frequent payments than ARC-CO. The year 2015 was chosen arbitrarily; Appendix A of this paper includes each year from 2014-2022 for each scenario as well as the difference maps.

Figure 1: EARC-CO and ARC-CO Payment Difference for Corn in 2015



This map demonstrates a clear increase in payments under EARC-CO compared to ARC-CO. A simple observation of this map shows that payments increased across the country for soybeans, with nearly the entirety of the map being greater than 0; this means that most counties across the country would have seen an increase in payment under EARC-CO as compared to ARC-CO. To show that this is not purely anecdotal, but rather an example of a phenomenon, EARC-CO can be more accurately analyzed by looking across years in the case study counties.

The effect of EARC-CO for corn can be studied by comparing enhanced payments with actual ARC-CO payments in the counties of interest. Using FSA data, the EARC-CO calculations can be performed and compared to historical ARC-CO payments. Further narrowing the data of interest to Illinois and Iowa can help tell the story of what EARC-CO would mean for Midwesterners. From 2014 to 2022, EARC-CO would have paid an average of $11.32 more per acre for corn in Illinois and $11.02 in Iowa. However, if only years where EARC-CO payments would have occurred are observed (meaning years where both ARC-CO and EARC-CO payments were 0 are dropped), then EARC-CO would have paid an average of $30.89 per acre more than ARC-CO for corn in Illinois and $32.66 in Iowa. The occurrence of a zero payment under ARC or one of the proposed policy changes should not be inherently viewed as a negative outcome; rather, it often signifies a successful crop year, where the yields and market conditions are favorable enough that farmers do not need support payments. The zero-payment scenario theoretically would reflect an ideal crop year, where the need for external financial assistance is minimized, highlighting the program's role as a safety net rather than a constant revenue source. However, this is not always the case, which is why the years where both EARC-CO and ARC-CO are 0 are removed rather than just when ARC-CO is 0; the years where both are 0 reflect

years where payments are not necessary, but years where only ARC-CO is 0 could reflect a shortcoming of the program.

Table 1: ARC-CO and EARC-CO Average Corn Payments in Illinois, 2014-2022

Payment Type	Average Payment	Difference
ARC-CO	16.17	--
EARC-CO	27.49	11.32
ARC-CO (EARC-CO is not 0)	44.12	--
EARC-CO (EARC-CO is not 0)	75.01	30.89

Table 2: ARC-CO and EARC-CO Average Corn Payments in Iowa, 2014-2022

Payment Type	Average Payment	Difference
ARC-CO	14.47	--
EARC-CO	25.49	11.02
ARC-CO (EARC-CO is not 0)	42.84	--
EARC-CO (EARC-CO is not 0)	75.5	32.66

The above tables show average payments in Illinois and Iowa for corn from 2014-2022. By examining one county in each state as a case study, changes in payments across the period can be studied to provide a more holistic picture of the economic benefit of EARC-CO for corn in the Midwest.

Table 3: ARC-CO and EARC-CO Payments for Corn in McLean County, Illinois

$P_{ARC\text{-}CO}$	P_E	Year
0.00	12.29	2014
68.66	105.26	2015
21.37	56.43	2016
0.00	0.00	2017
0.00	0.00	2018
0.00	2.98	2019
0.00	0.00	2020
0.00	0.00	2021
0.00	0.00	2022

In McLean County, ARC-CO paid out twice for corn from the inception of ARC/PLC in 2014 to the most recent available data in 2022. In that same time frame, EARC-CO would have paid out four times; in the years where ARC-CO paid, EARC-CO would have paid more.

Table 4: ARC-CO and EARC-CO Payments for Corn in Iowa County, Iowa

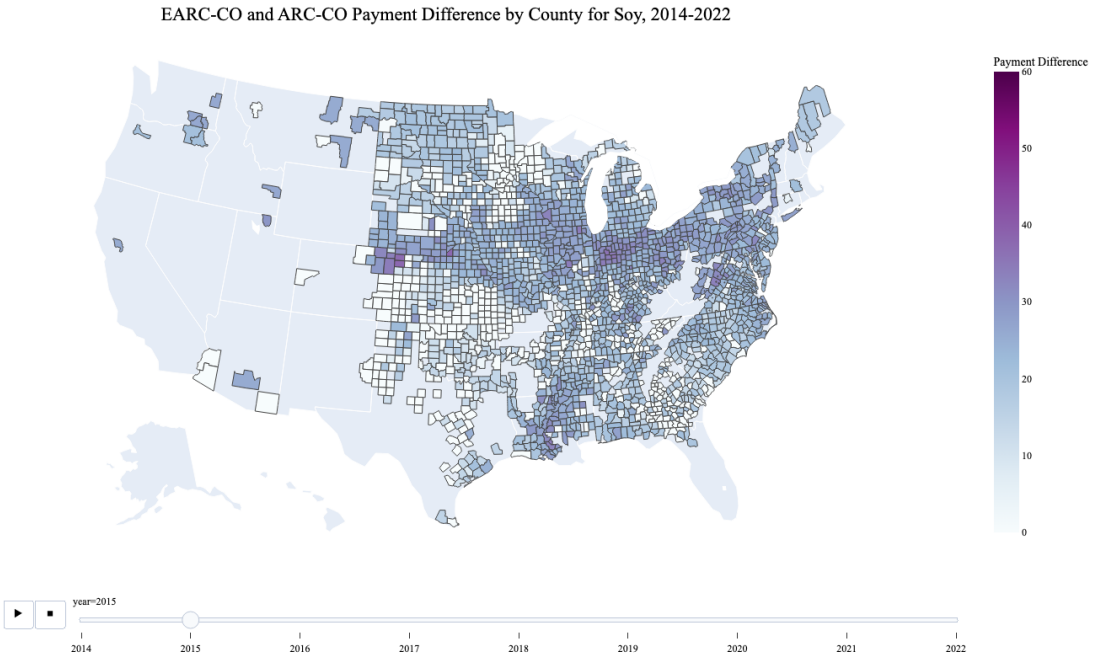
P_{ARC-CO}	P_E	Year
54.20	88.90	2014
27.71	62.41	2015
11.18	44.51	2016
0.00	0.00	2017
0.00	0.00	2018
0.00	0.00	2019
50.29	82.73	2020
0.00	0.00	2021
0.00	0.00	2022

In Iowa County, ARC-CO paid out four times for corn from the inception of ARC/PLC in 2014 to the most recent available data in 2022. EARC-CO would have paid in the same years, but it would have paid more each time.

3.2.2 Enhanced ARC-CO For Soybeans

Below, the country-wide county-level 2015 data for the difference between EARC-CO and ARC-CO are again shown, this time for soybeans. The dark purple indicates around a $60 increase in payment; this was chosen for consistency with other maps offered in this paper. The actual highest payment increase is around $45.

Figure 2: EARC-CO and ARC-CO Payment Difference for Soy in 2015



Once again, simple observation of the above scenario shows a clear improvement in payment disbursement under EARC-CO compared to ARC-CO in 2015 for soybeans. This relationship can be further examined by looking at the payment schemes in Illinois and Iowa.

From 2014-2022, EARC-CO would have paid an average of $5.78 more for soybeans in each year than ARC-CO did in Illinois and $6.22 in Iowa. However, if again the years where EARC-CO and ARC-CO payments were 0 are dropped, that number jumps to $20.35 in Illinois and $18.99 in Iowa.

Table 5: ARC-CO and EARC-CO Average Soybean Payments in Illinois, 2014-2022

Payment Type	**Average Payment**	**Difference**
ARC-CO	6.42	--
EARC-CO	12.2	5.78
ARC-CO (EARC-CO is not 0)	22.6	--
EARC-CO (EARC-CO is not 0)	42.95	20.35

Table 6: ARC-CO and EARC-CO Average Soybean Payments in Iowa, 2014-2022

Payment Type	Average Payment	Difference
ARC-CO	4.88	--
EARC-CO	11.1	6.22
ARC-CO (EARC-CO is not 0)	14.93	--
EARC-CO (EARC-CO is not 0)	33.92	18.99

The above tables show average payments in Illinois and Iowa for soybean from 2014-2022, which shows an obvious increase in payments for EARC-CO across the period as compared to ARC-CO. By examining one county in each state as a case study, changes in payments across the period can be studied to provide a more holistic picture of the economic benefit of EARC-CO for corn in the Midwest.

Table 7: ARC-CO and EARC-CO Payments for Soybeans in McLean County, Illinois

P_{ARC-CO}	P_E	Year
0.00	0.00	2014
28.68	56.65	2015
0.00	13.53	2016
0.00	0.00	2017
0.00	0.00	2018
19.62	45.63	2019
0.00	0.00	2020
0.00	0.00	2021
0.00	0.00	2022

In McLean County, ARC-CO paid out twice for soybeans from the inception of ARC/PLC in 2014 to the most recent available data in 2022. In that same time frame, EARC-CO would have paid out three times; in the years where ARC-CO payments went out, EARC-CO would have paid more.

Table 8: ARC-CO and EARC-CO Payments for Soybeans in Iowa County, Iowa

$P_{ARC\text{-}CO}$	P_E	Year
13.41	38.94	2014
47.51	73.04	2015
1.24	26.41	2016
0.00	5.32	2017
0.00	1.81	2018
1.62	23.28	2019
0.00	0.00	2020
0.00	0.00	2021
0.00	0.00	2022

In Iowa County, ARC-CO paid out four times for soybeans from the inception of ARC/PLC in 2014 to the most recent available data in 2022. EARC-CO would have paid out six times. In the years where ARC-CO payments went out, EARC-CO would have also paid out, but at a higher rate.

The comprehensive data and analyses presented in above provide a robust foundation for evaluating the proposed policy change in EARC-CO. The data demonstrates a clear case for increased payments for corn and soybeans in Illinois and Iowa, implying that EARC-CO provides better outcomes for midwestern farmers. The comparison between EARC-CO and ARC-CO, using county-level case studies and data visualization, reinforces the argument for these policy modifications. They highlight not only the increased financial support these changes could offer to farmers but also demonstrate the importance of aligning agricultural policies with evolving market realities. This work, therefore, can be used as a data-driven source to inform agricultural policy reform.

This work can also be studied for other regions and crops beyond the examples and case study offered here. The Google Drive coding companion to this paper allows the user to select a crop, state, and county to compare the payment schemes of EARC-CO to ARC-CO both over the period as well as averages across the period by state and crop.

3.3 ARC-CA

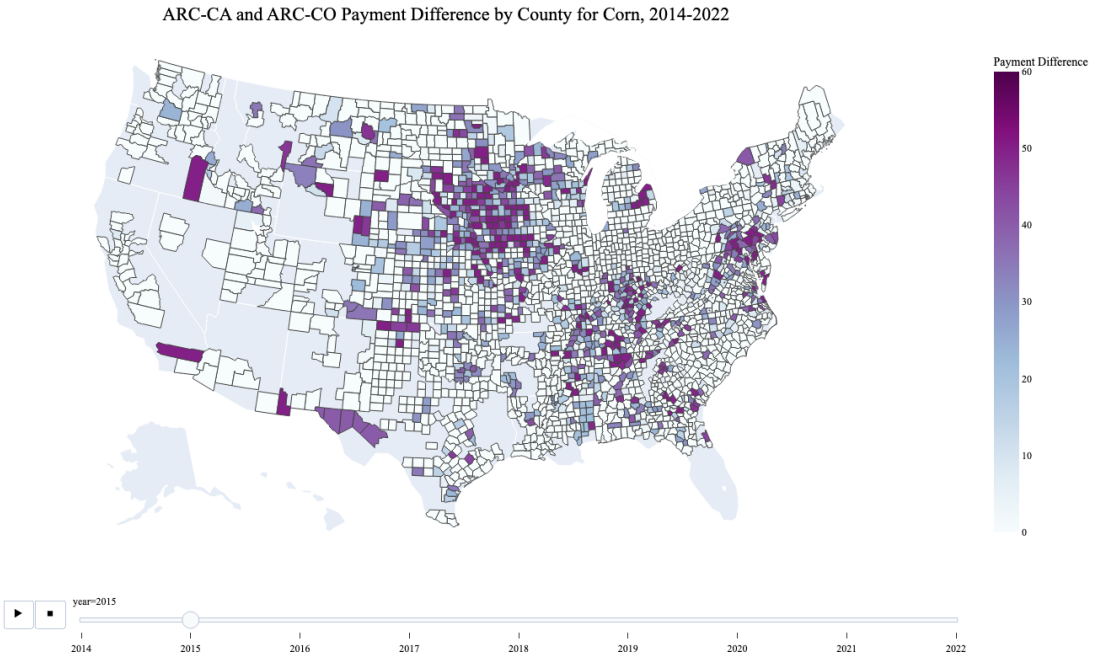
The second case study is for the proposed ARC-CA that would allow producers to be eligible for this recalculation of ARC-CO if they engage in cover cropping. In 2021, the uptake of cover crops was quadruple the rate of use in 2011, a surge closely linked to financial support provided in the aforementioned state and federal conservation initiatives in Section 1.5. Nonetheless, the prevalence of cover crop usage in the U.S. Midwest remains modest, at just 7.2% (Zhou et al., 2022). According to the National Agricultural Statistics Survey's 2017 Census of Agriculture, only 8% of McLean County farms engaged in cover cropping (2017b). The same census showed that 16% of Iowa County farms engaged in cover cropping (NASS, 2017a). Because of these low engagement numbers in the counties of interest, ARC-CA is a realistic program. Because engagement numbers are low, the cost of ARC-CA is far more realistic than other proposed updates to ARC/PLC.

The case study data demonstrates either an increased payout under ARC-CA or an ARC-CA payout when there was no ARC-CO payout in 18 out of the 36 observations below. This would serve as an incentive for increased cover crop adoption in the two representative counties of the Midwest, implying that this would provide an incentive across the Midwest.

3.3.1 ARC-CA for Corn

The ARC-CA country wide map demonstrates a clear increase in payments for corn across the country under the ARC-CA scenario as compared to ARC-CO in 2015. The year 2015 was again chosen arbitrarily but kept as a running example for continuity, and the scale is again maximized at a $60 per acre increase in payment.

Figure 3: ARC-CA and ARC-CO Payment Difference for Corn in 2015



As was done for EARC-CO, a more specific look at the effect of ARC-CA for corn can be obtained by taking a backwards look at ARC-CO input data for the counties of interest, McLean and Iowa. Again using FSA data, the ARC-CA calculations can be performed and compared to historical ARC-CO payments. From 2014 to 2022, ARC-CA would have paid an average of $9.33 more per acre for corn in Illinois and $10.45 in Iowa. If observations for years and counties where ARC-CO payments were 0 and ARC-CA payments would have been zero are dropped, then ARC-CA would have paid an average of $22.29 per acre more than ARC-CO for corn in Illinois and $26.66 in Iowa. The reasons for removing observations where both payments would be 0 are the same as mentioned in Section 3.2.1.

Table 9: ARC-CO and ARC-CA Average Corn Payments in Illinois, 2014-2022

Payment Type	Average Payment	Difference
ARC-CO	16.17	--
ARC-CA	25.5	9.33
ARC-CO (ARC-CA is not 0)	38.6	--
ARC-CA (ARC-CA is not 0)	60.89	22.29

Table 10: ARC-CO and ARC-CA Average Corn Payments in Iowa, 2014-2022

Payment Type	Average Payment	Difference
ARC-CO	14.47	--
ARC-CA	24.92	10.45
ARC-CO (ARC-CA is not 0)	36.91	--
ARC-CA (ARC-CA is not 0)	63.57	26.66

The case counties, McLean and Iowa, are shown below for ARC-CO and ARC-CA payments with a backwards look for corn to provide a more specific view of payment differences over time.

Table 11: ARC-CO and ARC-CA Payments for Corn in McLean County, Illinois

$P_{ARC\text{-}CO}$	$P_{ARC\text{-}CA}$	Year
0.00	25.90	2014
68.66	91.52	2015
21.37	71.37	2016
0.00	0.00	2017
0.00	0.00	2018
0.00	19.72	2019
0.00	0.00	2020
0.00	0.00	2021
0.00	0.00	2022

In McLean County, ARC-CO paid out twice for corn from the inception of ARC/PLC in 2014 to the most recent available data in 2022. In that same time frame, ARC-CA would have paid out four times; in the years where ARC-CO did pay, ARC-CA would have paid more.

Table 12: ARC-CO and ARC-CA Payments for Corn in Iowa County, Iowa

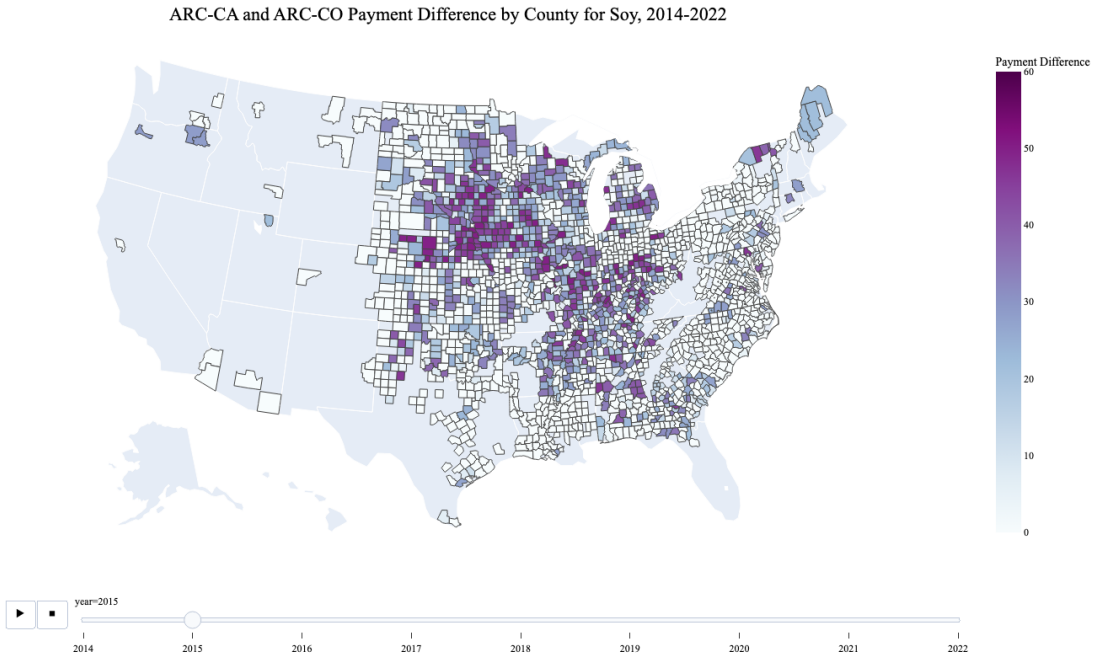
$P_{ARC\text{-}CO}$	$P_{ARC\text{-}CA}$	Year
54.20	86.76	2014
27.71	77.71	2015
11.18	61.18	2016
0.00	0.00	2017
0.00	0.00	2018
0.00	17.11	2019
50.29	81.09	2020
0.00	0.00	2021
0.00	0.00	2022

In Iowa County, ARC-CO paid out four times for corn from the inception of ARC/PLC in 2014 to the most recent available data in 2022. ARC-CA would have paid in the same years, but it would have paid more each time, as well as paying once when ARC-CO did not.

3.3.2: ARC-CA for Soybeans

The ARC-CA country wide map demonstrates a clear increase in payments for soybeans across the country under the ARC-CA scenario as compared to ARC-CO in 2015. The payment differences appear to be more consistent in value and geography than corn, but corn did see some higher payments than soybeans. The year 2015 was again chosen arbitrarily but kept as a running example for continuity.

Figure 4: ARC-CA and ARC-CO Payment Difference for Soy in 2015



From 2014-2022, ARC-CA would have paid an average of $9.74 more for soybeans in each year than ARC-CO did in Illinois and $13.88 in Iowa. However, if again the years where ARC-CA and ARC-CO payments were 0 are dropped, that number jumps to $23.96 more for ARC-CA per acre in Illinois and $28.49 in Iowa.

Table 13: ARC-CO and ARC-CA Average Soybean Payments in Illinois, 2014-2022

Payment Type	**Average Payment**	**Difference**
ARC-CO	6.42	--
ARC-CA	16.16	9.74
ARC-CO (ARC-CA is not 0)	15.8	--
ARC-CA (ARC-CA is not 0)	39.76	23.96

Table 14: ARC-CO and ARC-CA Average Soybean Payments in Iowa, 2014-2022

Payment Type	**Average Payment**	**Difference**
ARC-CO	4.88	--
ARC-CA	18.76	13.88
ARC-CO (ARC-CA is not 0)	10.03	--
ARC-CA (ARC-CA is not 0)	38.52	28.49

Below, the previous case counties are again examined with a backwards look for ARC-CO and ARC-CA to provide a more holistic picture of the changes in payments over the period for ARC-CA.

Table 15: ARC-CO and ARC-CA Payments for Soybeans in McLean County, Illinois

$P_{ARC\text{-}CO}$	$P_{ARC\text{-}CA}$	Year
0.00	0.00	2014
28.68	69.94	2015
0.00	36.00	2016
0.00	3.94	2017
0.00	0.00	2018
19.62	65.01	2019
0.00	0.00	2020
0.00	0.00	2021
0.00	0.00	2022

In McLean County, ARC-CO paid out twice for soybeans from the inception of ARC/PLC in 2014 to the most recent available data in 2022. In that same time frame, ARC-CA would have paid out four times; in the years where ARC-CO payments went out, ARC-CO would have paid more.

Table 16: ARC-CO and ARC-CA Payments for Soybeans in Iowa County, Iowa

$P_{ARC\text{-}CO}$	$P_{ARC\text{-}CA}$	Year
13.41	38.94	2014
47.51	73.04	2015
1.24	26.41	2016
0.00	5.32	2017
0.00	1.80	2018
1.62	23.28	2019
0.00	0.00	2020
0.00	0.00	2021
0.00	0.00	2022

In Iowa County, ARC-CO paid out four times for soybeans from the inception of ARC/PLC in 2014 to the most recent available data in 2022. ARC-CA would have paid out six times. In the years where ARC-CO payments went out, ARC-CA would also paid out, but at a higher rate.

CHAPTER 4: ANALYSIS

The data-driven approach, including the county-level case studies used here, provides a foundation for evaluating these policy changes across the agricultural sector. The modeling of hypothetical alternative policy designs' – EARC-CO and ARC-CA – estimated payments from 2014 to 2022 demonstrates a clear case for these policy modifications based on payment data. The results indicate that farmers would have received more frequent and higher payments under the two proposed programs, reflecting a better alignment of agricultural policies for large scale row cropping across the heartland. The detailed examination of McLean County in Illinois and Iowa County in Iowa serve as examples of a larger pattern; EARC-CO and ARC-CA provide more to the farmer who enrolls in them over the current programmatic structure of ARC-CO. The associated Google Drive and accompanying code further allows for extended analysis, offering a valuable resource for policymakers, researchers, and farmers alike. The analysis affirms the hypothesis that these two programs yield higher payments for the farmer; in turn, the assumption is that farmers would enroll in these programs at higher rates than they do ARC-CO. These findings further validate the role of data-driven analysis in shaping effective agricultural policy. The data suggests that such policy changes could influence farmer decisions and behaviors, highlighting the practical implications of these proposed policies in driving risk management decisions. In the case of ARC-CA, this also shows that incentivizing conservation outside of traditional avenues is possible; it avoids the complications of conservation programs while still providing the farmer a reason to engage in conservation.

These policies are each just an example of what modeling can mean for the policymaker. These models and others like them can help to inform political decisions, especially when considering that many policymakers take positions based on geographical issues that are

important to the area which they represent. Agriculture is inherently tied to geography; the same crops grow differently in different areas, and some crops are region specific. This makes spatial analysis critical for understanding how proposed policies will affect different regions. These models provide a quantitative and qualitative foundation for understanding the possible impacts of policies, allowing policymakers to engage in simple cost benefit analyses. By simulating policy outcomes and examining historical data, these models can enable more informed and evidence-based policy formulation. By leveraging data-driven and spatial models of policy, lawmakers can reason through the effectiveness of proposed agricultural policies for their states and districts. This helps to ensure that their policy decisions are not only grounded in scientific evidence but also are considerate of the specific needs of the agricultural industry that they represent.

Data visualization, whether through maps, graphs, tables, or more, has the potential to play a crucial role in making agricultural policy more accessible and actionable. In a world inundated by data, statistical and economic phenomena are difficult but critical to make sense of when creating policy. By translating complex datasets into something that is visually apparent and that is accessible to the average citizen, data visualization can enable policymakers to quickly grasp policy outcomes and insights relevant to their regional agricultural sector. This practical approach is especially valuable in agriculture, where both scientific and economic data abound when making the case for policy. Effective visualizations can highlight regional differences, forecast potential impacts of policy changes, and identify areas where policies need improvement. This not only aids in more informed decision-making but also facilitates better communication with stakeholders, including farmers, stakeholders, and the consumer.

CONCLUSION

The importance of a data-driven, geographically nuanced approach to agricultural policymaking has great potential to drive more informed policymaking. Through the detailed analysis of the hypothetical impacts of EARC-CO and ARC-CA, it becomes evident that these policies could substantially benefit midwestern row crop farmers across the American heartland. For EARC-CO, the recalculation involved demonstrated increased payments both overall as well as in high-payment years for the representative area, implying that EARC-CO would be an improvement over ARC-CO for midwestern growers. This analysis confirmed the hypothesis that EARC-CO would yield increased payments, and it implies that the rational farmer would be further incentivized to enroll in EARC-CO. Additionally, the findings also suggest that the proposed ARC-CA model, though not as robust as EARC-CO in terms of payment increases, still offered improvements over the current ARC-CO while also providing an incentive for cover crop adoption. These examples demonstrate a method of policy engagement that allows policymakers to engage with the areas that they represent and to make more informed decisions for their constituents. By simplifying complex data into clear visualizations, we offer policymakers, stakeholders, farmers, and consumers an opportunity to view real-world implications of policy change. Utilizing such models can guide policymakers in scientifically and economically sound decision-making tailored to the regions which they represent, allowing for a more nuanced approach to agricultural policymaking.

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APPENDIX A: FIGURES

Figure Set 1: ARC-CO Corn Payments, 2014-2022

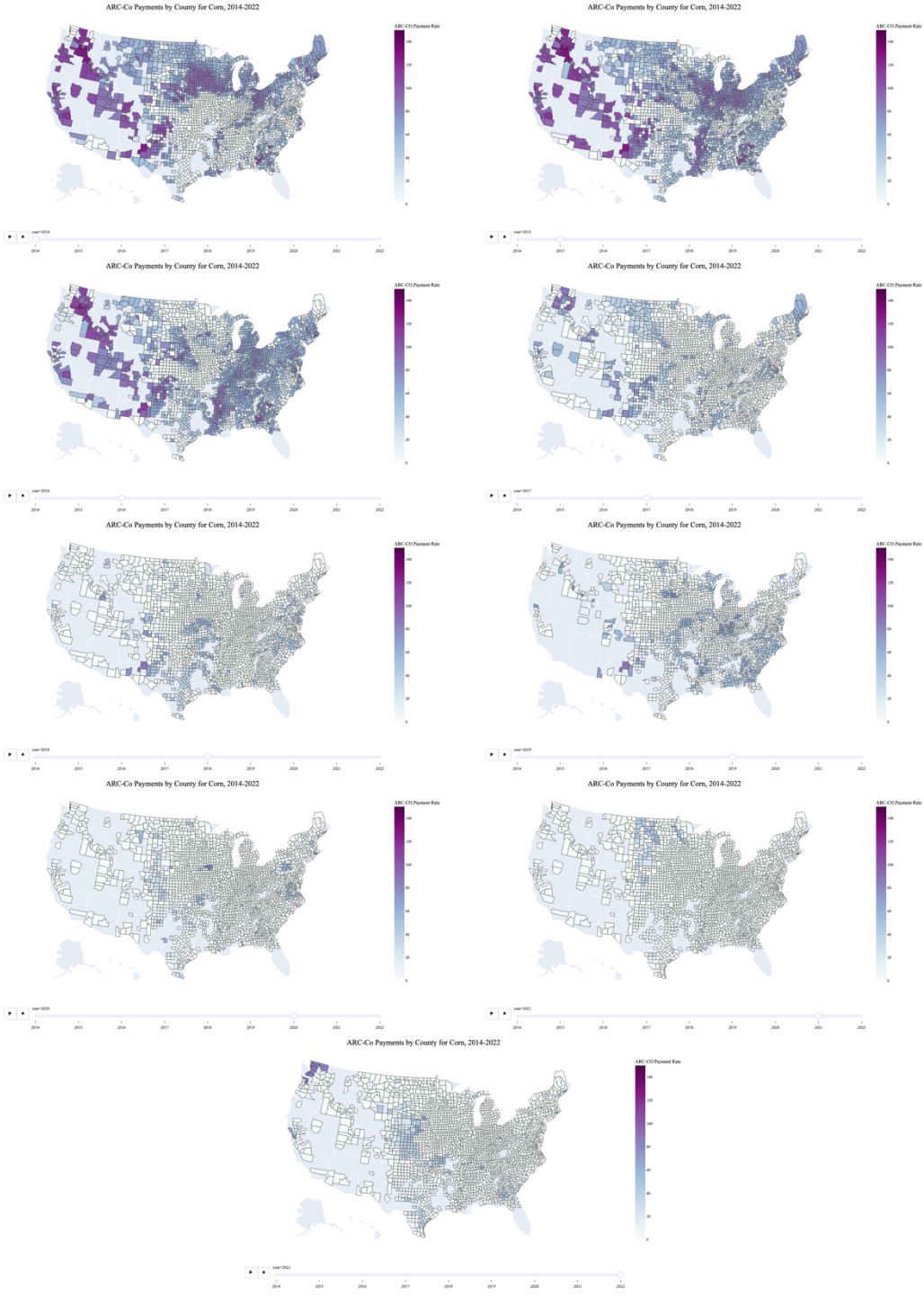


Figure Set 2: ARC-CO Soy Payments, 2014-2022

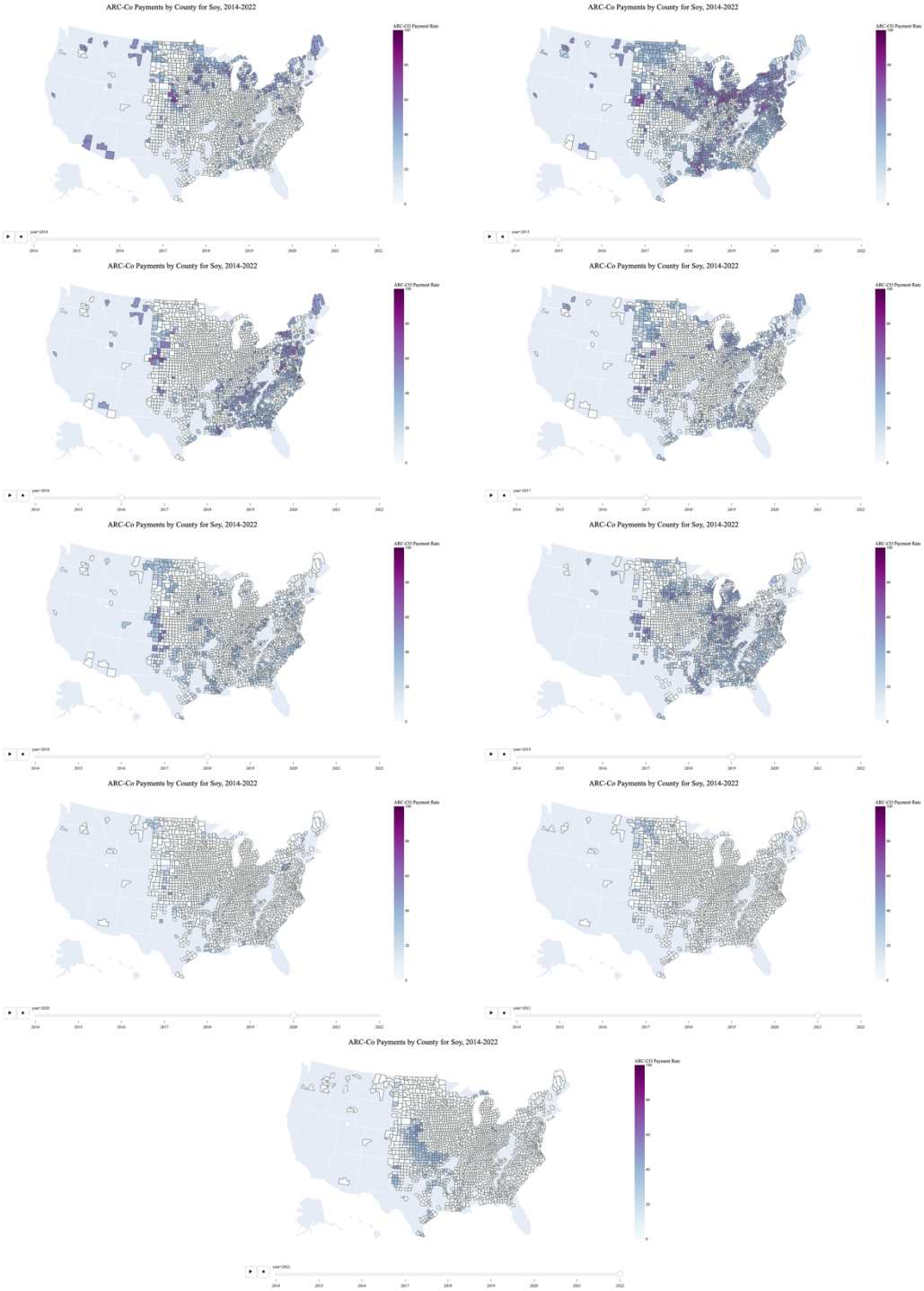


Figure Set 3: EARC-CO Corn Payments, 2014-2022

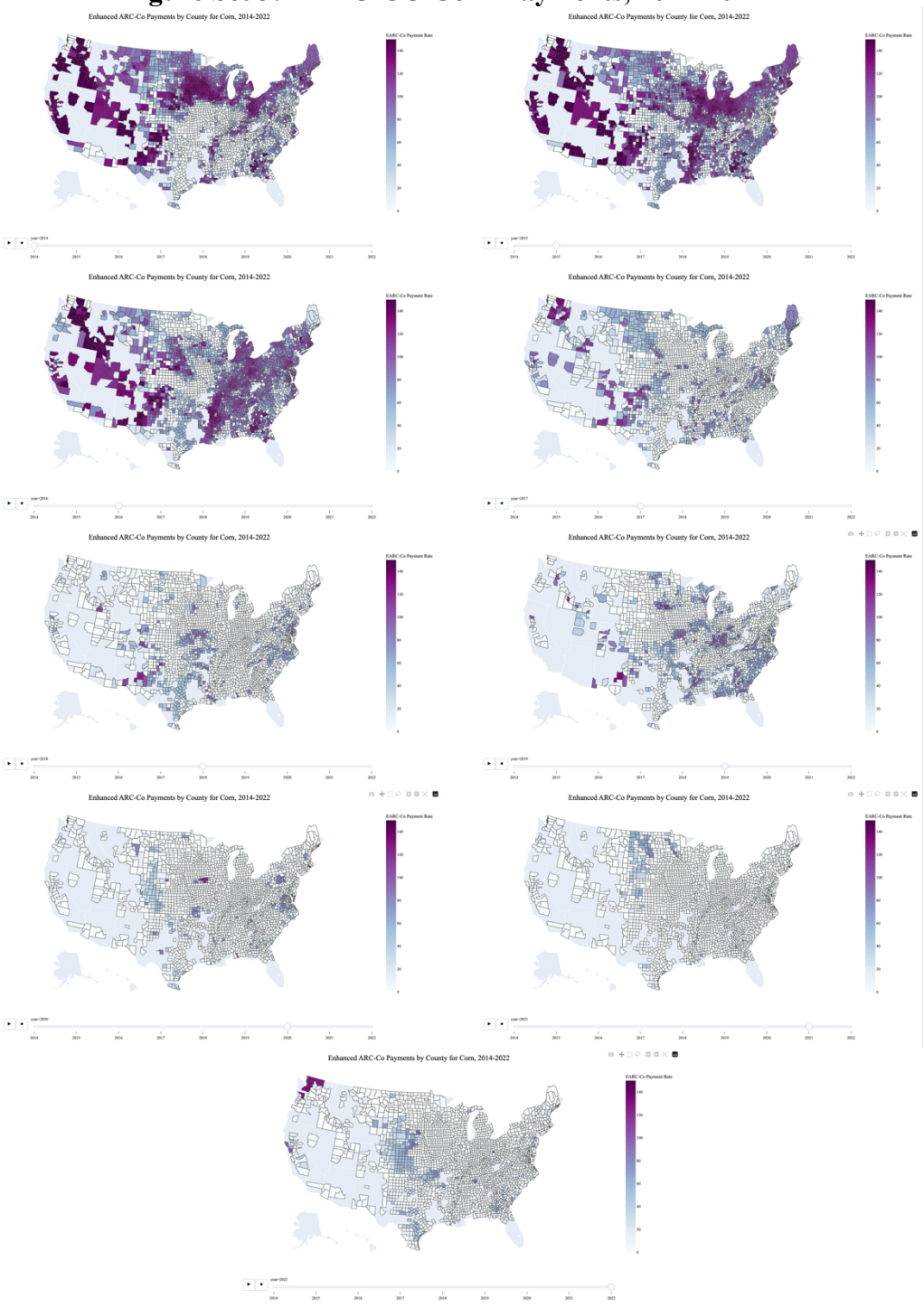


Figure Set 4: EARC-CO Soybean Payments, 2014-2022

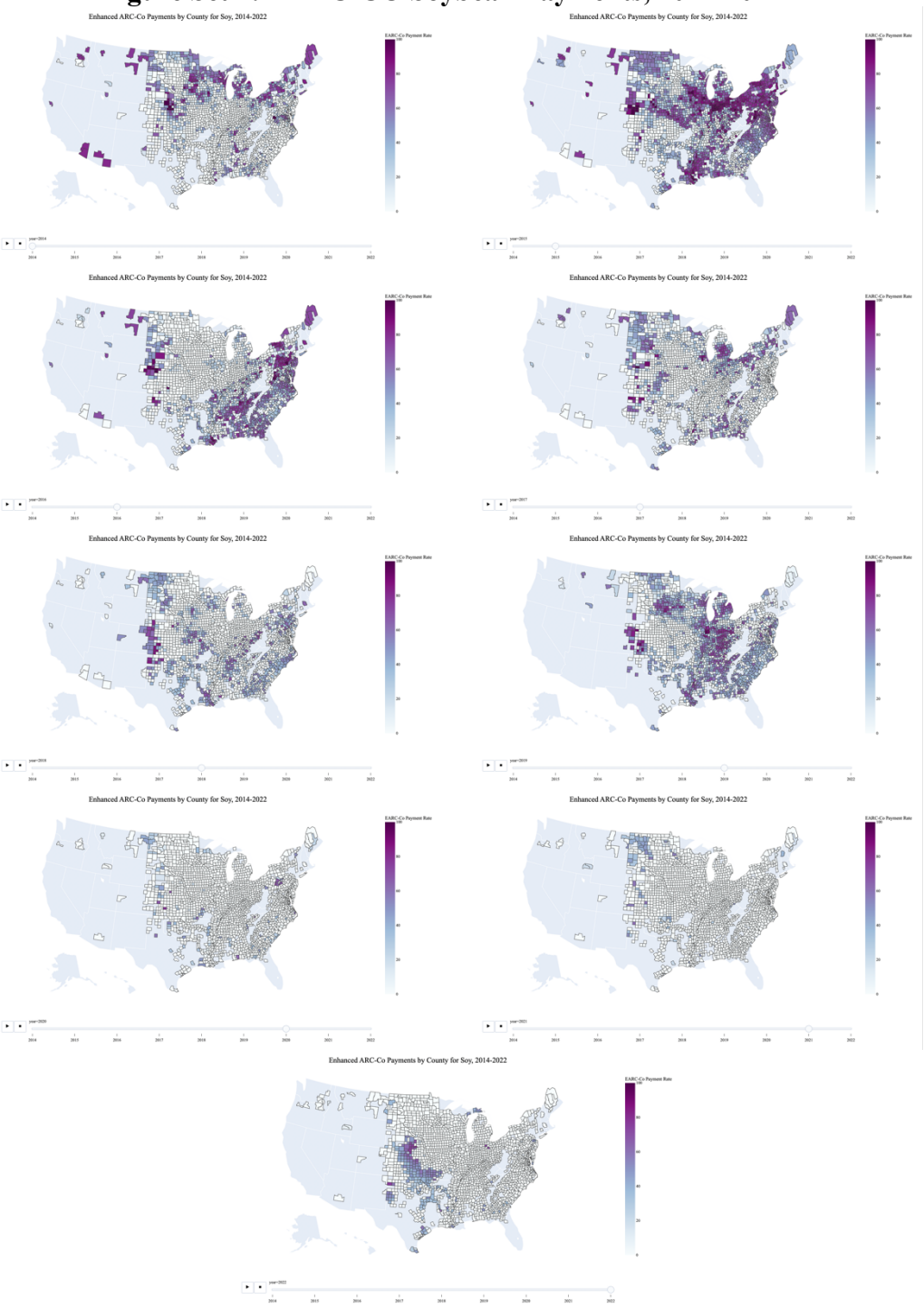


Figure Set 5: ARC-CA Corn Payments, 2014-2022

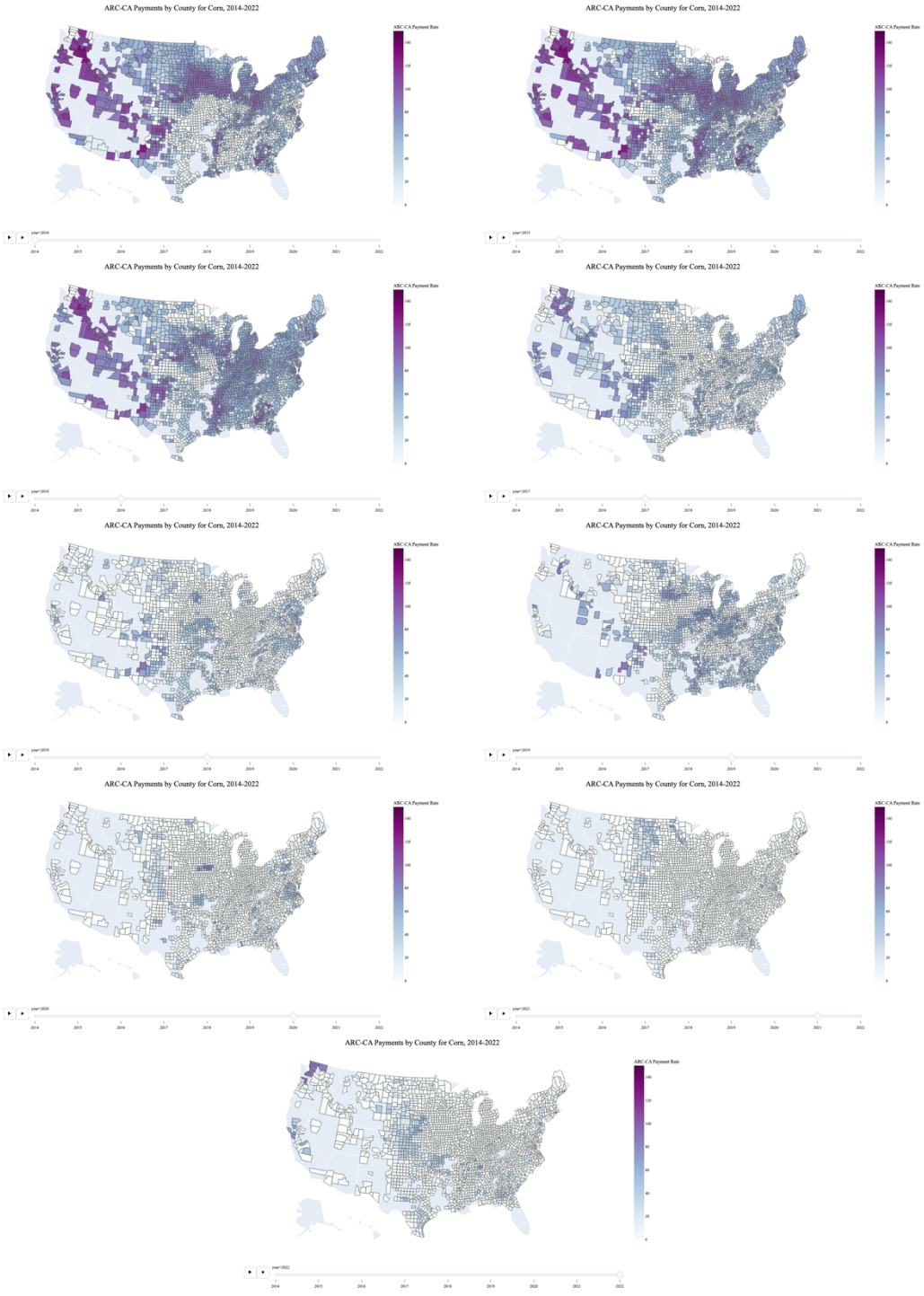


Figure Set 6: ARC-CA Soybean Payments, 2014-2022

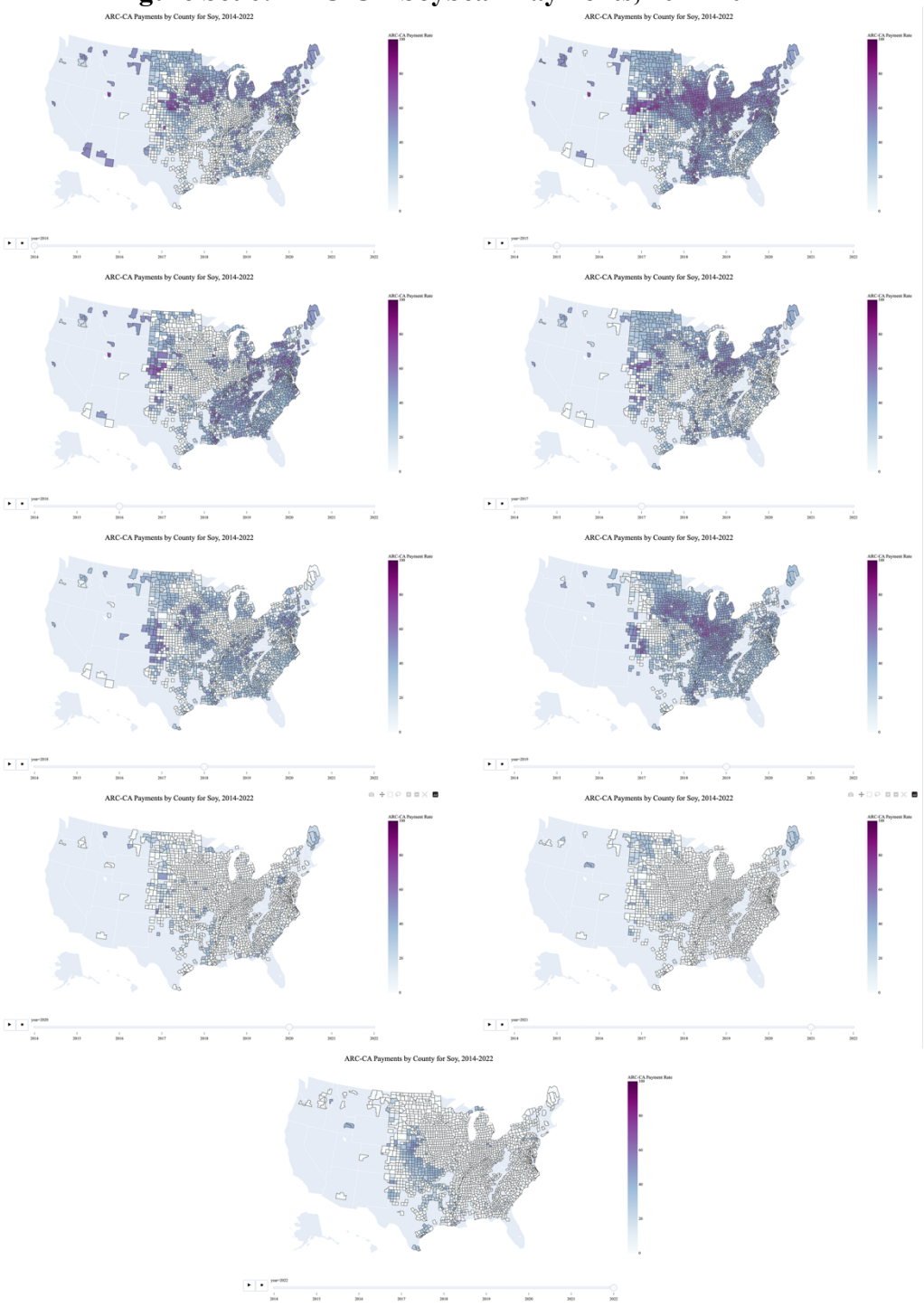


Figure Set 7: EARC-CO and ARC-CO Corn Payment Difference, 2014-2022

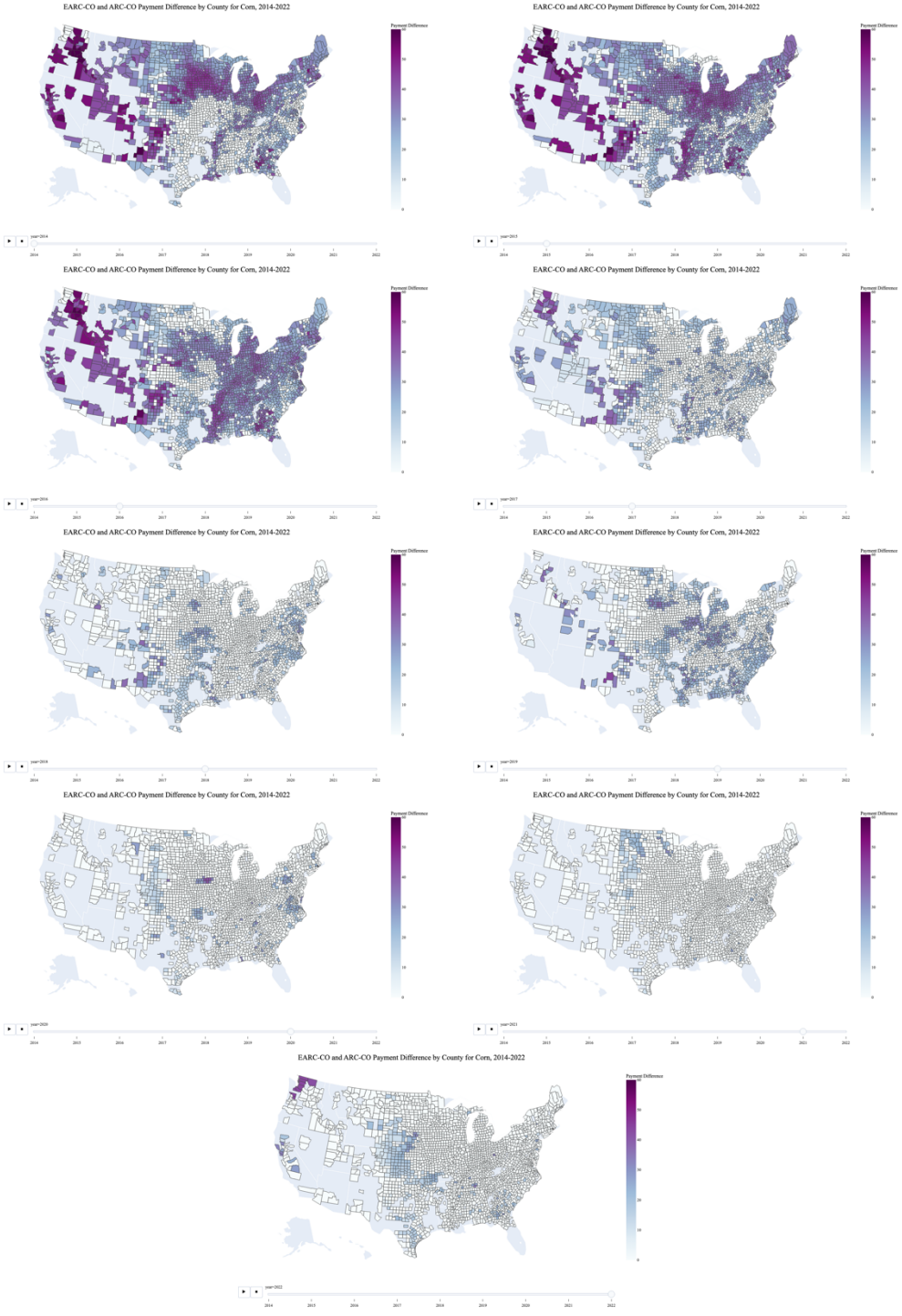


Figure Set 8: EARC-CO and ARC-CO Soy Payment Difference, 2014-2022

Figure Set 9: ARC-CA and ARC-CO Corn Payment Difference, 2014-2022

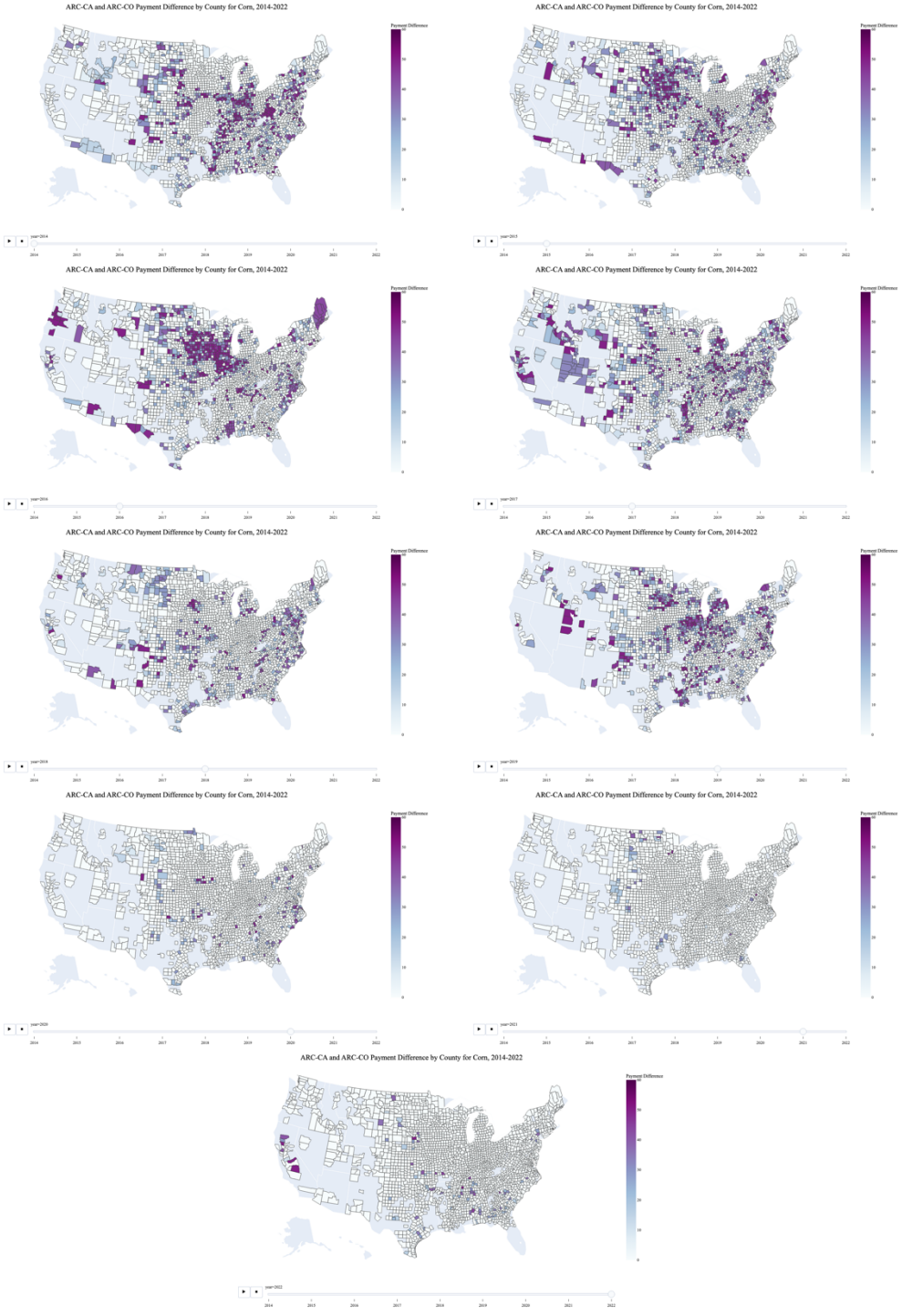
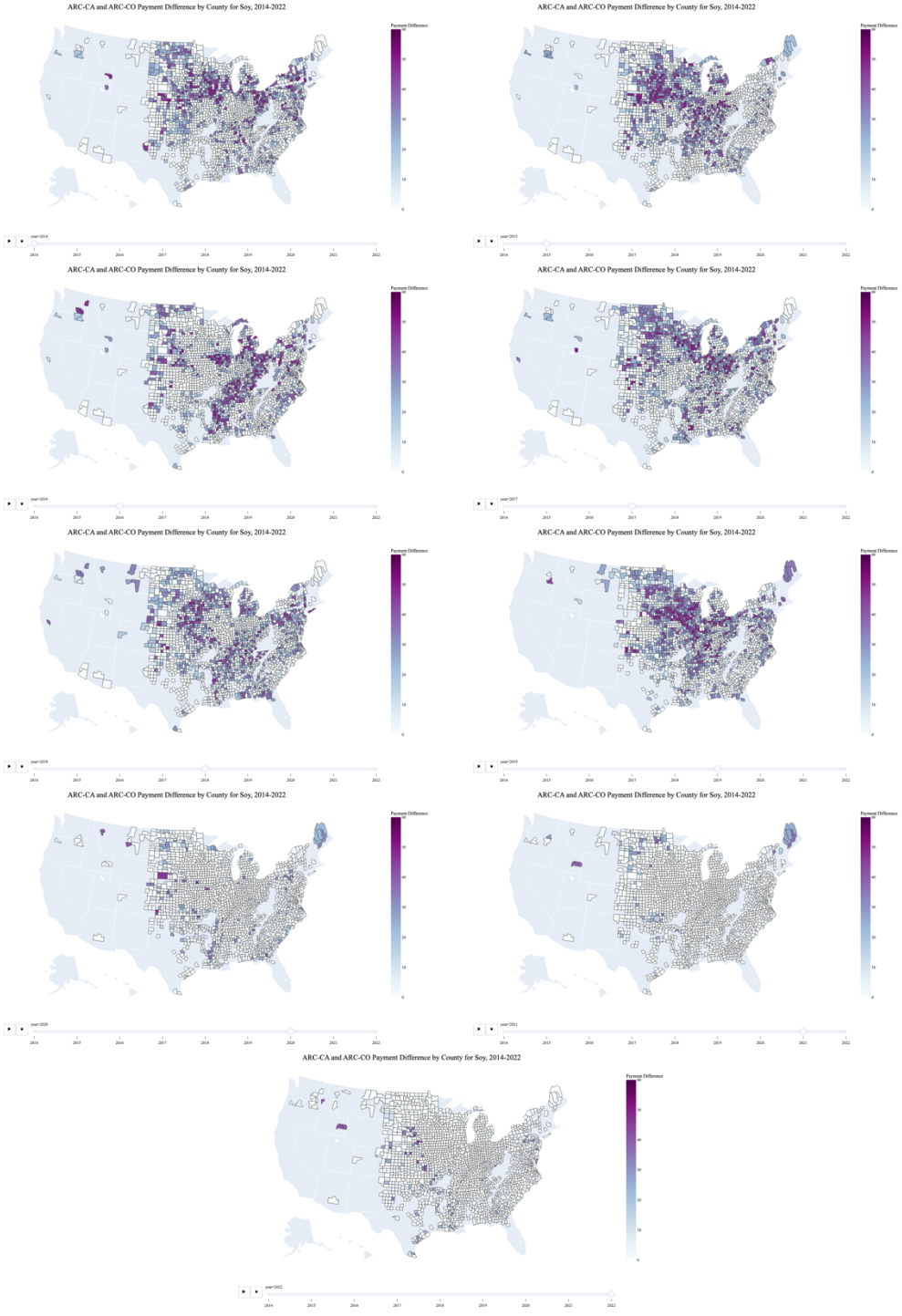


Figure Set 10: ARC-CA and ARC-CO Soy Payment Difference, 2014-2022



APPENDIX B: GOOGLE DRIVE

Live hyperlink to google drive containing source data and code below.

Google Drive Link

Plain link:

https://drive.google.com/drive/folders/1NCVJdJjWOEdEmTaKmSWgnA50qzLTulgR?usp=sharing