EVALUATING ARC-INDIVIDUAL AS A PRODUCER SAFETY NET CHOICE

A Thesis

by

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ABSTRACT

The U.S. has a history of providing a safety net to producers of agricultural commodities. Commodity safety net programs have evolved overtime and attempted to stay current with the nature and conditions of farms and commodity sectors. Currently, producers have three main program options (established by the 2014 farm bill): Price Loss Coverage (PLC), County Agricultural Risk Coverage (ARC-CO), and Individual Agricultural Risk Coverage (ARC-IC). The first is price-based; the latter two are revenue-based on county and individual levels, respectively, and are dependent upon both price and yield.

The objective of this study was to develop an ARC-IC decision tool to evaluate ARC-IC under risk. The decision tool generates stochastic prices and yields and calculates the range and probabilities of potential ARC-IC payments based on individual farm information. A secondary objective was to evaluate case studies using the ARC-IC tool to identify situations for which ARC-IC is a viable option relative to PLC and ARC-CO.

In the 2014-2018 commodity program election, ARC-IC was unpopular relative to PLC and ARC-CO. In 2019, the Midwest experienced major flooding, and as a result, many producers could not plant crops. A prevent plant (PP) rule included in ARC-IC caused producers affected by the flooding to consider ARC-IC as a viable option, especially with the shortened, two-year program election.

The model results indicated ARC-IC is a viable option for farms with 100 percent PP in 2019, however, producers should consider whether the maximum ARC-IC payment in 2019 makes up for the risk of zero payment in 2020. Farms with yield losses in 2019 may also consider ARC-IC, but with more attention on the analysis of risk associated with potential

payments. Again, the 2020 ARC-IC payment risk should factor into the decision, and producers should evaluate and compare two years of potential PLC or ARC-CO payments relative to ARC-IC.

The ARC-IC decision tool was useful for commodity producers wanting to evaluate potential ARC-IC payments to inform decisions regarding their farm safety net. Producers can benefit from this evaluation of ARC-IC and use of a future updated version of the decision tool when annual program election begins for 2021.

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The price projections were provided by the Food and Agricultural Policy Research Institute (FAPRI) at the University of Missouri. The projections used were from the 2020 FAPRI Baseline from February 2020. Historical data, base acre data, and planted acre data for the model farms were provided by the Agricultural and Food Policy Center (AFPC) at Texas A&M University. Other utilized data came from public sources, including the Farm Service Agency (FSA) and the National Agricultural Statistics Service (NASS).

The yield correlation and risk analysis portion of Chapter 3 was directed by Dr. Henry L. Bryant. All other work for the thesis was completed by the student independently.

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CHAPTER I

INTRODUCTION

For more than 80 years, U.S. producers have relied on farm commodity programs as a safety net, to provide protection from the inevitable risk in agriculture. The goal of the safety net is to offer farmers support in bad times so they can stay in business and continue to supply affordable food domestically and remain competitive in world markets. To continuously meet these goals, farm programs have evolved over time as agricultural practices and requirements for an effective safety net have changed.

The Agricultural Act of 2014 (2014 farm bill) established two new safety net programs for producers: price loss coverage (PLC) and agriculture risk coverage (ARC). PLC provides payments when the price of a covered commodity falls below the set reference price. ARC provides payments when actual revenue falls below a revenue guarantee level with coverage level options at the county level (ARC-CO) and individual farm level (ARC-IC). The 2014 farm bill required producers to make a five-year (2014-2018) program election for each covered commodity on each of their farms. However, if a producer selected ARC-IC for a farm, all commodities on that farm were enrolled in ARC-IC.

The 2014 farm bill also authorized funds for development of decision tools to help producers make informed program enrollment decisions. The Agricultural and Food Policy Center (AFPC) at Texas A&M University, in conjunction with the Food and Agricultural Policy and Research Institute (FAPRI) at the University of Missouri, developed one decision tool; the University of Illinois developed the other. The 2018 farm bill reauthorized PLC, ARC-CO, and ARC-IC programs with some changes. Producers made a two-year program election for 2019 and 2020 crop years and will make an annual decision for future crop years (2021, 2022, and 2023). The 2018 farm bill did not allocate funds for decision tool development, however, several groups, such as AFPC, still choose to provide decision tools to producers. Most 2018 farm bill decision tools only evaluated PLC versus ARC-CO and did not include ARC-IC due to the program's unpopularity during 2014 farm bill program election. Less than one percent of enrolled base acres were enrolled in ARC-IC for the 2014-2018 crop years (USDA/FSA, 2015), however, for the 2019 and 2020 sign-up, ARC-IC gained interest from producers due to the late timing of signup making 2019 yield information available prior to the March 15, 2020 sign-up date; and many cases of 100 percent prevented planting (PP), which results in a maximum ARC-IC payment rate. Increased interest in ARC-IC created the need for a decision tool that enables producers to analyze potential benefits of ARC-IC to weigh against PLC and ARC-CO.

Objectives

The primary objective of this thesis is to provide an educational tool to evaluate ARC-IC as a safety net program for 2019 and 2020. The tool will incorporate price and yield risk and simulate stochastic potential ARC-IC payment outcomes using producers' specific farm information. A secondary objective is to evaluate case studies of farms representing different commodities and production regions with the ARC-IC model to identify conditions for which ARC-IC is a viable option.

Justification

The need for an ARC-IC decision aid arose with the increased interest in the program after flooding in 2019 caused farmers to have to take prevented planting on millions of crop acres. When the PP rule applies to enrolled ARC-IC acres, the maximum ARC-IC payment is triggered. As ARC-IC gained relevance, changes to the time frame of commodity program elections also gave producers more decision flexibility. Program decisions are not as lasting and producers may make different choices than they would for a longer-term enrollment. ARC-IC was seen as a risky option for a five-year safety net. The shorter commitment adds to the ARC-IC appeal and there are specific conditions where the program is preferred to PLC and ARC-CO for the 2019 and 2020 crop years. An ARC-IC decision tool can help educate producers on the complexities of the program and enhance decision making by providing potential payment outcomes. The ARC-IC tool could also be adapted in the future to aid in the 2021, 2022, and 2023 program decisions.

CHAPTER II

REVIEW OF LITERATURE

This literature review is organized into four sections:

- Program choices in the 2014 farm bill
- Program choices in the 2018 farm bill
- Evolution of ARC-Individual as a safety net (rule of prevent plant)
- Stochastic Simulation

Program Choices in the 2014 Farm Bill

Commodity title programs, PLC, ARC-CO, and ARC-IC were established in Title I of the 2014 farm bill and gave producers the option to tailor their safety net to their operation. PLC and ARC are administered by the USDA Farm Service Agency (FSA). PLC is triggered by low prices, while ARC is triggered by low revenues on county (ARC-CO) and individual (ARC-IC) levels. Producers elected PLC or ARC-CO for each covered commodity on each farm or selected ARC-IC for an entire farm. If multiple farms were enrolled in ARC-IC, the farms were aggregated together into one ARC-IC Farm. Covered commodities included corn, soybeans, wheat, grain sorghum, peanuts, short and medium grain rice, long grain rice, temperate japonica rice, barley, oats, dry peas, lentils, small chickpeas, large chickpeas, and other oilseeds (USDA/FSA, 2018); seed cotton became eligible for PLC and ARC in 2018.

For all three programs, coverage applied to the base acres established for each covered commodity on each farm. During farm bill development, commodities and regions lobbied for significantly different types of support. In an attempt to pacify all groups, the farm bill created program options or choices instead of one common commodity program. PLC supporters were concerned with protecting against low prices, such as southern peanut and rice producers; ARC-

CO supporters, led by Midwest corn and soybean producers, wanted a shallow loss revenue program; and establishment of ARC-IC was most popular among smaller footprint crops in the Great Plains (Schnitkey and Zulauf, 2016). Regardless of choice, producers made a five-year decision, and the elected programs applied to the 2014-2018 crop years.

Decisions between PLC and ARC were important to a producers' bottom-line, but the novelty of the programs created uncertainty and the need for education and decision aid resources. Agriculture extension resources were offered in several states, and USDA funded AFPC, with FAPRI, and the University of Illinois to develop two decision tools to analyze program options for producers. The AFPC 2014 farm bill decision aid used producers' input information, such as county, crop base acres, and payment yields, and, with commodity price projections from FAPRI, the tool estimated potential 2014-2018 PLC and ARC-CO payments. Based on initial evaluations of ARC-IC, neither AFPC nor University of Illinois offered an ARC-IC decision aid for the 2014 farm bill. Producers used the analysis to understand the unfamiliar programs and make informed decisions for each crop and/or farm. The following text details the workings of the 2014 Title I programs.

PLC provides program payments when the effective price is less than the reference price for a covered commodity. The effective price is the higher of the Marketing Year Average (MYA) price or the national average loan rate. Reference prices for each covered commodity were set by Congress for the life of the 2014 farm bill (2014-2018). The payment rate is equal to the difference between the effective price and reference price in a given year for the covered commodity. PLC payments for a covered commodity are equal to the payment rate, multiplied by the payment yield, multiplied by 85 percent, multiplied by base acres. Each covered commodity on an individual farm has a unique PLC payment yield and number of base acres.

Equations for PLC payments are as follows, for each covered commodity, on a farm, in a given year (USDA/FSA, 2018):

PLC payment = payment rate x payment yield x 85% x base acres

ARC-CO provides payments when the actual county crop revenue is less than the ARC-CO guarantee for a covered commodity in the specified county. Actual county crop revenue equals the higher of the Marketing Year Average (MYA) price or the national average loan rate, multiplied by the county yield in a given year for the covered commodity. The ARC-CO guarantee equals 86 percent of the previous five-year Olympic average[1] of national MYA prices (guarantee price), multiplied by the five-year Olympic average of county yields (guarantee yield). A transitional yield (T-yield) is established each year for each county; if the county yield in any of the previous five years is below 70 percent of the T-yield (changed to 80 percent in the 2018 farm bill) (USDA/FSA, 2020c), then 70 (80) percent of the T-yield is substituted for the county yield for that year. ARC-CO payments for a covered commodity equal 85 percent, multiplied by base acres, multiplied by the difference between the county guarantee and the actual county crop revenue for the given covered commodity, not to exceed ten percent of the ARC-CO benchmark revenue (guarantee price, multiplied by guarantee yield). Equations for ARC-CO payments are as follows, for each covered commodity, on a farm, in a given year (USDA/FSA, 2018):

ARC-CO payment = 85% x base acres x minimum (county guarantee – actual county crop revenue, maximum payment rate)

County guarantee = 86% x previous 5-year Olympic average price x previous 5-year Olympic average yield

[1] The average, excluding the high and the low values.

Actual county crop revenue = higher of (MYA price, national average loan rate) x county yield

ARC-CO maximum payment rate= 10% x previous 5-year Olympic average price x previous 5-year Olympic average yield

ARC-IC provides payments when the actual ARC-IC Farm revenue falls below the ARC-IC revenue guarantee. An ARC-IC Farm is the sum of a producer's interests in all FSA farms enrolled in ARC-IC in the state (producers enroll in ARC-IC by farm, not by commodity), and payments are based on covered commodities planted in the current year rather than commodities to which base acres are attributed. Actual ARC-IC Farm revenue is equal to the sum of current year revenues (higher of MYA price or national average loan rate, times actual yield) multiplied by the weighting factors for each crop planted on each farm in the current year. The ARC-IC revenue guarantee is equal to 86 percent of the benchmark revenue. The benchmark revenue is the sum of the previous five-year Olympic average revenues (higher of MYA price or reference price, times actual yield from previous five years) multiplied by the weighting factors for each crop planted on each farm in the current year. Each commodity planted on each farm in the current year has a weighting factor equal to the producer share of acres of that commodity planted on that farm, divided by the total number of planted acres across the ARC-IC Farm.

If a crop had not previously been planted every year and actual yield history for any of the previous five years is not available to establish the benchmark revenue, then the county average yield for the missing data year(s) is used in the calculation. If the actual yield in any of the previous five years is below 70 percent of the T-yield (changed to 80 percent in the 2018 farm bill) (USDA/FSA, 2020c), then 70 (80) percent of the T-yield is substituted for the actual yield for that year. ARC-IC payments for an ARC-IC Farm equal 65 percent, multiplied by the producer's share of total ARC-IC Farm base acres, multiplied by the ARC-IC payment rate. The

ARC-IC payment rate is the minimum of the revenue guarantee minus the actual revenue and the maximum payment rate (10 percent of the benchmark revenue). Equations for ARC-IC payments are as follows, on an ARC-IC Farm (USDA/FSA, 2018):

ARC-IC payment = 65% x total ARC-IC Farm base acres x ARC-IC payment rate

ARC-IC payment rate = minimum (revenue guarantee – actual revenue, maximum payment rate)

Revenue guarantee = 86% x benchmark revenue

Benchmark revenue = [Σfor all crops (previous 5-year Olympic average revenue x weighting factor)][1]

Actual revenue = [Σfor all crops (current year revenue x weighting factor)][2]

Maximum payment rate = 10% x benchmark revenue

During 2014 farm bill sign up, approximately 76 percent of program enrolled base acres were enrolled in ARC-CO, 23 percent in PLC, and less than 1 percent in ARC-IC (USDA/FSA, 2015). Table 2.1 breaks down 2014 program enrollment by crop base acres and percentage of base acres allocated to each program by crop. Wheat had the largest number of base acres (1,258,950) enrolled in ARC-IC, followed by corn (323,106) and soybeans (191,053), however, ARC-IC participation for wheat, corn, and soybeans only equated to 1.98 percent, 0.33 percent, and 0.35 percent of total enrolled base acres for each crop, respectively. On a percentage by crop basis, ARC-IC was most popular among producers of large chickpeas, small chickpeas, lentils, dry peas, and mustard although there are significantly fewer existing base acres assigned to these commodities.

[2] Weighting factor is equal to the producer share of acres of a covered commodity planted on a farm divided by total crop acres planted across the ARC-IC Farm.

Table 2.1 2014-2018 National ARC/PLC Election – Base Acres and Percentages by Crop

Covered Commodity	PLC		ARC-CO		ARC-IC		Total Enrolled Base Acres
	Enrolled Base acres	% of Total Enrolled	Enrolled Base acres	% of Total Enrolled	Enrolled Base acres	% of Total Enrolled	
Barley	3,876,590	74.76%	1,127,214	21.74%	181,913	3.51%	5,185,717
Canola	1,436,766	97.32%	31,814	2.15%	7,736	0.52%	1,476,317
Corn	6,388,066	6.60%	90,057,276	93.06%	323,106	0.33%	96,768,447
Crambe	1,698	65.22%	889	34.16%	16	0.62%	2,603
Dry Peas	196,636	44.50%	219,471	49.67%	25,783	5.83%	441,890
Flaxseed	145,584	63.22%	82,871	35.99%	1,837	0.80%	230,292
Generic	-	0.00%	-	0.00%	8,294	0.05%	17,582,910
Grain Sorghum	5,965,661	66.44%	2,998,211	33.39%	15,557	0.17%	8,979,430
Large Chickpeas	19,412	22.67%	56,636	66.14%	9,587	11.19%	85,634
Lentils	151,080	52.63%	116,798	40.69%	19,185	6.68%	287,063
Mustard	13,845	56.02%	9,431	38.16%	1,439	5.82%	24,715
Oats	671,385	32.04%	1,410,063	67.30%	13,778	0.66%	2,095,226
Peanuts	2,013,443	99.66%	6,781	0.34%	18	0.00%	2,020,243
Rapeseed	1,100	44.36%	1,335	53.83%	45	1.81%	2,481
Rice, Long Grain	4,007,809	99.83%	6,912	0.17%	-	0.00%	4,014,721
Rice, Medium Grain	167,293	96.24%	6,532	3.76%	-	0.00%	173,824
Rice, Temperate Japonica	355,082	61.73%	197,020	34.25%	23,092	4.01%	575,194
Safflower	62,521	63.11%	33,401	33.72%	3,145	3.17%	99,068
Sesame	4,378	84.09%	828	15.91%	-	0.00%	5,206
Small Chickpeas	5,004	22.68%	15,006	68.00%	2,057	9.32%	22,067
Soybeans	1,688,365	3.10%	52,635,553	96.55%	191,053	0.35%	54,514,972
Sunflowers	920,546	55.76%	710,724	43.05%	19,683	1.19%	1,650,954
Wheat	27,045,581	42.46%	35,394,613	55.57%	1,258,950	1.98%	63,699,144
Total	55,137,845	22.75%	185,119,381	76.38%	2,106,275	0.87%	242,355,206

(USDA/FSA, 2015)

Program Choices in the 2018 Farm Bill

The 2018 farm bill reauthorized PLC and ARC, with few changes to ARC-IC. Added program election flexibility allowed producers to make a two-year, PLC or ARC decision for the 2019 and 2020 crop years and producers will make an annual decision for each succeeding crop year (2021, 2022, and 2023). Additional flexibility creates opportunities for producers to tailor their safety net to current conditions and specifics of their operation but also requires more frequent decision-making. A shorter-term decision involves less risk and likely results in producers considering different factors and making different choices than they would for longer-term program enrollment. Table 2.2 details the two-year program enrollment by base acres and percentage of base acres for each crop for the first 2018 farm bill sign-up. ARC-IC participation increased to 5.89 percent of enrolled corn base acres (5,625,060 acres), 6.23 percent of enrolled soybean base acres (3,364,056 acres), and 3.87 percent of total enrolled base acres (9,802,619 acres) (USDA/FSA, 2020b). ARC-IC experienced a decline in participation of smaller crops while corn and soybeans made up almost 91.7 percent of ARC-IC acres. There was also a shift in the majority of enrolled acres from ARC-CO to PLC; enrollment numbers in the two programs almost switched relative to 2014 program election.

Table 2.2 2019-2020 National ARC/PLC Election – Base Acres and Percentages by Crop

Covered Commodity	PLC		ARC-CO		ARC-IC		Total Enrolled Base Acres
	Enrolled Base acres	% of Total Enrolled	Enrolled Base acres	% of Total Enrolled	Enrolled Base acres	% of Total Enrolled	
Barley	5,091,290	94.09%	298,409	5.51%	21,227	0.39%	5,410,926
Canola	1,458,195	99.12%	12,620	0.86%	326	0.02%	1,471,141
Corn	72,050,732	75.50%	17,751,388	18.60%	5,625,060	5.89%	95,427,180
Crambe	2,192	83.41%	436	16.59%	0	0.00%	2,628
Dry Peas	420,942	95.16%	19,033	4.30%	2,368	0.54%	442,343
Flaxseed	220,446	95.73%	9,048	3.93%	785	0.34%	230,279
Grain Sorghum	8,111,813	93.38%	515,926	5.94%	58,963	0.68%	8,686,702
Large Chickpeas	76,262	92.94%	5,706	6.95%	84	0.10%	82,052
Lentils	273,875	95.81%	11,850	4.15%	127	0.04%	285,852
Mustard	22,046	88.47%	2,872	11.53%	0	0.00%	24,918
Oats	1,270,959	61.43%	759,062	36.69%	38,885	1.88%	2,068,906
Peanuts	2,449,867	99.90%	2,459	0.10%	41	0.00%	2,452,367
Rapeseed	2,321	96.19%	92	3.81%	0	0.00%	2,413
Rice, Long Grain	3,936,236	99.89%	4,207	0.11%	307	0.01%	3,940,750
Rice, Medium Grain	170,357	99.42%	996	0.58%	3	0.00%	171,356
Rice, Temperate Japonica	415,713	78.36%	113,974	21.48%	806	0.15%	530,493
Safflower	74,242	88.55%	9,461	11.28%	137	0.16%	83,840
Seed Cotton	12,833,019	99.07%	116,583	0.90%	4,174	0.03%	12,953,776
Sesame	5,598	93.32%	401	6.68%	0	0.00%	5,999
Small Chickpeas	20,512	92.55%	1,409	6.36%	241	1.09%	22,162
Soybeans	7,596,366	14.07%	43,020,667	79.70%	3,364,056	6.23%	53,981,089
Sunflowers	1,495,345	91.12%	122,570	7.47%	23,180	1.41%	1,641,095
Wheat	59,143,784	93.04%	3,764,080	5.92%	661,849	1.04%	63,569,713
Total	177,142,112	69.88%	66,543,249	26.25%	9,802,619	3.87%	253,487,980

(USDA/FSA, 2020b)

Evolution of ARC-Individual as a Safety Net

During the 2014 farm bill development, advocates from areas of the U.S. that have larger counties lobbied for ARC-IC as a revenue protection alternative to ARC-CO. ARC-IC proponents came from larger, diverse counties who claim county averages are not representative of individual operations in the county, as well as, farmers with actual crop yields that far exceed average yields for their county. However, in 2014, ARC-IC proved an unpopular choice for several reasons: 1) greater program complexity compared to PLC and ARC-CO; 2) program pays on 65 percent of base acres (versus 85 percent for PLC and ARC-CO; and 3) the long-term nature of a five-year decision added to the risk and uncertainty of a complex program with fewer payment acres.

According to Zulauf et al. (2019), some farm attribute(s) must be present to compensate for fewer ARC-IC payment acres, and there are certain circumstances under which ARC-IC should be considered. First, ARC-IC may be viable when all covered commodities on a farm are approved PP because the scenario results in a maximum ARC-IC payment. If a farm experiences only partial PP, then the PP rule does not apply; the ARC-IC payment will be based on the commodities that were planted and the corresponding yields and will ignore PP acres. Second, a producer should consider ARC-IC if the ARC-IC benchmark yield is significantly higher than both the PLC payment yield and the ARC-CO benchmark yield. Third, highly variable year-to-year production on a farm could mean ARC-IC is a valid option. Finally, ARC-IC has more non-payment acres available (35 percent versus 15 percent for PLC and ARC-CO) for planting of fruits and vegetables without reduction in farm program payments. All of these are applicable to the 2019-2020 decision; the latter three were also applicable to the 2014 farm bill decision (Zulauf and Schnitkey, 2014).

The PP consideration was important for ARC-IC during 2019 and 2020 program enrollment. Heavy flooding of the Mississippi, Arkansas, and Missouri Rivers inundated farmland in affected areas and caused acres to go unplanted. The FSA crop acreage data report published January 1, 2020, indicated 19.62 million PP acres filed for the 2019 crop year (USDA/FSA, 2020a). Table 2.3 shows PP acres by state and crop for the states and crops with the most 2019 PP acres. South Dakota reported the most PP acres (3.95 million) followed by Ohio (1.56 million), Illinois (1.51 million), Missouri (1.40 million), and Arkansas (1.33 million).

Much of the Midwest farmland was affected by the flooding, but the PP effects also reached southern states, such as Texas and Arkansas. Corn, soybeans, and wheat producers had the most unplanted cropland acres followed by rice, upland cotton, and grain sorghum. Producers with high 2019 PP acre numbers considered ARC-IC due to the maximum payment that results from 100 percent PP acres on a farm. Recall, ARC-IC calculates actual revenue by multiplying current year MYA price by actual yield. In the case of 100 percent PP, actual yield is zero, and the payment rate is equal to the maximum payment rate because the maximum payment rate is less than the difference between the revenue guarantee and the actual revenue. The important distinction is whether a farm experienced 100 PP or only partial PP. If partial PP occurred, PP acres are not included in the payment calculations, and payments are determined by commodities that were planted.

Table 2.3 2019 Prevent Plant Acres by Most Affected States and Crops

	Corn	Soybeans	Wheat	Rice	Upland Cotton	Grain Sorghum	Other Crops	**Total**
South Dakota	2,908,376	868,940	127,400			31,838	11,434	**3,947,988**
Ohio	928,742	629,815	6,057			4	93	**1,564,712**
Illinois	1,145,385	331,247	27,073	2,652	437	708	90	**1,507,591**
Missouri	750,739	483,094	85,016	61,499	18,173	2,280	128	**1,400,930**
Arkansas	327,740	187,929	255,928	511,819	38,348	6,536	972	**1,329,272**
Minnesota	1,000,683	161,246	7,557			2	1,932	**1,171,420**
Indiana	710,038	229,628	3,532			389	122	**943,709**
Michigan	522,774	363,921	20,285			6	2,070	**909,057**
Texas	175,441	9,145	376,719	42,569	186,433	57,668	19,110	**867,086**
North Dakota	590,469	201,883	60,534			0	3,855	**856,741**
Other States	2,373,071	994,584	1,249,971	133,209	251,033	73,295	47,089	**5,122,253**
Total	**11,433,459**	**4,461,432**	**2,220,072**	**751,749**	**494,425**	**172,726**	**86,895**	**19,620,758**

(USDA/FSA, 2020a)

The total national PP acres of approximately 19.62 million acres seems disproportionate to the 9.80 million acres enrolled in ARC-IC for 2019 and 2020 given a PP farm results in a maximum ARC-IC payment. Potential reasons all PP acres were not enrolled in ARC-IC for

2019 and 2020 relate to the idea that decisions are not made only on a financial basis and include:

1) Program complexity or lack of knowledge of PP rule steers producers away from ARC-IC and towards the more popular and familiar PLC and ARC-CO programs. Producers who enrolled in PLC or ARC-CO in 2014 and benefited from those programs may have decided to choose the same programs again for the sake of simplicity;
2) Reduction of payment base acres to 65 percent compared to 85 percent for PLC and ARC-CO;
3) Uncertainty of ARC-IC payment in 2020;
4) Some national PP acres exist on partial PP farms and, therefore, do not qualify for the ARC-IC maximum payment.

A less complicated (unpublished) version of the ARC-IC decision tool was developed prior to program sign-up for 2019 and 2020. The early version was a straight calculator without stochastic parameters and was used by producers across the U.S. The producers most interested in ARC-IC experienced 100 percent PP in 2019 and qualified for the maximum payment, eliminating the need for a 2019 price forecast. Several producers that qualified for the 2019 maximum payment indicated they were not interested in evaluating potential 2020 payments given market price levels at the time suggested there would be very little payment for either ARC-CO or PLC; thus, producers made program decisions based on 2019 payments alone. These producers assumed the ARC-IC payment in 2019 would outweigh two years of payments from PLC or ARC-CO for their farm(s).

Stochastic Simulation

A stochastic model incorporates risk for simulated variables that are assumed to have a known probability distribution. Stochastic simulation adds risk to a deterministic model by simulating a sample of values for each key output variable (KOV) to represent an estimate of the variable's probability distribution. Variability of historic data is included as risk to estimate the parameters for probability distributions of stochastic variables. A stochastic model is simulated 100 to 500 times using random draws of the risky (unknown) variables to estimate a range of probable outcomes for the KOVs (Richardson, 2008).

The focus for this study is to evaluate ARC-IC as a viable safety net program for both 2019 and 2020 and under what circumstances it should or should not be considered. For 2019 analysis, yields for most commodities are known variables while 2019 prices are simulated. For 2020 analysis, both price and yield variables are simulated. Stochastic simulation of unknown variables for 2019 and 2020 is necessary to incorporate risk and estimate a distribution of probable 2019 and 2020 ARC-IC payments. A model that includes price and yield risk to estimate ARC-IC payments does not exist as ARC-IC has been unpopular in the past due to program complexity and reduced percentage of eligible payment acres compared to PLC and ARC-CO. Numerous cases of PP in 2019 and some cases of heavy yield loss have sparked producer interest in ARC-IC because the program is responsive to these individual farm issues. The model created in this study aims to clarify the ARC-IC program rules and has the ability to simulate stochastic ARC-IC payment results for any farm inputted in the model.

CHAPTER III

METHODOLOGY

An ARC-IC decision tool was developed in this study and utilized to evaluate ARC-IC as a viable safety net option on case study farms. The ARC-IC decision tool was built in Excel to estimate ARC-IC payments for the 2019 and 2020 crop years. The initial (unpublished) version of the tool calculated potential ARC-IC payments but did not have stochastic functions to incorporate risk. The model was expanded to include stochastic simulation of future prices and yields to analyze various farm scenarios and determine types of operations suitable for ARC-IC. Images of the model layout with random farm inputs are included in the appendix.

Data

The ARC-IC decision tool requires the following individual information for each farm:

1) Number of base acres;
2) Covered commodities planted or prevented planted (PP), and number of acres of each[3], in 2019 and 2020;
3) Historical per-acre yields for each covered commodity planted (2013-2017 yields are used to calculate 2019 benchmark revenue, 2014-2018 yields are used to calculate 2020 benchmark revenue, 1999-2018 yields are used to forecast 2020 yields)[4].

This decision tool was designed to provide ARC-IC analysis for most covered commodities: wheat, barley, oats, peanuts, corn, grain sorghum, soybeans, dry peas, lentils, large chickpeas,

[3] PP acres are only included in ARC-IC calculations if all commodities on the farm are PP.
[4] For benchmark revenue calculations, ARC-IC uses the higher of the actual yield or 80% of the T-yield for historical years the crop was grown. In historical years the crop was not grown, ARC-IC substitutes 100% of the county average yield. This yield data for each county, comes from FSA (USDA/FSA, 2020e and 2020f).

small chickpeas, sunflower seed, seed cotton, long grain rice, medium and short grain rice, and temperate japonica rice.

Model Farms

Each model farm analyzed in this study is modeled after one of the AFPC representative farms. AFPC develops, on paper, farms representative of various agricultural areas in the U.S. by collecting and maintaining production data and financial data to model farms that are "representative" of farms across the U.S. (Outlaw et al., 2020).

Planted acre and historic yield information from three of the representative farms were used to create three model farms to evaluate under ARC-IC. Each model farm assumes the number of base acres is equal to number of planted acres. The details for each farm are listed in Table 3.1 (Outlaw et al., 2020). The Washington wheat farm is located in Whitman county and plants 5,800 acres of dryland and irrigated wheat and 2,600 acres of large chickpeas annually. The Iowa grain farm, in Webster county, consists of 3,400 acres of cropland, allocated to 2,210 acres of corn, and 1,190 acres of soybeans each year. The Texas cotton farm is in Crosby county located in the Southern Plains of Texas; this farm plants 4,700 acres of dryland and irrigated cotton and 300 acres of wheat.

Table 3.1 Model Farms - Base Acres and Planted Acres

Farm	**WA Wheat**	**IA Grain**	**TX Cotton**
Base Acres	8,400	3,400	5,000
Crop 1:	Wheat:	Corn:	Cotton:
Planted Acres	5,800	2,210	4,700
Crop 2:	Large Chickpeas:	Soybeans:	Wheat:
Planted Acres	2,600	1,190	300

(Outlaw et al., 2020)

The decision tool provides historical prices for specified covered commodities planted (2013-2017 prices are used to calculate 2019 benchmark revenue, and 2014-2018 prices are used to calculate 2020 benchmark revenue). ARC-IC historical prices are the higher of the reference price and the MYA price reported by FSA each year for each covered commodity (USDA/FSA, 2020d). The decision tool will use the given information and historical prices to calculate the following for 2019 and 2020 crop years:

1) Weighting factors for each planted or PP crop on each farm (number of acres of a crop planted on a farm divided by all crops planted on the ARC-IC Farm);
2) Historical revenue per acre for each planted or PP crop on each farm for each year of history (historical yield, multiplied by historical price);
3) Five-year Olympic average revenue per acre for each planted or PP crop on each farm;
4) Weighted five-year Olympic average revenue per acre for each planted or PP crop on each farm; and
5) Benchmark revenue for ARC-IC Farm (sum of weighted Olympic average revenues for all farms enrolled in ARC-IC in the State).

Stochastic Prices and Yields

The final required data points, actual MYA prices and individual yields, are used to calculate actual revenue and expected ARC-IC payments for 2019 and 2020. Stochastic price data for both years and yield data for 2020 are built into the model; 2019 yield data must be entered manually. The model uses 500 iterations of MYA price projections for each crop for both 2019 and 2020 actual prices. The projected MYA price iterations were generated by FAPRI in February 2020 (FAPRI, 2020). Prior to the March 15, 2020 program sign-up deadline, 2019 yield values for most crops had already been determined, therefore, the decision tool requires entry of a known yield value for 2019. Stochastic yields for 2020 are generated using a normal distribution of correlated yield deviates determined by 20 years of individual yield history and a typical correlation between crop yields. Historic yield data from 15 counties was used to define one "typical" county crop yield correlation matrix to represent a common correlation between any two crops in any county. The correlation is based on 20 years (2000-2019) of corn, soybean, and wheat county yields from counties in South Dakota, Ohio, Illinois, Missouri, and Arkansas (the commodities and states with the highest number of 2019 PP acres reported, for which ARC-IC was likely more popular). Yield data from three counties in each of the five states was collected from USDA National Agricultural Statistics Service (2020). Counties in each state were selected based on number of PP acres and available data for the applicable crops. Selected counties included Jackson, Mississippi, and Phillips in Arkansas; Bureau, Henry, and Kankakee in Illinois; Carroll, Mississippi, and St. Charles in Missouri; Hardin, Williams, and Wood in Ohio; and Beadle, Hutchinson, and Spink in South Dakota. Processes for determining crop yield correlations and simulating prices and yields are further discussed in the following yield correlation and risk analysis section.

The decision tool uses price and yield values for 2019 and 2020 to calculate:

1) Actual revenue per acre for each planted or PP crop on each farm (expected yield, multiplied by expected MYA price);
2) Weighted actual revenue per acre of each planted or PP crop on each farm (weighting factor, multiplied by actual revenue for each farm);
3) Actual revenue for ARC-IC Farm (sum of weighted actual revenues for all farms enrolled in ARC-IC);
4) Revenue guarantee (86% of benchmark revenue for ARC-IC Farm);

5) Revenue guarantee minus actual revenue;

6) Maximum payment (10% of benchmark revenue for ARC-IC Farm);

7) Payment rate (smaller of revenue guarantee minus actual revenue or the maximum payment, or zero if revenue guarantee minus actual revenue is less than zero);

8) Total expected ARC-IC payment (payment rate, times total number of base acres on ARC-IC Farm, multiplied by 65%).

The expected ARC-IC payment depends on the combination of farms included in the ARC-IC Farm. In the initial version of the ARC-IC decision tool, information could be entered for up to ten farms and a toggle feature allowed producers to change which farms were included in the analysis. The risk-incorporated version of the model allows up to two farms to be included for a few reasons: 1) to simplify the model for the purpose of stochastic yield simulation; 2) to focus the analysis on the types of operations well suited for ARC-IC rather than strategies for combining farms; and 3) to still capture the program rule that aggregates farms within a state into one ARC-IC Farm (rather than modifying the model to consider one farm only).

Yield Correlation and Risk Analysis

This section will describe the methods used to include stochastic prices and determine stochastic 2020 yield data "on the fly" as yield histories are entered. The 2019 analysis assumes known actual yields and incorporates price risk to generate a distribution of expected ARC-IC payments. The 2020 analysis includes price and yield risk. The model utilizes Simetar®, an Excel-based simulation model (Richardson et al., 2008), to incorporate risk on 2019 prices and 2020 prices and yields. Incorporation of risk further guides producer decisions by presenting a distribution of possible outcomes rather than a single deterministic payment estimation based on one price and one yield.

For each covered commodity included in the model, 500 iterations of forecasted 2019 prices and 500 iterations of forecasted 2020 prices are used to calculate 500 different potential ARC-IC payments for each year. For 2019, these prices are applied to a single yield to determine a distribution of possible payments. For 2020, the 2020 price iterations are used with a stochastic yield and generate 500 different outcomes based on two unknowns.

Several steps were taken to develop the model's 2020 individual stochastic yield simulation capability. The goals for the simulation were to: 1) generate a unique stochastic yield for each individual yield history entered into the model; 2) simultaneously simulate yields for multiple crops for farms that plant more than one commodity; 3) simulate yields for two farms at once for operations that have two farms enrolled in ARC-IC. The latter two goals required correlation between crops and between farms. Pairwise correlations between historical yield deviates for corn, soybeans, and wheat were calculated for 15 counties (listed in data section). Calculations were accomplished in Simetar® (Richardson et al., 2008) starting with a simple Ordinary Least Squares regression of 20 years of yield data on trend for each crop in each county. Linear correlation matrices were developed from yield deviates between crops for each county. Corresponding values in each of the 15 matrices were averaged and created one correlation matrix with ones on the diagonal and the mean between-crop correlation values for the off-diagonal elements. This initial matrix represents the typical correlation between corn, soybeans, and wheat in any county and is displayed in Figure 3.1.

The ARC-IC decision tool was intended for analysis of 16 major commodities, not just corn, soybeans, and wheat, and was designed to analyze up to seven crops on one farm and up to two farms as one ARC-Farm. Therefore, the correlation matrix in Figure 3.1 was expanded into the correlation matrix shown in Figure 3.2, with some assumptions: 1) any of the commodities, other than corn, soybeans, and wheat, that this decision tool was designed to analyze can be entered for Crop 4, 5, 6, or 7; 2) correlation between any two crops, excluding wheat, is equal to the correlation between corn and soybeans (0.48); 3) correlation between wheat and any crop other than corn and soybeans is 0.14, the midpoint of the wheat correlations with corn and soybeans; and 4) correlations between the same crop on farm 1 and farm 2 is .75, approximately the midpoint between the correlation between two different crops and the correlation of one crop on one farm with itself.

The resulting 14 by 14 correlation matrix represents the typical correlation of yield deviates between crops on two farms that will be used for each individual simulation of 2020 yields. Cholesky factorization of the correlation matrix decomposed the matrix into the product of a lower triangular matrix and its conjugate transpose. A Cholesky factorization matrix can be multiplied by a matrix of uncorrelated random variables to create correlated variables, useful to this model for yield simulation purposes.

	Corn	Soybeans	Wheat
Corn	1	0.48	0.21
Soybeans		1	0.07
Wheat			1

Figure 3.1 Initial Between Crop Correlation Matrix – Corn, Soybeans, and Wheat

Farm: Crop	1: Corn	1: Soybeans	1: Wheat	1: Crop 4	1: Crop 5	1: Crop 6	1: Crop 7	2: Corn	2: Soybeans	2: Wheat	2: Crop 4	2: Crop 5	2: Crop 6	2: Crop 7
1: Corn	1	0.48	0.21	0.48	0.48	0.48	0.48	0.75	0.48	0.21	0.48	0.48	0.48	0.48
1: Soybeans	0.48	1	0.07	0.48	0.48	0.48	0.48	0.48	0.75	0.07	0.48	0.48	0.48	0.48
1: Wheat	0.21	0.07	1	0.14	0.14	0.14	0.14	0.21	0.07	0.75	0.14	0.14	0.14	0.14
1: Crop 4	0.48	0.48	0.14	1	0.48	0.48	0.48	0.48	0.48	0.14	0.75	0.48	0.48	0.48
1: Crop 5	0.48	0.48	0.14	0.48	1	0.48	0.48	0.48	0.48	0.14	0.48	0.75	0.48	0.48
1: Crop 6	0.48	0.48	0.14	0.48	0.48	1	0.48	0.48	0.48	0.14	0.48	0.48	0.75	0.48
1: Crop 7	0.48	0.48	0.14	0.48	0.48	0.48	1	0.48	0.48	0.14	0.48	0.48	0.48	0.75
2: Corn	0.75	0.48	0.21	0.48	0.48	0.48	0.48	1	0.48	0.21	0.48	0.48	0.48	0.48
2: Soybeans	0.48	0.75	0.07	0.48	0.48	0.48	0.48	0.48	1	0.07	0.48	0.48	0.48	0.48
2: Wheat	0.21	0.07	0.75	0.14	0.14	0.14	0.14	0.21	0.07	1	0.14	0.14	0.14	0.14
2: Crop 4	0.48	0.48	0.14	0.75		0.48	0.48	0.48	0.48	0.14	1	0.48	0.48	0.48
2: Crop 5	0.48	0.48	0.14	0.48	0.75	0.48	0.48	0.48	0.48	0.14	0.48	1	0.48	0.48
2: Crop 6	0.48	0.48	0.14	0.48		0.75	0.48	0.48	0.48	0.14	0.48	0.48	1	0.48
2: Crop 7	0.48	0.48	0.14	0.48	0.48	0.48	0.75	0.48	0.48	0.14	0.48	0.48	0.48	1

Figure 3.2 Expanded Between-Crop Correlation Matrix – Two Farms, Seven Crops

The twenty years of individual yield history provided for each crop planted on each farm is used to determine a standard deviation of yields for each crop. Historic yields are regressed on trend to produce slope and intercept values for each crop. Residuals are calculated for each year of historical data using the equation:

$$r = y - \hat{y},$$

where r is the residual, y is the observed historic value and $\hat{y}$ is the predicted value. Predicted $\hat{y}$ values are calculated for each year of historical data using the equation:

$$\hat{y} = intercept + (slope\ x\ year).$$

The standard deviation of the residuals for each crop is calculated for each crop and defined as the yield standard deviation. Next, the model generates stochastic normal distribution values, using Simetar®. The independent standard normal draws are multiplied by the Cholesky factorization of the correlation matrix to create correlated standard normal draws. Correlated and scaled yield deviates are computed by multiplying the yield deviate standard deviations by the correlated standard normal draws for each crop. Finally, the 2020 stochastic yield values for each crop are determined by:

2020 stochastic yield = intercept + (slope x 2020) + correlated yield deviate.

The 2020 stochastic yields are inputted as 2020 actual yields and used to calculate actual revenue and determine ARC-IC payments. The model assumes zero correlation between national price realizations and individual producer yield realizations.

The decision tool concludes with results of Monte Carlo simulation of the 2019 and 2020 stochastic ARC-IC payments. The 2019 simulation produces 500 iterations of potential payments based on 500 draws of prices for each crop; the 2020 simulation produces 500 potential payments based on 500 draws of prices and 500 draws of yields for each crop.

Model Farm Analysis and Scenarios

Each model farm was analyzed to illustrate ARC-IC program specifics, show how the decision model works, and evaluate the efficacy of ARC-IC for different operations. The farms are modeled after representative farms developed and maintained by AFPC. Representative farms chosen for this study are diverse, allowing for analysis of ARC-IC for varying crops and regions. Model farms include Washington wheat, Iowa grain, and Texas cotton. For all three farms, the following entries were made in the decision tool:

1) For 2019 the tool requires base acres, planted acres, producer share of planted acres, 2013-2017 yield history for each crop planted in 2019, and actual 2019 yields.
2) For 2020 the tool carries over base acres information from 2019 and requires planted acres, producer share of planted acres, and 1999-2018 yield history for each crop planted in 2019.

The resulting ARC-IC payment outcome is simulated for each scenario for 2019 and 2020 to create a distribution of potential payments. Scenarios for varying levels of 2019 yield loss were analyzed for each model farm to determine, with FAPRI price iterations, the loss in yield required to trigger an ARC-IC payment. Table 3.2 details 2019 yield loss scenarios which are defined by percentage of expected yield analyzed for each model farm.

Table 3.2 2019 Yield Loss Scenarios for Model Farms

Model Farm	Scenario	Crop	Yield
WA Wheat	100% of Expected Yield	Wheat	89 bu/ac
		Large Chickpeas	1550 lb/ac
	75% of Expected Yield	Wheat	66.75 bu/ac
		Large Chickpeas	1162.5 lb/ac
	50% of Expected Yield	Wheat	44.5 bu/ac
		Large Chickpeas	775 lb/ac
	25% of Expected Yield	Wheat	22.25 bu/ac
		Large Chickpeas	387.5 lb/ac
	0% of Expected Yield (PP)	Wheat	0 bu/ac
		Large Chickpeas	0 lb/ac
IA Grain	100% of Expected Yield	Corn	196 bu/ac
		Soybeans	57 bu/ac
	75% of Expected Yield	Corn	147 bu/ac
		Soybeans	42.75 bu/ac
	50% of Expected Yield	Corn	98 bu/ac
		Soybeans	28.5 bu/ac
	25% of Expected Yield	Corn	49 bu/ac
		Soybeans	14.25 bu/ac
	0% of Expected Yield (PP)	Corn	0 bu/ac
		Soybeans	0 bu/ac
TX Cotton	100% of Expected Yield	Cotton	1662 lb/ac
		Wheat	11 bu/ac
	75% of Expected Yield	Cotton	1246.5 lb/ac
		Wheat	8.25 bu/ac
	50% of Expected Yield	Cotton	831 lb/ac
		Wheat	5.5 bu/ac
	25% of Expected Yield	Cotton	415.5 lb/ac
		Wheat	2.75 bu/ac
	0% of Expected Yield (PP)	Cotton	0 lb/ac
		Wheat	0 bu/ac

CHAPTER IV

RESULTS

The equations required to evaluate ARC-IC discussed in Chapter III were programmed into an excel spreadsheet, and the Excel Add-in Simetar® was used to develop stochastic yields for the different crops. The three representative farms were entered into the decision aid to validate the equations and test whether the decision aid could handle a variety of crops.

Results from the ARC-IC analysis of the Washington, Iowa, and Texas representative farms are discussed in this chapter. ARC-IC payments for 2019 and 2020 are the key out variables (KOVs). There was flexibility built into the 2019 stochastic yields to allow for an evaluation of payment outcomes at varying levels of expected yield.

The following yield loss scenarios were analyzed for each farm:

- zero percent (2019 yield equals expected yield);
- 25 percent (75 percent of expected yield);
- 50 percent (50 percent of expected yield);
- 75 percent (25 percent of expected yield); and
- 100 percent (zero percent of expected yield).

Prices for 2019 and 2020 are 500 stochastic draws from FAPRI. Crop yields for 2020 are stochastic, correlated random draws, therefore, results for both years are a distribution of potential payments.

Cumulative distribution function (CDF) graphs, created using Simetar®, were used to illustrate the risk in the potential ARC-IC payments. The CDF graphs include the 500 simulated iterations of the model output for 2019 and 2020. ARC-IC payments are on the x-axis and the corresponding probability values are on the y-axis. Summary tables are included for each model farm to show benchmark revenues, revenue guarantees, and maximum payment rates for 2019 and 2020. These values are based on historical MYA prices from USDA and historical yield and planted acre data from AFPC representative farms. For the representative farms analyzed in this study, the crop mix and the number of acres planted each year are held constant, therefore differences in the benchmark from 2019 to 2020 are small and generally a function of assumed genetic improvement in yields.

If additional farms with a changing crop mix or number of acres planted in 2019 and 2020 were analyzed, benchmark revenues and maximum payments would differ considerably year-to-year. When the actual revenue falls below the revenue guarantee (equal to 86% of the benchmark revenue), an ARC-IC payment was triggered. The payment is equal to 65% of a producers' ARC-IC enrolled base acres in the state, multiplied by the payment rate. The payment rate equals the minimum between the revenue guarantee minus the actual revenue and the maximum payment (10% of the benchmark revenue). If the revenue guarantee minus the actual revenue is zero or negative, the ARC-IC payment is zero. When considering the maximum potential payments that a farm can receive, this analysis did not take payment limits into account.

Washington Wheat Farm Results

Table 4.1 contains the 2019 and 2020 benchmark revenue, revenue guarantee, and maximum payment rate. The maximum possible ARC-IC payments for the Washington wheat farm are $269,012.25 for 2019 and $270,853.50 for 2020. To trigger an ARC-IC payment for either year, the actual revenue must fall below approximately $420 per acre.

Table 4.1 Washington Wheat ARC-IC Benchmark Summary

2019 ARC-IC Summary	
Benchmark Revenue per Acre	$486.94
Revenue Guarantee (Benchmark Revenue * 86%)	$418.77
Maximum Payment (Benchmark Revenue * 10%)	$48.69
2020 ARC-IC Summary	
Benchmark Revenue per Acre	$490.21
Revenue Guarantee (Benchmark Revenue * 86%)	$421.58
Maximum Payment (Benchmark Revenue * 10%)	$49.02

Summary statistics for simulated stochastic expected ARC-IC payments for 2019 are displayed in Table 4.2. Potential 2019 payments were simulated for each yield scenario. The expected yields (or 100 percent of the expected yields) were gathered from AFPC representative farm data. To illustrate how 2019 payment results change as yields decrease and discover what the yield loss must be relative to the expected yield in order to trigger an ARC-IC payment, the simulation was run with decreasing percentages of expected yield. Table 4.2 results are summary statistics of expected payments for each yield scenario, starting with the expected yield (89 bu./ac for wheat, 1550 lb./ac for large chickpeas) and decreasing in 25 percent increments down to zero percent, which represents a PP scenario. For each level of yield, the Washington wheat farm realizes some likelihood of a potential 2019 ARC-IC payment. Figure 4.1 is the ARC-IC payment CDF graph for expected yield, 75 percent of expected yield, and zero percent of expected yield (or PP). The CDF graphs for 50 percent and 25 percent of expected yield are identical to that of zero percent expected yield and are not included. If the farm realizes zero to 50 percent of its expected yield, the probability of a maximum payment is one or 100 percent. If the farm experiences 75 percent of expected yield, the probability of no ARC-IC payment is 0.01, the probability of any payment is 0.99, and the probability of a maximum payment is 0.92.

If the farm experiences 100 percent of expected yield, the probability of no ARC-IC payment is 0.47, the probability of any payment is 0.53, and the probability of a maximum payment is 0.17.

Table 4.3 presents summary statistics for the 2020 ARC-IC expected payment simulation. Figure 4.2 is the CDF graph for 2020 ARC-IC payments. The potential payment results indicate 54 percent likelihood of zero payment, 46 percent likelihood of a payment greater than zero, and 22 percent likelihood of maximum payment. These results suggest that this wheat farm would have enrolled in ARC-IC for 2019 and 2020 if they experienced 100 percent PP or anticipated some yield loss in 2019. As a revenue-based program, ARC-IC payments are dependent on both price and yield parameters. For the 2019 analysis, yields change in each scenario while the 500 iterations of prices remain constant. Given these price samples, the Washington wheat farm does not require a considerable yield loss to trigger an ARC-IC payment. If 2019 projected prices for this model farm's planted commodities, wheat and large chickpeas, were lower, it follows that less yield loss would have to occur to generate an ARC-IC payment. Conversely, if 2019 projected prices for these commodities were higher, then payment would be triggered at higher yield loss levels. Producers who do not have 100 percent PP acres should consider price loss relative to previous years' MYA prices used to set the benchmark revenue, in conjunction with yield loss, when evaluating ARC-IC as a viable option. Historical MYA prices for wheat and large chickpeas are graphed in Figure 4.3.

Table 4.2 Washington Wheat 2019 Expected ARC-IC Payment Summary Statistics

	WA Wheat
Expected Yield - Wheat	89 bu/ac
Expected Yield - Large Chickpeas	1550 lb/ac
Expected ARC-IC Payment	
Mean	$91,963
Standard Deviation	107,947
CV	117
Minimum	$0
Maximum	$269,034
75% of Expected Yield - Wheat	66.75 bu/ac
75% of Expected Yield - Large Chickpeas	1162.5 lb/ac
Expected ARC-IC Payment	
Mean	$260,222
Standard Deviation	39,835
CV	15
Minimum	$0
Maximum	$269,034
50% of Expected Yield - Wheat	44.5 bu/ac
50% of Expected Yield - Large Chickpeas	775 lb/ac
Expected ARC-IC Payment	
Mean	$269,034
Standard Deviation	0
CV	0
Minimum	$269,034
Maximum	$269,034
25% of Expected Yield - Wheat	22.25 bu/ac
25% of Expected Yield - Large Chickpeas	387.5 lb/ac
Expected ARC-IC Payment	
Mean	$269,034
Standard Deviation	0
CV	0
Minimum	$269,034
Maximum	$269,034
0% of Expected Yield (PP) - Wheat	0 bu/ac
0% of Expected Yield (PP) - Large Chickpeas	0 lb/ac
Expected ARC-IC Payment	
Mean	$269,034
Standard Deviation	0
CV	0
Minimum	$269,034
Maximum	$269,034

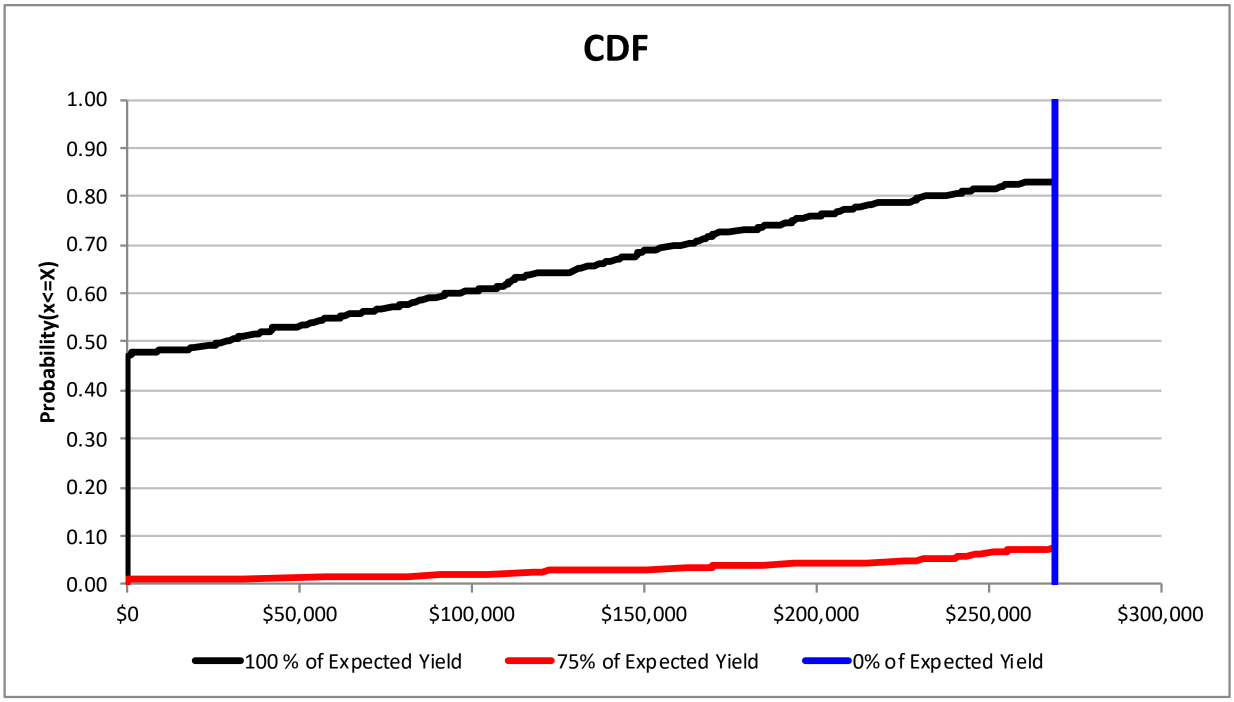

Figure 4.1 2019 ARC-IC payments for WA wheat farm, CDF

Table 4.3 Washington Wheat 2020 Expected ARC-IC Payment Summary Statistics

Expected ARC-IC Payment	WA Wheat
Mean	$90,302
Standard Deviation	116,870
CV	129
Minimum	$0
Maximum	$270,840

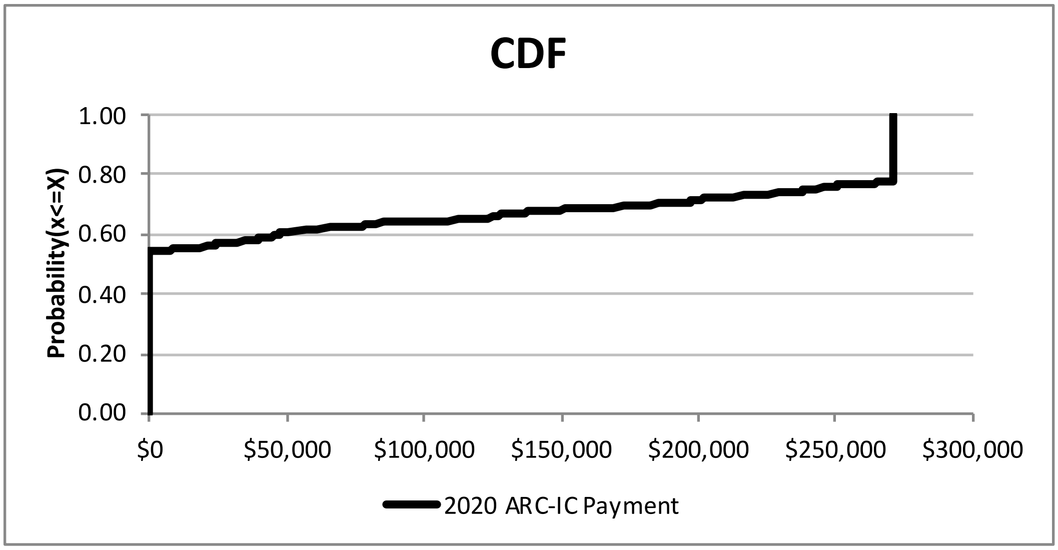

Figure 4.2 2020 ARC-IC payments for WA wheat farm, CDF

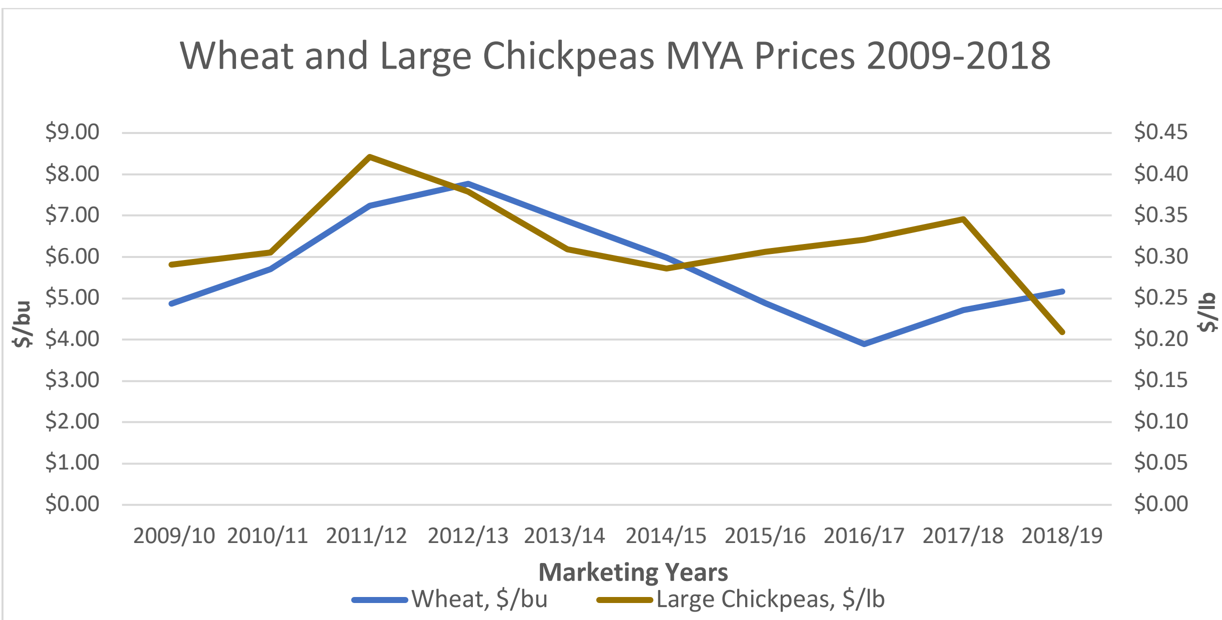

Figure 4.3 Historic MYA Prices - Wheat and Large Chickpeas (USDA/FSA, 2016; USDA/FSA, 2020d)

Iowa Grain Farm Results

The 2019 and 2020 benchmark revenue, revenue guarantee, and maximum payment rate for the Iowa grain farm are shown in Table 4.4. The maximum possible ARC-IC payment is $144,664 for 2019 and $142,746 for 2020. A per acre actual revenue below $562.94 in 2019 and below $555.49 in 2020 will prompt an ARC-IC payment.

Table 4.4 Iowa Grain ARC-IC Benchmark Summary

2019 ARC-IC Summary	
Benchmark Revenue per Acre	$654.59
Revenue Guarantee (Benchmark Revenue * 86%)	$562.94
Maximum Payment (Benchmark Revenue * 10%)	$65.46
2020 ARC-IC Summary	
Benchmark Revenue per Acre	$645.91
Revenue Guarantee (Benchmark Revenue * 86%)	$555.49
Maximum Payment (Benchmark Revenue * 10%)	$64.59

Table 4.5 displays summary statistics for simulated stochastic ARC-IC payments for the Iowa grain farm. Similar to the Washington wheat farm, potential payments for 2019 were simulated for five yield scenarios representing varying levels of expected yield to evaluate changes in payments due to changes in actual yield. Table 4.5 contains summary statistics of expected payments for each yield level, starting with the expected yield (196 bu./ac for corn, 57 bu./ac for soybeans) and decreasing in 25 percent increments down to zero percent, which represents a PP scenario. Figure 4.4 is the ARC-IC payment CDF graph for expected yield, 75 percent of expected yield, and zero percent of expected yield (or PP). The CDF graphs for 25 percent of expected yield and 50 percent of expected yield are identical to that of zero percent of expected yield and are not included. If the farm was prevented from planting a 2019 crop or realizes up to 50 percent of expected yield, the probability of the maximum ARC-IC payment is one. If the farm experiences 75 percent of expected yield, the probability of no ARC-IC payment is 0.19, the probability of a payment greater than $50,000 is 0.75, the probability of a payment greater than $100,000 is 0.66, and the probability of a maximum payment is 0.57. Finally, if the farm realizes expected yields for corn and soybeans, the probability of no payment is 0.79, the probability of a payment greater than $50,000 is 0.15, the probability of a payment greater than $100,000 is 0.09, and the probability of a maximum payment is 0.05. Probability

Density Function (PDF) graphs, created in Simetar®, are available in Figures 4.5 and 4.6 for 2019 ARC-IC expected payments using expected yields and 75 percent of expected yields, respectively.

Table 4.6 presents summary statistics for the 2020 ARC-IC expected payment. The corresponding CDF in Figure 4.7 shows the probability of this grain farm receiving a payment in 2020. The PDF is shown in Figure 4.8. For 2020, the probability of this Iowa grain farm not receiving an ARC-IC payment is about 0.35. The probability of an ARC-IC payment greater than $100,000 is 0.23, and the probability of qualifying for the maximum payment is 0.20.

These results suggest that this corn and soybean farm is likely to have enrolled in ARC-IC for 2019 and 2020, especially if they experienced 100 percent PP or any decline in yields relative to the expected yield in 2019. Corn and soybeans price expectations for 2019 are such that extreme yield loss for the two commodities is not necessary to prompt an ARC-IC payment. Historical corn and soybean MYA prices are graphed in Figure 4.9. During the 2013-2017 benchmark period, corn and soybean prices declined and have remained low and steady, therefore, not working against low yields to trigger an ARC-IC payment. In the case of yield loss or PP in 2019, this farm is less likely to benefit from an ARC-IC payment in 2020 than 2019, however, the producer may expect the 2019 payment to be greater than benefits from two years of PLC or ARC-CO.

Table 4.5 Iowa Grain 2019 Expected ARC-IC Payment Summary Statistics

	IA Grain
Expected Yield - Corn	196 bu/ac
Expected Yield - Soybeans	57 bu/ac
Expected ARC-IC Payment	
Mean	$18,303
Standard Deviation	41,550
CV	227
Minimum	$0
Maximum	$144,664
75% of Expected Yield - Corn	147 bu/ac
75% of Expected Yield - Soybeans	42.75 bu/ac
Expected ARC-IC Payment	
Mean	$101,490
Standard Deviation	59,545
CV	59
Minimum	$0
Maximum	$144,664
50% of Expected Yield - Corn	98 bu/ac
50% of Expected Yield - Soybeans	28.5 bu/ac
Expected ARC-IC Payment	
Mean	$143,927
Standard Deviation	8,419
CV	6
Minimum	$4,187
Maximum	$144,664
25% of Expected Yield - Corn	49 bu/ac
25% of Expected Yield - Soybeans	14.25 bu/ac
Expected ARC-IC Payment	
Mean	$144,664
Standard Deviation	0
CV	0
Minimum	$144,664
Maximum	$144,664
0% of Expected Yield (PP) - Corn	0 bu/ac
0% of Expected Yield (PP) - Soybeans	0 bu/ac
Expected ARC-IC Payment	
Mean	$144,664
Standard Deviation	0
CV	0
Minimum	$144,664
Maximum	$144,664

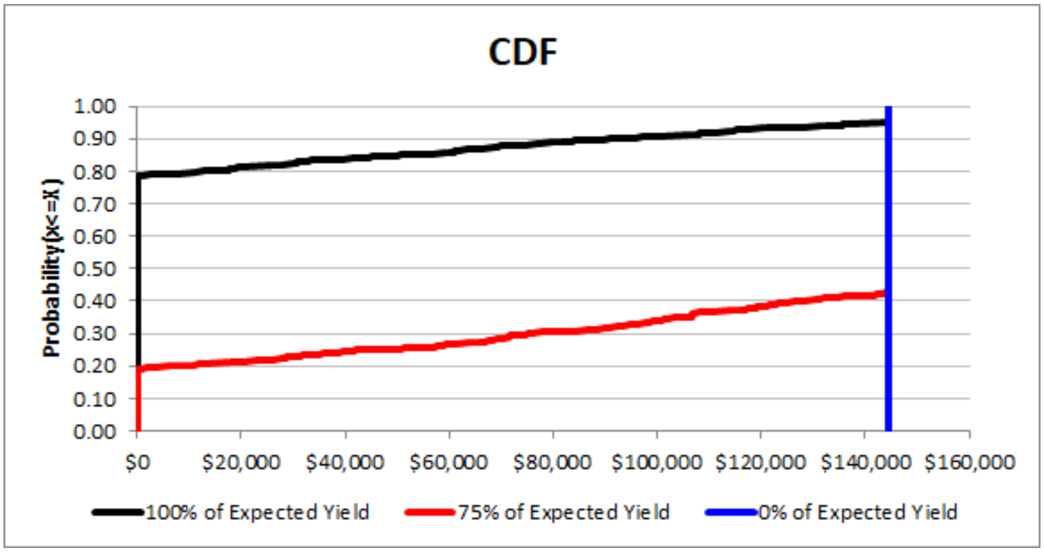

Figure 4.4 2019 ARC-IC payments for IA grain farm, CDF

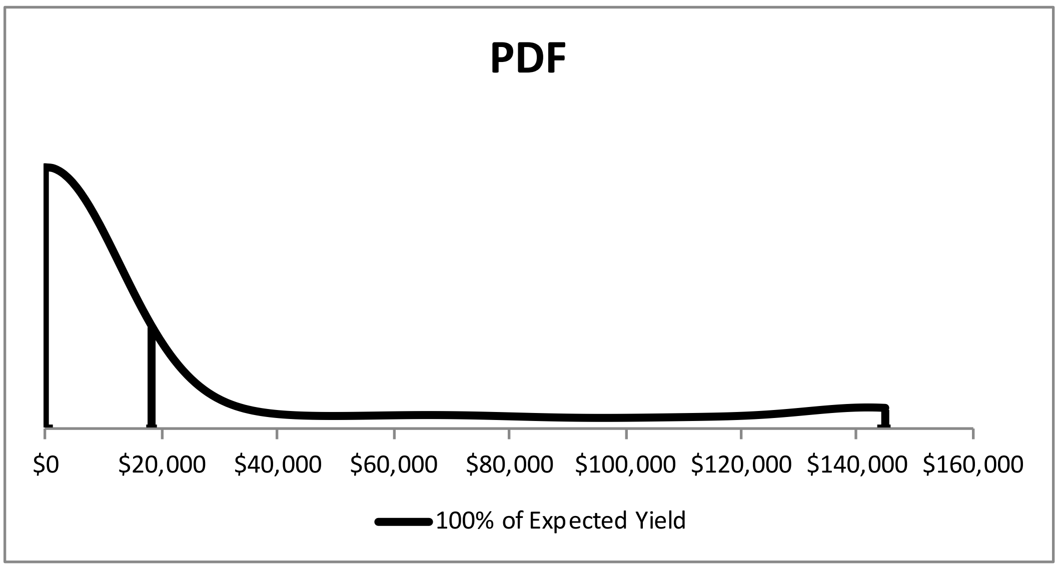

Figure 4.5 2019 ARC-IC payments for IA grain farm with expected yields, PDF

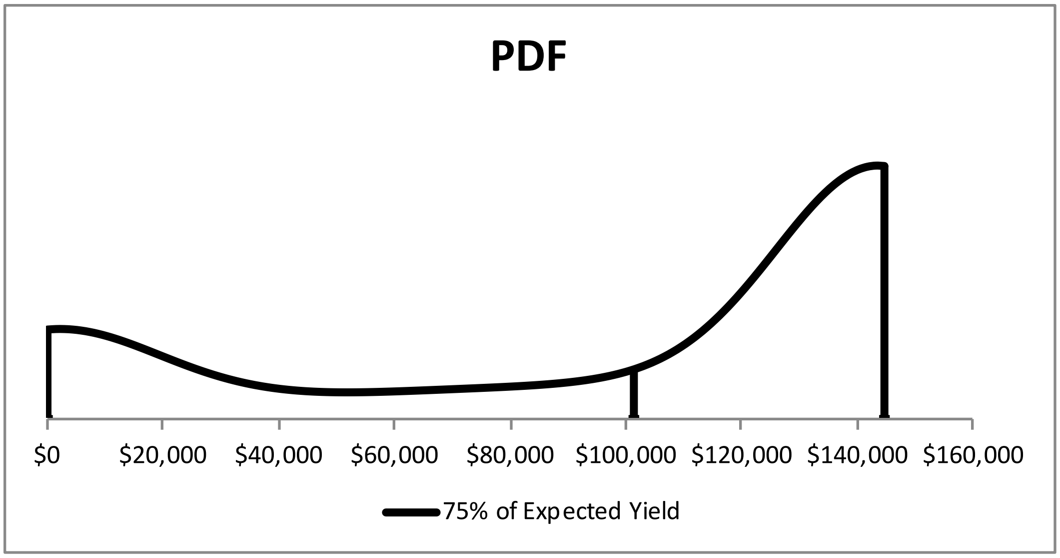

Figure 4.6 2019 ARC-IC payments for IA grain farm with 75% of expected yields, PDF

Table 4.6 Iowa Grain 2020 Expected ARC-IC Payment Summary Statistics

Expected ARC-IC Payment	IA Grain
Mean	$37,786
Standard Deviation	58,788
CV	156
Minimum	$0
Maximum	$142,747

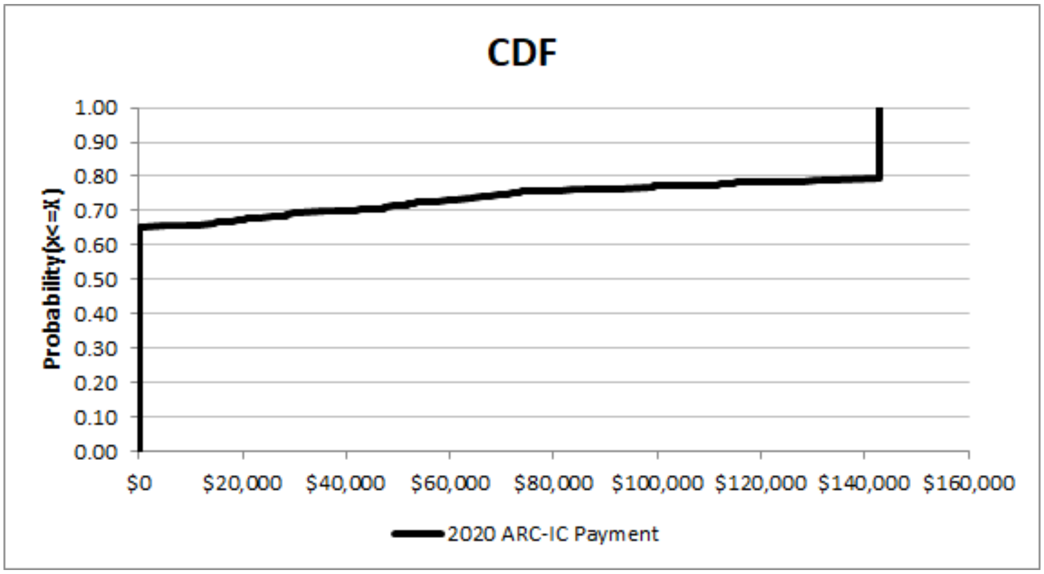

Figure 4.7 2020 ARC-IC payments for IA grain farm, CDF

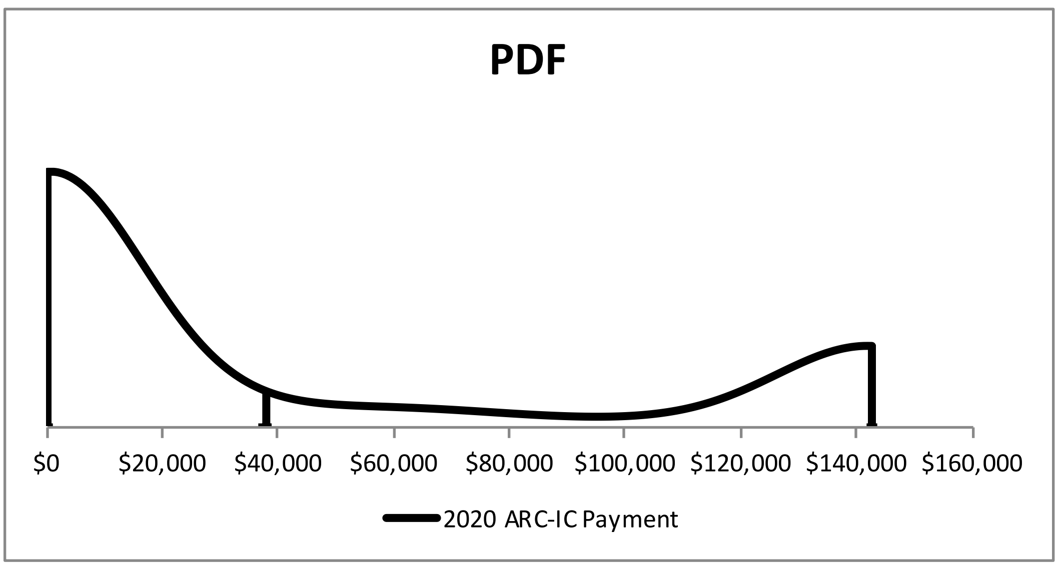

Figure 4.8 2020 ARC-IC payments for IA grain farm, PDF

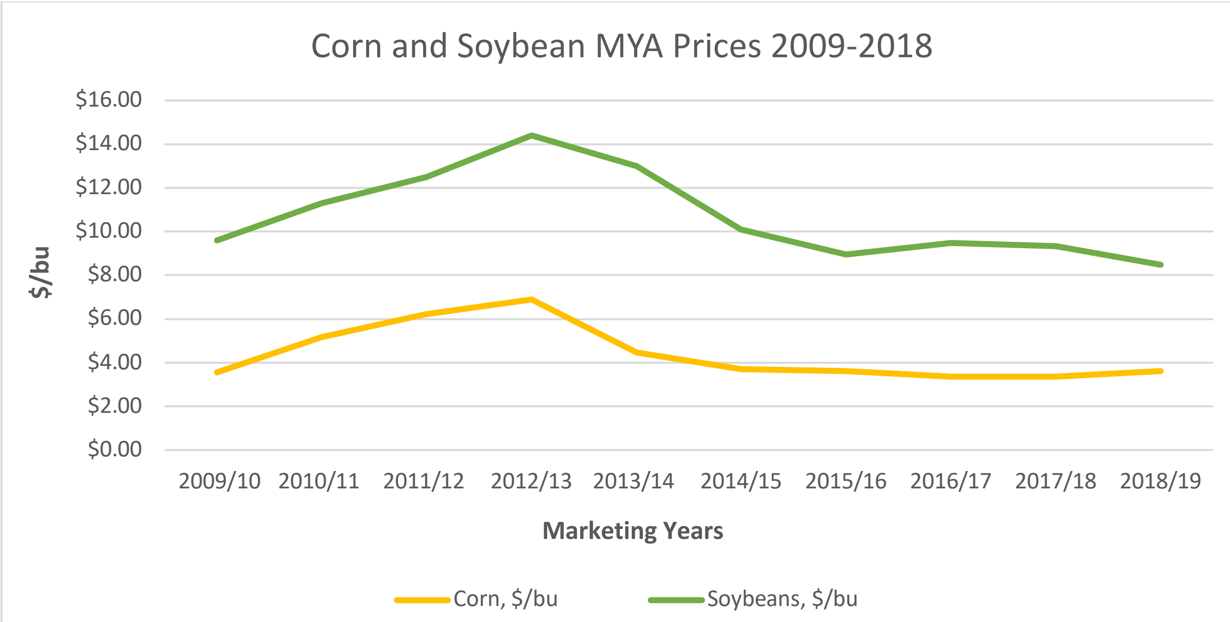

Figure 4.9 Historic MYA Prices – Corn and Soybeans (USDA/FSA, 2016; USDA/FSA, 2020d)

Texas Cotton Farm Results

ARC-IC benchmark revenue, revenue guarantee and maximum payment parameters for the two study crop years are available in Table 4.7. Actual revenue in 2019 must fall below $558.45 per acre to cause an ARC-IC payment, and the tipping point for actual revenue per acre in 2020 is $557.32.

Table 4.7 Texas Cotton ARC-IC Benchmark Summary

2019 ARC-IC Summary	
Benchmark Revenue per Acre	$649.36
Revenue Guarantee (Benchmark Revenue * 86%)	$558.45
Maximum Payment (Benchmark Revenue * 10%)	$64.94
2020 ARC-IC Summary	
Benchmark Revenue per Acre	$648.04
Revenue Guarantee (Benchmark Revenue * 86%)	$557.32
Maximum Payment (Benchmark Revenue * 10%)	$64.80

Summary statistics for stochastic 2019 ARC-IC payments are shown in Table 4.8. For this Texas cotton farm, 2019 payments were also simulated for five scenarios of varying levels of expected yield. Results in Table 4.8 are summary statistics of expected payments for each yield scenario, starting with the expected yield (1662 lb./ac for seed cotton, 11 bu./ac for wheat) and decreasing in 25 percent increments down to zero percent, to represent a PP scenario. Using these levels of yield, the Texas cotton farm realizes a maximum 2019 ARC-IC payment for all yield loss levels except zero percent yield loss (or 100 percent of the expected yield). Figure 4.10 is the ARC-IC payment CDF graph for expected yield and zero percent of expected yield (or PP). The CDF graphs for 75 percent, 50 percent, and 25 percent of expected yield are identical to that of zero percent of expected yield and are not included. If the farm experiences yield loss from zero to 75 percent, the probability of a maximum payment is one. If the farm was prevented from planting a 2019 crop, the actual yield is zero and the probability of the maximum ARC-IC payment is one. If the farm realizes 100 percent of expected yields, the probability of no ARC-IC payment is 0.21, the probability of a payment greater than $100,000 is 0.66, and the probability of a maximum payment is 0.49. The historical MYA prices for seed cotton and wheat are graphed in Figure 4.11. Similar to the Washington wheat and Iowa grain farms there is some probability of an ARC-IC payment for each level of expected yields. The expected commodity prices relative to previous benchmark years do not require high yield losses to generate ARC-IC payments.

Table 4.9 presents summary statistics for the 2020 ARC-IC expected payment simulation. The CDF in Figure 4.12 illustrates 2020 ARC-IC payment probabilities. The probability of a 2020 ARC-IC payment is 0.73; the probability of a maximum payment is 0.59. These results suggest 2019 and 2020 ARC-IC enrollment for this Texas cotton farm was reasonable, especially if they experienced yield loss or PP in 2019.

Summary

Consideration of ARC-IC is most relevant for producers who experienced 100 percent PP or, in some cases, yield loss in 2019. Under these circumstances, producers should still evaluate potential 2019 and 2020 payments from PLC and ARC-CO relative to ARC-IC. Although not illustrated by the model farms in this study, a farm with base acres assigned to different crops than those planted may also want to consider ARC-IC. ARC-IC payments are dependent on planted commodities rather than base acre commodities, so a producer with base in commodities expecting low PLC and ARC-CO payments that planted or PP a different crop may decide ARC-IC is better tailored to their operation.

Table 4.8 Texas Cotton 2019 Expected ARC-IC Payment Summary Statistics

	TX Cotton
Expected Yield - Seed Cotton	1662 lb/ac
Expected Yield - Wheat	11 bu/ac
Expected ARC-IC Payment	
Mean	$137,140
Standard Deviation	89,225
CV	65
Minimum	$0
Maximum	$211,041
75% of Expected Yield - Seed Cotton	1246.5 lb/ac
75% of Expected Yield - Wheat	8.25 bu/ac
Expected ARC-IC Payment	
Mean	$209,083
Standard Deviation	16,359
CV	8
Minimum	$3,646
Maximum	$211,041
50% of Expected Yield - Seed Cotton	831 lb/ac
50% of Expected Yield - Wheat	5.5 bu/ac
Expected ARC-IC Payment	
Mean	$211,041
Standard Deviation	0
CV	0
Minimum	$211,041
Maximum	$211,041
25% of Expected Yield - Seed Cotton	415.5 lb/ac
25% of Expected Yield - Wheat	2.75 bu/ac
Expected ARC-IC Payment	
Mean	$211,041
Standard Deviation	0
CV	0
Minimum	$211,041
Maximum	$211,041
0% of Expected Yield (PP) - Seed Cotton	0 lb/ac
0% of Expected Yield (PP) - Wheat	0 bu/ac
Expected ARC-IC Payment	
Mean	$211,041
Standard Deviation	0
CV	0
Minimum	$211,041
Maximum	$211,041

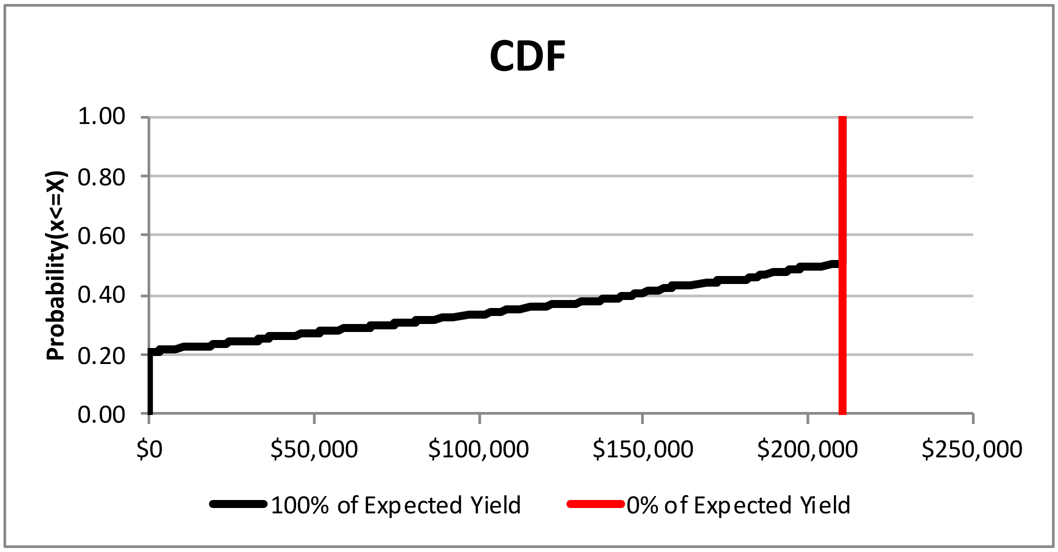

Figure 4.10 2019 ARC-IC payments for TX cotton farm, CDF

Table 4.9 Texas Cotton 2020 Expected ARC-IC Payment Summary Statistics

Expected ARC-IC Payment	TX Cotton
Mean	$138,913
Standard Deviation	94,520
CV	68
Minimum	$0
Maximum	$210,614

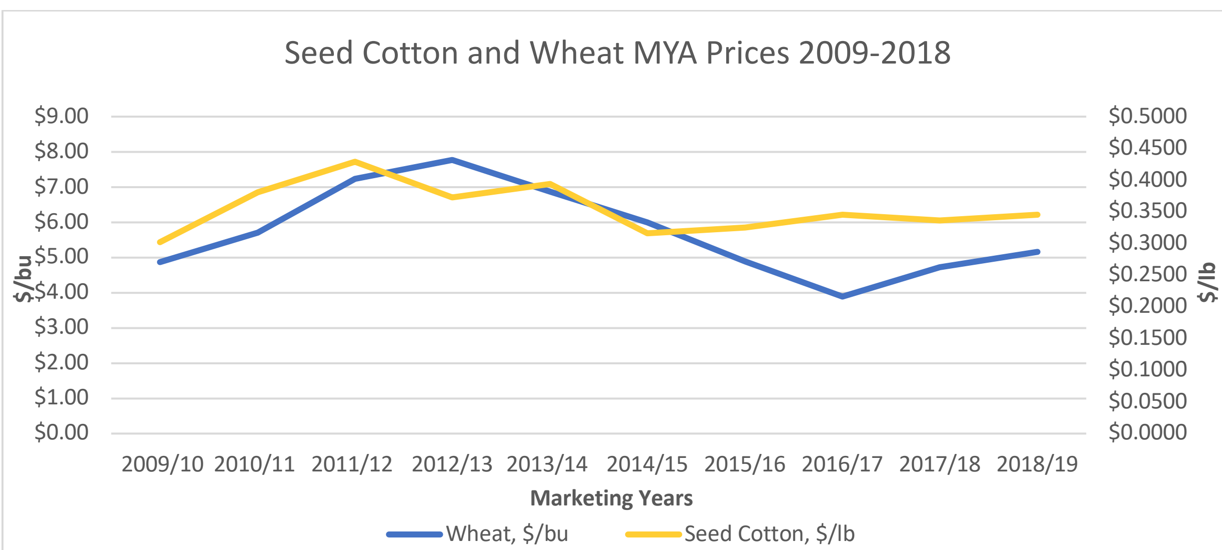

Figure 4.11 Historic MYA Prices – Seed Cotton and Wheat (USDA/FSA, 2016; USDA/FSA, 2020d)

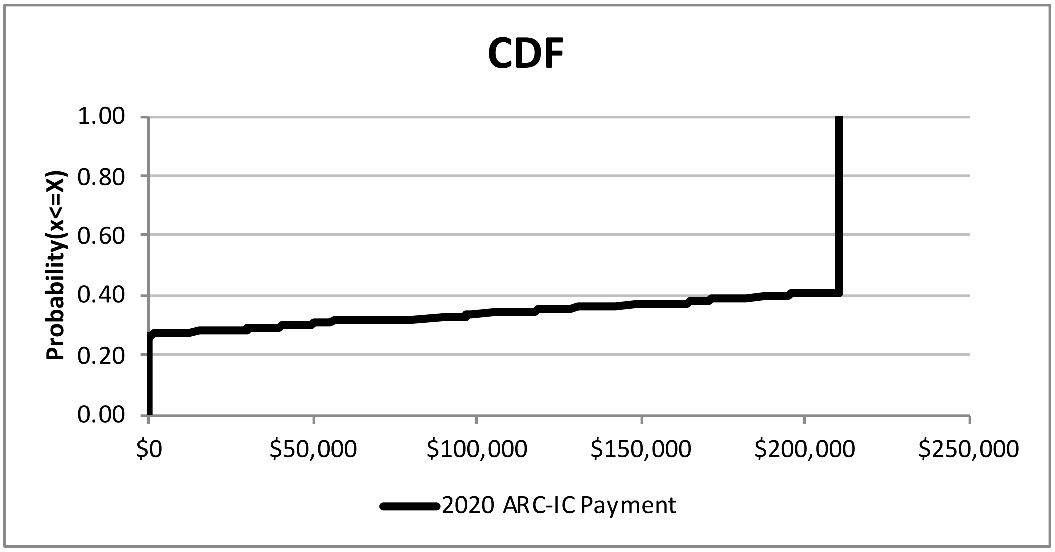

Figure 4.12 2020 ARC-IC payments for TX cotton farm, CDF

CHAPTER V

CONCLUSIONS

The U.S. has a long history of providing producers a farm safety net to protect against risk in agriculture. Commodity safety net programs have evolved overtime into the current PLC, ARC-CO, and ARC-IC programs, established in the 2014 farm bill and continued in the 2018 farm bill. In 2015, producers chose between PLC, ARC-CO, and ARC-IC for the 2014-2018 crop years, but in 2019, the choice was only made for 2019 and 2020 crop years, with an annual decision to follow. The two-year decision gave producers an advantage relative to the previous five-year decision; there is less risk to consider for the shorter decision period. For both 2014 and 2018 farm bill program sign-up, decision aids were available for producers to evaluate PLC and ARC-CO. ARC-IC was excluded from decision aids because of its complexity and unpopularity among producers.

In spring and summer of 2019, flooding in the Midwest and some Southern states caused many cases of PP. Roughly one year after the flooding, 2018 farm bill sign-up ended. At the time of sign-up, many producers knew 2019 yields and made program decisions accordingly. Producers who experienced PP in 2019 learned about an ARC-IC rule that allows for a zero actual yield to be reported to FSA for 100 percent PP farms, which triggers a maximum ARC-IC payment on an enrolled farm. With millions of 2019 PP acres in the U.S., the discovery and spreading of this nuance sparked producer interest in ARC-IC and created the need for an ARC-IC decision tool, to help producers evaluate the program for their individual operation.

Objectives

The purpose of this study was to create a decision tool that would analyze ARC-IC, under risk, as individual farm information was inputted. The secondary objective was to use the decision tool to evaluate case study farms under ARC-IC. Incorporation of risk in the model was important to establish a range and probability distribution of potential payment outcomes, giving producers more information than a single, deterministic outcome. To include risk in the model, variability of historical data was used to estimate distributions and create stochastic variables. Using stochastic price and yield parameters, resulting ARC-IC payments were simulated 500 times to generate a range of probable outcomes.

Results

The model was utilized to evaluate three case study farms based off of three AFPC representative farms: Washington wheat, Iowa grain, and Texas cotton. For each model farm, 2019 and 2020 ARC-IC payments were simulated. Simulation for 2019 used 500 iterations of price projections for each crop, provided by FAPRI, and five scenarios of yield loss; 2020 simulation utilized 500 FAPRI prices and stochastic yields generated using the individual farm's yield history. Prices and yields worked in conjunction to determine likelihood of an ARC-IC payment. If yield losses occurred but crop prices did not fall, then greater levels of yield loss were required to trigger a payment. If crop prices declined, ARC-IC payments could be expected with less yield loss. All three farms were likely to benefit from ARC-IC enrollment. Farms generated some potential for a 2019 payment at each yield level and triggered the maximum payment before total yield loss or PP scenarios occurred. The three model farms also expected high probability of an ARC-IC payment in 2020.

Future Research

The ARC-IC decision tool developed in this study evaluated ARC-IC for the two-year commodity program decision for 2019 and 2020 crop years. During 2019 and 2020 sign-up, producers were already well into the 2019 crop year and had the advantage of a known variable (yields) to aid in their decision. For future annual program elections (2021, 2022, and 2023), sign-up will occur before each respective crop year begins and without knowledge of planted (or PP) acres or yield information, and producers will have two unknowns, both price and yield, to consider for each crop. The ARC-IC model developed in this study can easily be adapted to simulate 2021, 2022, and 2023 prices and yields to estimate ARC-IC payments and aid in annual program decisions.

Future adaptation of the ARC-IC decision tool could address the limitation in this study related to the aggregation of multiple farms into one ARC-IC Farm. To simplify stochastic yield simulation, only one farm was evaluated in ARC-IC for each model farm rather than a study of various combinations of farms. A key component of ARC-IC is the combining and weighting of farms, within the same a state and operated by the same producer, and evaluation of the effects on ARC-IC payments when different combinations of farms are analyzed.

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APPENDIX

2019 Crop Year

Table 1. Farm Number's to Enroll in ARC-IC

	1	2
FSA Farm Number	FSA 101	FSA 102
Total Cropland on Farm	1000	500
Base Acres on Farm	1000	500
Include Farm in Analysis	Yes	Yes

Figure A.1 Table 1 from Decision Model

Table 2. 2019 Planted Acres and Producer's Share of Crop Production

Enter covered commodities planted in the 2019 crop year, number of acres planted, and your % share of production (stated on the FSA 578 form) on each farm number.
PP acres are not entered unless 100% of the FSA farm's initial planted covered commodities are approved PP. Then, enter number of PP acres and enter a 0 yield in Table 6.

	Acres	Your Share of Crop Production, %	Weighting Factors, %
Crop		**FSA 101**	
Corn	500	100%	33.33%
Soybeans	500	100%	33.33%
			0.00%
			0.00%
			0.00%
			0.00%
			0.00%
Total Acres	1000		
Wtd Avg % Share		100%	
Crop		**FSA 102**	
Corn	250	100%	16.67%
Soybeans	250	100%	16.67%
			0.00%
			0.00%
			0.00%
			0.00%
			0.00%
Total Acres	500		
Wtd Avg % Share		100%	

Figure A.2 Table 2 from Decision Model

Table 3. ARC-IC Farm, total acres on all farm numbers enrolled in ARC-IC

Crop	Acres	
	Total	Producer Share
Corn	750	750
Soybeans	750	750
	0	0
	0	0
	0	0
	0	0
	0	0
Total Acres	1500	1500

Table 4. Higher of MYA or Reference Price, $

Crop (unit)	2013	2014	2015	2016	2017
Corn (bu)	$ 4.46	$ 3.70	$ 3.70	$ 3.70	$ 3.70
Soybeans (bu)	$ 13.00	$ 10.10	$ 8.95	$ 9.47	$ 9.33

Figure A.3 Table 3 and 4 from Decision Model

Table 5. 2019 Benchmark Revenue
Enter the 5 year yield history (2013-2017) for every program crop planted in 2019
Enter the higher of actual yield and 80% of county T-Yield in years (2013-2017) the crop was grown.
For years (2013-2017) the crop was not grown, enter 100% of the year's county average yield.

Crop (unit)	Your Farm Yields per Acre				
	2013	2014	2015	2016	2017
	FSA 101				
Corn (bu)	150	160	155	160	165
Soybeans (bu)	50	40	45	50	40
	FSA 102				
Corn (bu)	160	165	145	150	160
Soybeans (bu)	45	45	50	50	45

Figure A.4 Table 5 from Decision Model

Table 5. 2019 Benchmark Revenue, Continued

Revenue per Acre					2019	
2013	2014	2015	2016	2017	5-year Olympic Avg	Wtd by Crop Acres
FSA 101						
669.00	592.00	573.50	592.00	610.50	598.17	$ 199.37
650.00	404.00	402.75	473.50	373.20	426.75	$ 142.24
FSA 102						
713.60	610.50	536.50	555.00	592.00	585.83	$ 97.66
585.00	454.50	447.50	473.50	419.85	458.50	$ 76.43
			Benchmark Revenue per Acre -->			$ 515.70

Figure A.5 Table 5 from Decision Model Continued

Table 6. 2019 Actual Revenue
Enter the **expected** 2019 yields for each crop.
For PP, enter 0 for the yield.

Crop (unit)	2019 MYA Price	2019 Yields per Acre	2019 Actual Revenue per Acre	Actual Revenue Wtd by Crop Year
		FSA 101		
Corn (bu)	3.39	0	0	0
Soybeans (bu)	7.57	0	0	0
		FSA 102		
Corn (bu)	3.39	0	0	0
Soybeans (bu)	7.57	0	0	0
ARC-IC Farm				**Total Revenue by Crop**
Corn (bu)				0
Soybeans (bu)				0
		Actual Revenue per Acre -->		$ -

Figure A.6 Table 6 from Decision Model

Table 7. 2019 ARC-IC Summary

Benchmark Revenue per Acre	$ 515.70
Revenue Guarantee (86% of Benchmark)	$ 443.50
Actual Revenue per Acre	$ -
Revenue Guarantee - Actual Revenue	$ 443.50
Maximum Payment (Benchmark Revenue * 10%)	$ 51.57
Payment Rate	$ 51.57

Base Acres:

Farm	FSA 101	FSA 102	Total
Base Acres	1000	500	
Weighted Share	100%	100%	
Your Base	1000	500	1500
Farm Included in Analysis	Yes	Yes	

Total Payment (Pmt Rate* Base Acres* 65%)	$ 50,280

Figure A.7 Table 7 from Decision Model