The Role of U.S. Safety Net Programs in Incentivizing Farm Growth: A Simulation Approach

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Abstract

Safety net programs affect farm income and farmers ability to manage risk. Some economists argue that safety net programs benefit large farmers more and accelerate farm consolidation. The purpose of the paper is to test the hypothesis that the U.S. 2014 Farm Bill safety net programs are structurally biased to benefit large crop farms in the United States. A Monte Carlo simulation of 16 pairs of moderate and large farms in principal production regions of the U.S. are analyzed to estimate the $/acre benefits of farm programs (ARC and PLC) and federal crop insurance. Results of the analysis suggest that for commercial size crop farms, safety net programs provide greater $/acre benefits to moderate size farms compared to large farms. Additionally, the analysis showed that crop insurance programs are essentially neutral, providing about equal benefits to moderate and large scale crop farms.

Safety net programs affect farm income and the ability of farmers to manage risk. If these programs benefit large farms more than moderate and small farms, then safety net programs could change the future structure of agriculture by accelerating structural changes. The 2014 farm program provides income supports and risk management tools through two safety net programs Agricultural Risk Coverage (ARC) and Price Loss Coverage (PLC) and a subsidized insurance program. The PLC program provides payments based on historical production if the season average price falls below a reference price established by the Congress. The ARC program pays producers if county revenue falls below a benchmark defined as the moving average of historical revenue for the county. Both ARC and PLC make equal payments per acre for all size farms suggesting no overt structural affects from these programs.

The impact of these programs is especially relevant as the E.U. begins the process of preparing for the next CAP reform. In 2016, a workshop entitled "Reflections on the agricultural challenges post-2020 in the EU: preparing the next CAP reform" organized by the European Parliament's Committee on Agriculture and Rural Development (COMAGRI) and its Policy Department (AGRI Research) researchers identified the U.S. safety net programs as one of three potential future structures for the next CAP reform (Matthews). In light of the interest in U.S. safety net programs and the E. U. desire to remain structurally neutral, a closer look at U.S. programs is warranted.

U.S. crop producers had a one-time irrevocable decision to elect Agriculture Risk Coverage (ARC) or Price Loss Coverage (PLC) on a commodity-by-commodity basis for each crop on the farm. This decision lasts for the length of the bill (2014 to 2018).

ARC is a revenue program that uses the prior 5 year Olympic moving average of marketing year average prices multiplied by the prior 5 year Olympic moving average of actual county yields to establish a revenue benchmark for each crop. The producer receives a payment if the actual county yield multiplied by the actual marketing year average price is lower than 86% of the revenue benchmark. The payment band for ARC is limited to losses that occur between 86% and 76% of the Revenue Benchmark. The ARC payment for a commodity would equal the difference between actual county revenue for the crop and 86% of the revenue benchmark multiplied by .85. The payment is capped to not exceed 10% of the revenue benchmark. The .85 is a fraction that has been used in the United States for many years to reduce the amount of all producer payments. There was also an individual ARC program that used a producer's own yields but it was not widely adopted.

PLC provides producers price support by paying them the difference between a government established reference price for each commodity and the marketing year average price any year the marketing year average price falls below the reference price. This difference is referred to as the payment rate. To calculate a producer's payment the payment rate is multiplied by the base acres for the commodity, the producer's historical payment yield for the commodity and .85.

U.S. crop producers found that having their choice of safety net programs between ARC and PLC allowed them to tailor their safety net to their unique situations. For example, if a producer had recently experienced several drought years then the protection provided by ARC would be less than PLC due to the poor yields role in calculating the ARC revenue guarantee. Conversely, if a producer had recently experienced record county yields in addition to very high commodity prices producers tended to choose ARC as the revenue benchmark would be set very high in that situation and safety net payments would be made if the income for the crop fell below 86% of a high benchmark.

The overwhelming majority of U.S. producers chose ARC for corn and soybeans and PLC for grain sorghum, rice and peanuts with wheat being split nearly equal percentages between ARC and PLC.

Federal crop insurance protects farm income from either yield losses or low revenue. Farmers who elect yield insurance are paid a fixed price per unit of yield shortfall below a pre-specified fraction (e.g., 55%, 65%, 70%, 75%, 80%) of their historical average yield. The federal government insurance agency sets the premiums based on historical losses for each insured fraction by county and the set price used to calculate indemnities. All farmers receive the same price per unit of insured yield loss. Farmers who elect a revenue protection insurance program insure a specified fraction (e.g., 50%, 55%, 65%, 70%, 75%, 80%, 85%) of their revenue which is calculated as the product of their actual yield and a pre-specified price. The premiums are set by the federal insurance agency based on yield risk for the crop and price risk for the year in question and the pre-specified price. Like yield insurance, all producers who have insured losses receive indemnities based on a common price per unit. These two insurance policies are designed to assist farmers in bad years and are not used to stabilize farm incomes. Both insurance programs pay producers based on their individual losses and are not structurally biased towards small or large farms.

Despite the fact that insurance and the ARC and PLC programs are paid on a per acre basis, these programs are thought to affect future farm structure in the United States (Mercier; Jolly; Hueth; and Ray and Schaffer).

The purpose of this paper is to test the hypothesis that the 2014 farm bill (ARC, PLC and insurance programs) are structurally biased to benefit large commercial crop farms in the United States.

Methodology

Following the methodology suggested by Haen (1973) a systems simulation model is used to simulate representative crop farms under alternative policies. A farm level simulation model (FLIPSIM) is used to simulate representative crop farms in principal production regions with and without the 2014 ARC and PLC programs.[1] The model is also used to simulate the farms with and without crop insurance. The model has been used extensively to analyze the farm level impacts of alternative safety net programs (Richardson and Nixon, 1981 and 1986; Richardson et al., 1982a, 1982b, 2013, and 2017; Adams and Richardson, 2001; and Knutson et al., 1998).

FLIPSIM is a Monte Carlo simulation model that simulates the annual production, marketing, farm program, insurance, financial, and income tax functions of a farm. The model generates stochastic yields using a multivariate empirical (MVE) distribution (Richardson, Klose, and Gray). The MVE procedure insures that the historical correlation of yields among the farm's crops is maintained (Appendix A). Stochastic national crop prices come from the December 2016 FAPRI Baseline and are localized to the representative farm using historical basis wedges for the farm's location and marketing procedures. The model is simulated for eight years recursively and the planning horizon is repeated for 500 iterations. For each iteration, a separate sample of random yields are drawn from the MVE distribution and the FAPRI stochastic prices. The stochastic national prices from FAPRI are correlated temporally because they are the product of a multi-sector agricultural model that incorporates the unexplained risk for the econometric equations, i.e., the OLS residuals.

Data

Data to simulate representative crop farms comes from the Texas A&M University Agricultural and Food Policy Center (AFPC) data base of crop farms in 29 states. AFPC maintains a data base for simulating representative farms that are updated every 2 to 3 years using interviews with actual producers (Richardson, et al., 2017). The producer panels are interviewed in a modified Delphi process where each of the 4 to 6 producers present their costs, yields, prices, and assets and the panel arrives at a consensus to develop a virtual farm that represents the panel. The interview process has been used since 1985 with most of the original panels still engaged in the updates. Many of the retiring panel farmers are now represented by their sons and daughters.

Actual yield histories for the producers are obtained and used in the FLIPSIM to model yield risks. Pricing history and marketing methods are captured in the panel interviews to relate national crop prices to the local markets. Farm program participation decisions for the

[1] FLIPSIM was developed by Richardson and Nixon (1981 and 1986) and has been updated annually for farm policy and income tax changes.

representative farms come from the producer panels as well as their historical base acres and payment yields for each crop.

For this study 32 of the AFPC representative farms were selected. The farms were picked because both a moderate size and a large farm are available in each region. The characteristics for the 32 farms are summarized in Table 1. Further details for these farms are available in Appendix A of Richardson, et al., 2017. The farms are simulated for a base case:

- Participation in the 2014 ARC or PLC provisions, as specified by the farm panels, and
- Participation in the federal crop insurance program, either yield or revenue protection using the coverage levels specified by the farm panel for each crop.

The No Program option assumes the farms do not participate in the ARC or PLC programs but purchase federal crop insurance. The No Insurance scenario assumes the farms participate in the 2014 ARC or PLC programs but do not purchase crop insurance.

The Food and Agricultural Policy Research Institute (FAPRI) 2016 December Baseline provides a 10 year outlook of crop and livestock prices. The baseline projections on their website shows the season average prices for the crops. The averages they present come from simulating 500 random draws of residuals from the econometric equations in a sector level model of U.S. and world agriculture. The 500 random prices for 2016-2021 are used in FLIPSIM to incorporate the stochastic nature of crop prices. A summary of the stochastic crop prices used for this paper is provided in Table 2.

Results

The results from simulating the 32 representative crop farms are summarized in Table 3. Sixteen production regions have a pair of farms that represent moderate and large farms in the county. The Base scenario assumes the farms participate in the safety net program of choice (ARC or PLC) and the crop insurance choice the farms specified (revenue or yield protection). The No Program scenario assumes the farm does not receive ARC or PLC payments, but participates in crop insurance. The No insurance scenario assumes the farm does not purchase crop insurance but is eligible for ARC and PLC payments.

The key output variables (KOVs) from FLIPSIM in Table 1 are: total annual cash receipts (2016-2021), annual government payments (2016-2021), annual crop insurance indemnities (2016-2021), annual net cash farm income (2016-2021), ending cash reserves in 2021, and nominal net worth in 2021. Average values calculated over the 500 draws are reported for each KOV. The change in total payments and the per acre change in payments from the Base are reported for government payments, insurance indemnities, net cash farm income, and ending cash reserves.

Table 1. Characterisitcs of the Representative Crop Farms

Feedgrain farms	IAG544	IAG1371	NEG968	NEG1734	NDG1210	NDG3226	ING403	ING887
County	Webster	Webster	Dawson	Dawson	Barnes	Barnes	Shelby	Shelby
Total Cropland	1,350	3,400	2,400	4,300	3,000	8,000	1,000	2,200
Acres Owned	290	1,100	600	2,150	720	4,000	300	770
Acres Leased	1,060	2,300	1,800	2,150	2,280	4,000	700	1,430
2015 Planted Acres								
Total	1,350	3,400	2,400	4,300	3,100	8,000	1,000	2,200
Corn	880	1,870	1,600	3,000	1,000	3,000	500	1,100
Wheat	0	0	0	0	500	1,500	0	0
Soybeans	470	1,530	800	1,000	1,500	3,000	500	1,100
Hay	0	0	0	300	0	0	0	0

Feedgrain farms	MOCG927	MOCG1694	TNG363	TNG887	TXNP1391	TXNP4290
County	Carroll	Carroll	Henry	Henry	Moore	Moore
Total Cropland	2,300	4,200	900	2,200	3,450	10,640
Acres Owned	1,380	1,800	150	550	2,590	3,511
Acres Leased	920	2,400	750	1,650	860	7,129
2015 Planted Acres						
Total	2,300	4,200	1,000	2,500	3,105	9,931
Corn	1,150	2,310	500	1,100	1,430	4,000
Wheat	0	0	100	300	1,170	713
Soybeans	1,150	1,890	400	1,100	0	0
Sorghum	0	0	0	0	345	2,105
Cotton	0	0	0	0	160	3,113

Wheat farms	WAW806	WAW3226	COW1210	COW2274	KSCW806	KSCW2137	KSNW1613	KSNW2411
County	Whitman	Whitman	Washington	Washington	Sumner	Sumner	Thomas	Thomas
Total Cropland	2,000	8,000	3,000	5,640	2,000	5,300	4,000	5,980
Acres Owned	800	2,310	2,100	1,880	700	1,325	1,170	1,800
Acres Leased	1,200	5,690	900	3,760	1,300	3,975	2,830	4,180
2015 Planted Acres								
Total	2,000	7,600	1,988	3,930	2,000	5,300	3,000	4,980
Wheat	1,320	4,950	1,013	1,900	1,000	3,445	1,500	1,820
Grain Sorghum	0	0	0	0	333	265	500	740
Barley	140	0	0	0	0	0	0	0
Corn	0	0	675	890	333	795	1,000	2,290
Soybeans	0	0	0	0	334	795	0	130
Dry Peas	540	2,400	0	0	0	0	0	0
Millet	0	0	0	890	0	0	0	0
CRP	0	250	300	250	0	0	0	0

Cotton Farms	TXSP1008	TXSP1815	TXCB1210	TXCB3710	TNC1008	TNC1633
County	Dawson	Dawson	San Patricio	Nueces	Fayette	Haywood
Total Cropland	2,500	4,500	3,000	9,200	2,500	4,050
Acres Owned	500	900	600	920	250	1,000
Acres Leased	2,000	3,600	2,400	8,280	2,250	3,050
2015 Planted Acres						
Total	2,500	4,167	3,000	9,200	2,280	4,525
Cotton	1,298	4,047	1,350	3,680	250	2,025
Grain Sorghum	500	0	1,500	3,680	250	0
Wheat	0	120	0	0	0	475
Corn	0	0	150	1,840	500	600
Soybeans					1,250	1,425
Peanuts	703	0	0	0	0	0
CRP	0	0	0	0	30	0

Rice Farms	CAR222	CAR1210	TXR605	TXR1210
County	Sutter	Sutter	Colorado	Colorado
Total Cropland	550	3,000	1,500	3,000
Acres Owned	275	769	405	0
Acres Leased	275	2,231	1,095	3,000
2015 Planted Acres				
Total	500	3,000	600	1,500
Rice	500	3,000	600	1,500

Table 2. Summary Statistics for Crop Prices, 2016-2021.

	2016	2017	2018	2019	2020	2021
Corn ($/bu.)						
Mean	3.31	3.62	3.81	3.86	3.85	3.84
Std Dev	0.70	0.86	0.91	0.99	0.90	0.94
Coef Variation	21.19	23.70	23.77	25.70	23.43	24.58
Minimum	1.45	1.68	2.05	1.56	1.94	1.45
Maximum	7.11	7.57	7.06	11.20	7.49	9.01
Soybeans ($/bu.)						
Mean	9.39	9.42	9.71	9.88	9.76	9.70
Std Dev	2.05	2.22	2.37	2.54	2.26	2.42
Coef Variation	21.85	23.58	24.43	25.74	23.18	24.93
Minimum	4.35	4.19	4.32	3.98	3.56	4.50
Maximum	15.76	17.23	17.59	21.71	17.43	18.85
Wheat ($/bu.)						
Mean	3.73	4.47	4.90	5.09	5.23	5.22
Std Dev	0.67	1.05	1.21	1.25	1.18	1.19
Coef Variation	18.03	23.47	24.72	24.50	22.60	22.74
Minimum	2.21	1.50	2.14	2.15	2.17	1.70
Maximum	6.24	7.83	9.14	10.33	9.74	9.01
Sorghum ($/bu.)						
Mean	2.97	3.29	3.41	3.46	3.49	3.50
Std Dev	0.70	0.82	0.89	0.92	0.86	0.92
Coef Variation	23.62	25.02	26.11	26.60	24.69	26.18
Minimum	0.57	0.79	1.46	1.33	1.12	1.37
Maximum	6.09	6.77	6.46	8.65	6.24	8.16
Rice ($/cwt.)						
Mean	10.52	11.04	11.48	11.57	11.71	11.92
Std Dev	1.27	1.42	1.39	1.53	1.48	1.51
Coef Variation	12.07	12.85	12.09	13.18	12.63	12.67
Minimum	6.99	6.98	6.41	7.23	7.42	7.32
Maximum	14.13	14.45	14.87	15.46	16.11	16.71
Cotton ($/lb.)						
Mean	0.65	0.63	0.61	0.62	0.62	0.62
Std Dev	0.11	0.11	0.11	0.11	0.11	0.11
Coef Variation	0.64	0.62	0.60	0.61	0.61	0.61
Minimum	0.66	0.64	0.62	0.63	0.63	0.64
Maximum	16.35	17.64	17.82	17.07	17.37	17.38
Peanuts ($/ton)						
Mean	382.11	365.17	361.49	361.70	362.59	363.35
Std Dev	50.39	55.50	60.54	64.91	64.22	67.03
Coef Variation	13.19	15.20	16.75	17.95	17.71	18.45
Minimum	279.82	259.97	252.53	252.23	252.64	229.07
Maximum	623.73	712.51	670.40	656.59	640.03	706.43

Source: FAPRI. https://www.fapri.missouri.edu/publications/outlook/

Table 3. Comparison of Farm Program and Crop Insurance Impacts on Moderate and Large Representative Crop Farms in the United States.

Iowa Grain Farm	IAG1350 BASE	IAG1350 NO PROG	IAG1350 NOINSR	IAG3400 BASE	IAG3400 NO PROG	IAG3400 NOINSR
Government Payments						
2016-2021 Average ($1000)	27.8	-	27.8	63.4	-	63.4
Change ($1000)		(27.8)			(63.4)	
Change ($/acre)		(20.6)			(18.6)	
Crop Insurance Indemnities						
2016-2021 Average ($1000)	16.5	16.5	-	36.6	36.6	-
Change ($1000)			(16.5)			(36.6)
Change ($/acre)			(12.2)			(10.8)
Net Cash Farm Income						
2016-2021 Average ($1000)	(38.7)	(76.0)	(50.2)	404.9	327.6	380.3
Change ($1000)		(37.3)	(11.5)		(77.2)	(24.6)
Change ($/acre)		(27.6)	(8.5)		(22.7)	(7.2)
Ending Cash Reserves						
2021 Average ($1000)	(1,350.4)	(1,645.0)	(1,407.4)	415.5	(181.2)	295.9
Change ($1000)		(294.7)	(57.1)		(596.7)	(119.6)
Change ($/acre)		(218.3)	(42.3)		(175.5)	(35.2)

Nebraska Grain Farm	NEG2400 BASE	NEG2400 NO PROG	NEG2400 NOINSR	NEG4300 BASE	NEG4300 NO PROG	NEG4300 NOINSR
Government Payments						
2016-2021 Average ($1000)	66.0	-	66.0	113.2	-	113.0
Change ($1000)		(66.0)			(113.2)	(0.2)
Change ($/acre)		(27.5)			(26.3)	(0.0)
Crop Insurance Indemnities						
2016-2021 Average ($1000)	24.9	24.9	-	45.8	45.8	-
Change ($1000)			(24.9)			(45.8)
Change ($/acre)			(10.4)			(10.7)
Net Cash Farm Income						
2016-2021 Average ($1000)	466.1	393.2	467.2	799.9	670.3	822.0
Change ($1000)		(72.9)	1.1		(129.6)	22.1
Change ($/acre)		(30.4)	0.5		(30.1)	5.1
Ending Cash Reserves						
2021 Average ($1000)	2,019.8	1,486.8	2,053.6	2,488.3	1,469.8	2,730.6
Change ($1000)		(533.0)	33.8		(1,018.5)	242.2
Change ($/acre)		(222.1)	14.1		(236.9)	56.3

Missouri Grain Farm	MOCG2300 BASE	MOCG2300 NO PROG	MOCG2300 NOINSR	MOCG4200 BASE	MOCG4200 NO PROG	MOCG4200 NOINSR
Government Payments						
2016-2021 Average ($1000)	53.6	-	53.6	55.4	-	55.4
Change ($1000)		(53.6)			(55.4)	
Change ($/acre)		(23.3)			(13.2)	
Crop Insurance Indemnities						
2016-2021 Average ($1000)	17.5	17.5	-	23.5	23.5	-
Change ($1000)			(17.5)			(23.5)
Change ($/acre)			(7.6)			(5.6)
Net Cash Farm Income						
2016-2021 Average ($1000)	694.5	637.8	689.2	1,343.8	1,287.8	1,343.8
Change ($1000)		(56.7)	(5.3)		(56.1)	-
Change ($/acre)		(24.7)	(2.3)		(13.3)	-
Ending Cash Reserves						
2021 Average ($1000)	949.2	676.0	939.8	3,716.0	3,377.4	3,745.9
Change ($1000)		(273.1)	(9.3)		(338.5)	29.9
Change ($/acre)		(118.8)	(4.1)		(80.6)	7.1

Table 3. Continued.

Indiana Grain Farm	ING1000 BASE	ING1000 NO PROG	ING1000 NOINSR	ING2200 BASE	ING2200 NO PROG	ING2200 NOINSR
Government Payments						
2016-2021 Average ($1000)	28.5	-	28.5	65.0	-	65.0
Change ($1000)		(28.5)			(65.0)	
Change ($/acre)		(28.5)			(29.6)	
Crop Insurance Indemnities						
2016-2021 Average ($1000)	7.7	7.7	-	18.5	18.5	-
Change ($1000)			(7.7)			(18.5)
Change ($/acre)			(7.7)			(8.4)
Net Cash Farm Income						
2016-2021 Average ($1000)	208.6	177.4	209.9	298.9	224.1	292.1
Change ($1000)		(31.2)	1.3		(74.8)	(6.9)
Change ($/acre)		(31.2)	1.3		(34.0)	(3.1)
Ending Cash Reserves						
2021 Average ($1000)	(38.7)	(170.8)	(19.6)	(951.1)	(1,406.6)	(973.7)
Change ($1000)		(132.1)	19.1		(455.5)	(22.7)
Change ($/acre)		(132.1)	19.1		(207.1)	(10.3)
North Dakota Grain Farm	**NDG1210 BASE**	**NDG1210 NO PROG**	**NDG1210 NOINSR**	**NDG3226 BASE**	**NDG3226 NO PROG**	**NDG3226 NOINSR**
Government Payments						
2016-2021 Average ($1000)	48.1	-	48.1	105.7	-	105.7
Change ($1000)		(48.1)			(105.7)	
Change ($/acre)		(39.7)			(32.8)	
Crop Insurance Indemnities						
2016-2021 Average ($1000)	18.1	18.1	-	50.8	50.8	-
Change ($1000)			(18.1)			(50.8)
Change ($/acre)			(15.0)			(15.7)
Net Cash Farm Income						
2016-2021 Average ($1000)	191.9	133.7	195.9	951.0	826.4	965.4
Change ($1000)		(58.2)	4.0		(124.6)	14.4
Change ($/acre)		(48.1)	3.3		(38.6)	4.5
Ending Cash Reserves						
2021 Average ($1000)	(294.8)	(701.8)	(231.3)	723.2	(157.8)	928.8
Change ($1000)		(407.0)	63.5		(880.9)	205.7
Change ($/acre)		(336.4)	52.5		(273.1)	63.7
Tennessee Grain Farm	**TNG900 BASE**	**TNG900 NO PROG**	**TNG900 NOINSR**	**TNG2200 BASE**	**TNG2200 NO PROG**	**TNG2200 NOINSR**
Government Payments						
2016-2021 Average ($1000)	12.2	-	12.2	38.6	-	38.6
Change ($1000)		(12.2)			(38.6)	
Change ($/acre)		(13.5)			(17.6)	
Crop Insurance Indemnities						
2016-2021 Average ($1000)	5.7	5.7	-	12.6	12.6	-
Change ($1000)			(5.7)			(12.6)
Change ($/acre)			(6.4)			(5.7)
Net Cash Farm Income						
2016-2021 Average ($1000)	108.7	91.1	108.9	198.2	146.9	198.0
Change ($1000)		(17.6)	0.2		(51.3)	(0.2)
Change ($/acre)		(19.5)	0.2		(23.3)	(0.1)
Ending Cash Reserves						
2021 Average ($1000)	(484.7)	(616.7)	(472.5)	(1,144.2)	(1,527.1)	(1,121.9)
Change ($1000)		(132.0)	12.2		(382.8)	22.3
Change ($/acre)		(146.7)	13.6		(174.0)	10.2

Table 3. Continued

Texas Grain Farm	TXNP3450 BASE	TXNP3450 NO PROG	TXNP3450 NOINSR	TXNP8000 BASE	TXNP8000 NO PROG	TXNP8000 NOINSR
Government Payments						
2016-2021 Average ($1000)	132.2	-	132.2	361.4	-	361.4
Change ($1000)		(132.2)			(361.4)	
Change ($/acre)		(38.3)			(45.2)	
Crop Insurance Indemnities						
2016-2021 Average ($1000)	29.6	29.6	-	211.4	211.4	-
Change ($1000)			(29.6)			(211.4)
Change ($/acre)			(8.6)			(26.4)
Net Cash Farm Income						
2016-2021 Average ($1000)	840.6	705.8	863.3	1,772.6	1,381.9	1,683.3
Change ($1000)		(134.8)	22.7		(390.7)	(89.3)
Change ($/acre)		(39.1)	6.6		(48.8)	(11.2)
Ending Cash Reserves						
2021 Average ($1000)	3,430.4	2,760.1	3,506.0	7,157.6	4,690.2	6,765.5
Change ($1000)		(670.4)	75.6		(2,467.5)	(392.2)
Change ($/acre)		(194.3)	21.9		(308.4)	(49.0)
Washington Wheat Farm	**WAW2000 BASE**	**WAW2000 NO PROG**	**WAW2000 NOINSR**	**WAW8000 BASE**	**WAW8000 NO PROG**	**WAW8000 NOINSR**
Government Payments						
2016-2021 Average ($1000)	35.4	-	35.4	133.1	-	133.1
Change ($1000)		(35.4)			(133.1)	
Change ($/acre)		(17.7)			(16.6)	
Crop Insurance Indemnities						
2016-2021 Average ($1000)	5.6	5.6	-	23.1	23.1	-
Change ($1000)			(5.6)			(23.1)
Change ($/acre)			(2.8)			(2.9)
Net Cash Farm Income						
2016-2021 Average ($1000)	279.8	242.7	280.7	446.9	293.0	451.3
Change ($1000)		(37.1)	0.9		(153.9)	4.4
Change ($/acre)		(18.6)	0.4		(19.2)	0.6
Ending Cash Reserves						
2021 Average ($1000)	659.1	483.0	664.0	(1,318.2)	(2,242.0)	(1,275.8)
Change ($1000)		(176.1)	4.9		(923.8)	42.4
Change ($/acre)		(88.1)	2.4		(115.5)	5.3
Colorado Wheat Farm	**COW3000 BASE**	**COW3000 NO PROG**	**COW3000 NOINSR**	**COW5640 BASE**	**COW5640 NO PROG**	**COW5640 NOINSR**
Government Payments						
2016-2021 Average ($1000)	31.0	-	31.0	63.5	-	63.5
Change ($1000)		(31.0)			(63.5)	
Change ($/acre)		(10.3)			(11.3)	
Crop Insurance Indemnities						
2016-2021 Average ($1000)	5.1	5.1	-	5.5	5.5	-
Change ($1000)			(5.1)			(5.5)
Change ($/acre)			(1.7)			(1.0)
Net Cash Farm Income						
2016-2021 Average ($1000)	103.1	67.3	103.8	80.8	1.5	87.0
Change ($1000)		(35.8)	0.7		(79.4)	6.2
Change ($/acre)		(11.9)	0.2		(14.1)	1.1
Ending Cash Reserves						
2021 Average ($1000)	(256.2)	(396.9)	(244.6)	(1,278.7)	(1,755.0)	(1,221.4)
Change ($1000)		(140.6)	11.7		(476.3)	57.3
Change ($/acre)		(46.9)	3.9		(84.4)	10.2

Table 3. Continued

Kansas Wheat Farm	KSNW4000 BASE	KSNW4000 NO PROG	KSNW4000 NOINSR	KSNW5980 BASE	KSNW5980 NO PROG	KSNW5980 NOINSR
Government Payments						
2016-2021 Average ($1000)	74.1	-	74.1	104.1	-	104.1
Change ($1000)		(74.1)			(104.1)	
Change ($/acre)		(18.5)			(17.4)	
Crop Insurance Indemnities						
2016-2021 Average ($1000)	11.3	11.3	-	19.6	19.6	-
Change ($1000)			(11.3)			(19.6)
Change ($/acre)			(2.8)			(3.3)
Net Cash Farm Income						
2016-2021 Average ($1000)	145.0	58.0	180.7	18.8	(105.7)	80.2
Change ($1000)		(87.0)	35.7		(124.5)	61.4
Change ($/acre)		(21.8)	8.9		(20.8)	10.3
Ending Cash Reserves						
2021 Average ($1000)	(684.2)	(1,212.5)	(388.4)	(2,825.3)	(3,601.1)	(2,316.3)
Change ($1000)		(528.3)	295.9		(775.9)	509.0
Change ($/acre)		(132.1)	74.0		(129.7)	85.1
Kansas Wheat Farm	**KSCW2000 BASE**	**KSCW2000 NO PROG**	**KSCW2000 NOINSR**	**KSCW5300 BASE**	**KSCW5300 NO PROG**	**KSCW5300 NOINSR**
Government Payments						
2016-2021 Average ($1000)	20.8	-	20.8	56.6	-	56.6
Change ($1000)		(20.8)			(56.6)	
Change ($/acre)		(10.4)			(10.7)	
Crop Insurance Indemnities						
2016-2021 Average ($1000)	6.6	6.6	-	16.5	16.5	-
Change ($1000)			(6.6)			(16.5)
Change ($/acre)			(3.3)			(3.1)
Net Cash Farm Income						
2016-2021 Average ($1000)	77.0	50.8	89.5	338.7	277.0	362.9
Change ($1000)		(26.1)	38.7		(61.7)	85.9
Change ($/acre)		(13.1)	19.4		(11.6)	16.2
Ending Cash Reserves						
2021 Average ($1000)	(637.5)	(819.9)	(576.0)	703.9	283.8	709.1
Change ($1000)		(182.4)	61.5		(420.0)	5.2
Change ($/acre)		(91.2)	30.8		(79.3)	1.0
Texas Cotton Farm	**TXSP2500 BASE**	**TXSP2500 NO PROG**	**TXSP2500 NOINSR**	**TXSP4500 BASE**	**TXSP4500 NO PROG**	**TXSP4500 NOINSR**
Government Payments						
2016-2021 Average ($1000)	199.3	-	199.3	155.5	-	155.5
Change ($1000)		(199.3)			(155.5)	
Change ($/acre)		(79.7)			(34.6)	
Crop Insurance Indemnities						
2016-2021 Average ($1000)	44.2	44.2	-	98.6	98.6	-
Change ($1000)			(44.2)			(98.6)
Change ($/acre)			(17.7)			(21.9)
Net Cash Farm Income						
2016-2021 Average ($1000)	253.6	19.6	219.1	491.5	314.1	418.6
Change ($1000)		(234.1)	(34.5)		(177.4)	(72.9)
Change ($/acre)		(93.6)	(13.8)		(39.4)	(16.2)
Ending Cash Reserves						
2021 Average ($1000)	286.7	(1,193.0)	105.3	888.6	(312.2)	486.7
Change ($1000)		(1,479.7)	(181.5)		(1,200.8)	(402.0)
Change ($/acre)		(591.9)	(72.6)		(266.8)	(89.3)

Table 3. Continued

Texas Cotton Farm	**TXCB3000 BASE**	**TXCB3000 NO PROG**	**TXCB3000 NOINSR**	**TXCB9200 BASE**	**TXCB9200 NO PROG**	**TXCB9200 NOINSR**
Government Payments						
2016-2021 Average ($1000)	116.53	0	116.53	362.54	0	362.54
Change ($1000)		(116.5)			(362.5)	
Change ($/acre)		(38.8)			(39.4)	
Crop Insurance Indemnities						
2016-2021 Average ($1000)	55.05	55.05	0	131.3	131.3	0
Change ($1000)			(55.1)			(131.3)
Change ($/acre)			(18.4)			(14.3)
Net Cash Farm Income						
2016-2021 Average ($1000)	72.81	-138.08	56.66	329.94	-245.29	318.32
Change ($1000)		(210.9)	(16.2)		(575.2)	(11.6)
Change ($/acre)		(70.3)	(5.4)		(62.5)	(1.3)
Ending Cash Reserves						
2021 Average ($1000)	-869.35	-2219.51	-915.74	-584.69	-4295.44	-471.64
Change ($1000)		(1,350.2)	(46.4)		(3,710.8)	113.1
Change ($/acre)		(450.1)	(15.5)		(403.3)	12.3
Tennessee Cotton Farm	**TNC2500 BASE**	**TNC2500 NO PROG**	**TNC2500 NOINSR**	**TNC4050 BASE**	**TNC4050 NO PROG**	**TNC4050 NOINSR**
Government Payments						
2016-2021 Average ($1000)	45.3	-	45.3	172.3	-	172.3
Change ($1000)		(45.3)			(172.3)	
Change ($/acre)		(18.1)			(42.5)	
Crop Insurance Indemnities						
2016-2021 Average ($1000)	17.5	17.5	-	56.2	56.2	-
Change ($1000)			(17.5)			(56.2)
Change ($/acre)			(7.0)			(13.9)
Net Cash Farm Income						
2016-2021 Average ($1000)	367.1	311.8	367.4	366.6	63.4	332.9
Change ($1000)		(55.3)	0.3		(303.2)	(33.7)
Change ($/acre)		(22.1)	0.1		(74.9)	(8.3)
Ending Cash Reserves						
2021 Average ($1000)	2,299.6	1,999.0	2,325.3	1,120.9	(887.1)	927.9
Change ($1000)		(300.6)	25.7		(2,008.0)	(193.0)
Change ($/acre)		(120.2)	10.3		(495.8)	(47.7)
California Rice Farm	**CAR550 BASE**	**CAR550 NO PROG**	**CAR550 NOINSR**	**CAR3000 BASE**	**CAR3000 NO PROG**	**CAR3000 NOINSR**
Government Payments						
2016-2021 Average ($1000)	74.1	-	74.1	361.9	-	361.9
Change ($1000)		(74.1)			(361.9)	
Change ($/acre)		(134.7)			(120.6)	
Crop Insurance Indemnities						
2016-2021 Average ($1000)	5.7	5.7	-	-	-	-
Change ($1000)			(5.7)			-
Change ($/acre)			(10.3)			-
Net Cash Farm Income						
2016-2021 Average ($1000)	71.9	(19.6)	68.0	421.2	21.7	421.2
Change ($1000)		(91.5)	(4.0)		(399.5)	-
Change ($/acre)		(166.3)	(7.2)		(133.2)	-
Ending Cash Reserves						
2021 Average ($1000)	(968.6)	(1,534.5)	(987.7)	(196.1)	(2,722.6)	(196.1)
Change ($1000)		(565.9)	(19.1)		(2,526.5)	-
Change ($/acre)		(1,028.9)	(34.7)		(842.2)	-

Table 3. Continued

Texas Rice Farm	TXR1500 BASE	TXR1500 NO PROG	TXR1500 NOINSR	TXR3000 BASE	TXR3000 NO PROG	TXR3000 NOINSR
Government Payments						
2016-2021 Average ($1000)	127.4	-	127.4	208.1	-	208.1
Change ($1000)		(127.4)			(208.1)	
Change ($/acre)		(84.9)			(69.4)	
Crop Insurance Indemnities						
2016-2021 Average ($1000)	8.3	8.3	-	18.2	18.2	-
Change ($1000)			(8.3)			(18.2)
Change ($/acre)			(5.6)			(6.1)
Net Cash Farm Income						
2016-2021 Average ($1000)	212.6	72.2	205.5	262.1	27.7	247.0
Change ($1000)		(140.4)	(7.1)		(234.4)	(15.2)
Change ($/acre)		(93.6)	(4.7)		(78.1)	(5.1)
Ending Cash Reserves						
2021 Average ($1000)	205.5	(672.2)	167.9	378.0	(1,082.7)	297.1
Change ($1000)		(877.7)	(37.6)		(1,460.7)	(80.9)
Change ($/acre)		(585.1)	(25.1)		(486.9)	(27.0)

Farm Programs

The moderate and large size Iowa corn and soybean farms have 1350 and 3400 acres. The moderate size farm receives an average government payment of $27,800/year and the large farm receives $63,400/year. Putting these payments on a dollar per acre basis, the moderate farm receives $20.60/acre and the large farm receives $18.63/acre so the farm program is not structurally biased towards the large Iowa farm. Similar results are observed for the crop insurance program which provides a $12.22/acre average indemnity for the moderate Iowa farm and $10.77/acre for the large farm. Net cash farm incomes decline more from a loss in government programs than from a loss of crop insurance. Again the loss in net cash income per acre is greater for the moderate size farm than the large Iowa farm ($27.66/ acre vs. $22.70/acre for government payments and $8.50/acre vs. $7.26/acre for insurance). If the farm program or insurance is structurally biased towards large farms the dollar per acre loss of ending cash reserves in 2021 will be greater for the large farm than the moderate farm. The results for the Iowa farms are just the opposite because the loss of farm programs reduces ending cash more for the moderate than the large farm ($218.30/acre vs. $175.50/acre). A similar result is observed for the impact of crop insurance. The results for the Iowa farms are particularly important because both farms purchase the same type and level of crop insurance and both farms elected the ARC-county farm program.

The per acre farm program payments for the 32 representative farms can be summarized as follows:

- Nine of the 16 moderate size farms receive greater per acre payments than the large farms in the same county.
- Four of the seven large farms who's per acre payments exceed their moderate size neighbor's payments were only about $1.00/acre greater than the moderate farm (ING887, TXCB3710, KSCW2137, and COW2274).
- Only three of the large farms (TXNP3226, TNG887, and TNG1633) receive payments more than $4.03/acre than their moderate size neighbors.

The three large farms that receive larger per acre government payments than their moderate size neighbors have a greater proportion of their farms planted to soybeans and corn.

Examining the average ending cash reserves for the large vs. the moderate size farms shows that nine of the moderate size farms can expect to see a greater increase in ending cash than the larger farms because of their participation in farm programs. For example, the moderate central Missouri (MOCG927) grain farm's average ending cash in 2021 is $70.48/acre greater due to farm programs than the large farm's (MOCG1694). On the other hand, the Texas Northern Plains grain farm (TXNP3226) has a $2,467,000 increase in ending cash due to farm program payments and the moderate farm (TXNP1391) has a $670,400 increase. On a per acre basis the large farm increased ending cash by $114.11/acre more than the moderate size farm.

Two of the primary causes for the differences by farm size are average yields experienced on each of the farm sizes and payment limits for the ARC and PLC. Differences in actual harvested yields, PLC payment yields, and insurance yields very likely account for much of the differences in farm results. While many farms in the U.S. are structured such that payment limits are not binding, for those that are not, the larger the farm the more likely payment limits will reduce the amount of safety net support.

Crop Insurance

The average per acre insurance indemnity payments are greater for moderate size farms in seven of the 16 regions. In five of the regions the per acre payments are less than $0.48/acre difference between the moderate and large farms. The average per acre indemnity payments are greater for the large farm in the Texas Southern Plains (TXSP) because the crop mix for the large farm is much different than the moderate size farm and a smaller portion of land is irrigated. Overall the crop insurance program is structurally neutral to biased towards the moderate size crop farms included in the study.

Nineteen of the 32 representative crop farms would experience an increase in nominal ending cash reserves in 2021 if they did not purchase crop insurance. These results suggest that crop insurance premiums are too high relative to the actual risk faced by the representative farms. On a per acre basis the crop insurance benefits are about neutral with nine of the moderate farms receiving greater benefits than the large farms.

Summary

The U.S. safety net programs in the 2014 Farm Bill are paid on a per base acre basis if prices or revenues fall below specified levels. Crop insurance indemnity payments are paid based on verified damages to yields and/or calculated losses in revenue on actual acres. The question remains are farm program payments and crop insurance structurally neutral?

The purpose of this paper was to test the hypothesis that farm programs and crop insurance are structurally biased to benefit large farms. A Monte Carlo farm simulation model was used to simulate crop farms (moderate and large) from 16 principal production regions in the United States. The farms used for the analysis are representative of feed grain, wheat, oilseed, cotton, and rice farms developed from individual farm panel (focus group) interviews with commercial size, fulltime farmers.

The 2016-2021 planning horizon was simulated using stochastic crop yields drawn from multivariate probability distributions estimated using actual farmer's historical yields. Stochastic crop prices in the FAPRI December 2016 Baseline were used as national prices, which were localized based on the panels' historical marketing basis.

Results of the analysis indicate that the per acre farm program payments are not biased towards large farms. In fact, the results show that moderate size farms receive greater dollar per acre government payments than large farms. Regarding crop insurance benefits, the analysis suggests that crop insurance is structurally neutral or slightly biased toward moderate size farms. In nine of the 16 regions the moderate farms received greater per acre payments than the large farms while the payment per acre is less than a $1.05 difference for four farm regions. These results suggest that we should reject the null hypothesis that farm programs and crop insurance are structurally biased in favor of large farms.

The simulation model calculates the ending cash reserves for the farms in 2021. Seven of the large farms have greater ending cash reserves due to farm programs than the moderate farms. The greater ending cash for these farms is not an indication that farm programs are structurally biased but it is due to the large farms having more acres. To the extent that large farms can generate more cash reserves it affords them the financial ability to grow faster than smaller farms.

References

Adams, G.M. and J.W. Richardson (August 2001). "Exploring Options for a New Farm Bill." *Journal of Agricultural and Applied Economics*, 33(2), pp. 261-270. http://ageconsearch.umn.edu/bitstream/15027/1/33020261.pdf

Haen, D.H. (1973). "Systems Models to Simulate Structural Change in Agriculture." *European Review of Agricultural Economics*, 1(4), pp. 367-389. http://agris.fao.org/agris-search/search.do?recordID=EY7513003

Hueth, B. (Feb 2000). "The Goals of U.S. Agricultural Policy: A Mechanism Design Approach." *American Journal of Agricultural Economics*, 82, pp. 14-24. https://www.jstor.org/stable/1244475?seq=1#page_scan_tab_contents

Jolly, D. (Fall 1999). "Agricultural Policies and the Future of U.S. Family Farming." University of California Cooperative Extension. [Online] DOI: http://sfp.ucdavis.edu/pubs/SFNews/Fall99/djagtour/

Knutson, R.D., E.G. Smith, D.P. Anderson, and J.W. Richardson (July 1998). "Southern Farmers' Exposure to Income Risk Under the 1996 Farm Bill." *Journal of Agricultural and Applied Economics*, 30(1), pp. 35-46. http://ageconsearch.umn.edu/bitstream/15101/1/30010035.pdf

Matthews, A. (2016). "The Future of Direct Payments." *Research for AgriCommittee -- CAP Reform Post-2020 – Challenges in Agriculture*. Directorate-General for Internal Policies, Policy Department B: Structural and Cohension Policies, Workshop Documentation, Brussels, European Union. https://polcms.secure.europarl.europa.eu/cmsdata/upload/c47caf54-2bfc-4deb-b144-cbdc48d50fda/1_Matthews%20Future%20of%20Direct%20payments%20AGRI%20Committee%20Nov%202016%20revised.pdf

Mercier, S. (November 2011). "Review of U.S. Farm Programs. Agree: Transforming Food and Ag Policy." [Online] DOI: http://foodandagpolicy.org/sites/default/files/Review%20of%20US%20Farm%20Programs-S%20Mercier%20110611_0.pdf

Ray, D. E. and H. D. Schaffer (July 2005). "How Federal Farm Policy Influences the Structure of Our Agriculture." University of Tennessee. [Online] DOI: http://www.agpolicy.org/publication/RaystructuresessionSummary.pdf

Richardson, J.W. and C.J. Nixon (1981). "The Farm Level Income and Policy Simulation Model: FLIPSIM." Departmental Technical Report, DTR No. 81-2, Department of Agricultural Economics, Texas A&M University. http://agris.fao.org/agris-search/search.do?recordID=US8124788

Richardson, J.W. and C.J. Nixon (July 1982a). "Producer's Preference for a Cotton Farmer Owned Reserve: An Application of Simulation and Stochastic Dominance." *Western Journal of Agricultural Economics*, 7(1), pp. 123-132. https://www.jstor.org/stable/40987567?seq=1#page_scan_tab_contents

Richardson, J.W., C.J. Nixon, and E.G. Smith (December 1982b). "Economic Impacts of the 1981 Agricultural Act and the 1981 Tax Act on Texas High Plains Farmers." *Southern Journal of Agricultural Economics*, 14(2), pp. 71-76. http://ageconsearch.umn.edu/bitstream/30441/1/14020071.pdf

Richardson, J.W. and C.J. Nixon (July 1986). "Description of FLIPSIM V: A General Firm Level Policy Simulation Model." Texas Agricultural Experiment Station, Bulletin B-1528. http://agris.fao.org/agris-search/search.do?recordID=US8708667

Richardson, J.W., S.L. Klose, and A.W. Gray (August 2000). "An Applied Procedure for Estimating and Simulating Multivariate Empirical (MVE) Probability Distributions in Farm-Level Risk Assessment and Policy Analysis." *Journal of Agricultural and Applied Economics*, 32(2), pp. 299-315. https://www.researchgate.net/publication/5139131_An_Applied_Procedure_for_Estimating_and_Simulating_Multivariate_Empirical_MVE_Probability_Distributions_In_Farm-Level_Risk_Assessment_and_Policy_Analysis

Richardson, J.W., J.L. Outlaw, G.M. Knapek, J.M. Raulston, H.L. Bryant, B.K. Herbst, and D.P. Ernstes (October 2013). "Economic Impacts of the Safety Net Provisions in the Senate (S. 954) and House (H.R. 2642) 2013 Farm Bills on AFPC's Representative Crop Farms." Texas AgriLife Research, Texas AgriLife Extension Service, Texas A&M University, Department of Agricultural Economics, Agricultural and Food Policy Center Working Paper 13-3. https://www.afpc.tamu.edu/pubs/0/589/WP-13-03-Farm-Bill-Report.pdf

Richardson, J.W., J.L. Outlaw, G.M. Knapek, J.M. Raulston, B.K. Herbst, D.P. Anderson, H.L. Bryant, S.L. Klose, and P. Zimmel (March 2017). "Representative Farms Economic Outlook for the January 2017 FAPRI/AFPC Baseline." Texas AgriLife Research, Texas AgriLife Extension Service, Texas A&M University, Department of Agricultural Economics, Agricultural and Food Policy Center Working Paper 17-1. https://www.afpc.tamu.edu/pubs/0/684/WP_17-1.pdf

Appendix A: Brief Description of the Multivariate Empirical Distribution

Richardson, Klose, and Gray (2007) introduced a procedure for simulating random variables from a multivariate distribution. Their application was described for an empirical distribution, but the procedure can be used for any type of probability distribution. The multivariate empirical (MVE) procedure is described here for a distribution with prices and yields.

- The non-random component of a historical price or yield series is the residuals from a regression equation. For J random variables with T observations, we estimate J regressions, such as:

  $\hat{Y}_{jt} = \hat{a} + \hat{b} \cdot Trend_t$

  and the residuals are the stochastic component

  $\hat{e}_{jt} = Y_{jt} - \hat{Y}_{jt}$

  The residuals are assembled into the E_{jt} matrix of residuals.

  $E_{jt} = (e_{1t,} e_{2t,} \dots, e_{Jt})$

- For an empirical probability distribution, the next step is to convert the residuals in $(\hat{e}_{jt})$ to fractions of their respective forecasted values.

  $d_{jt} = \hat{e}_{jt}/\hat{Y}_{jt}$

- The fractional deviates are then sorted from their minimums to maximums and reassembled into the S matrix.

  $s_{jt} = Sorted\left(d_{jt}\right)$

  $S_{jt} = \left(s_{1t,} s_{2t,} \dots, s_{jt}\right)$

- A vector of probabilities associated with the s_{jt} named $P(s_t)$ is developed to reflect the probability of observing a lower s_t as:

  P(1) = 0.0
  P(2) = P(1) + (1.0/T)
  P(3) = P(2) + (1.0/T)
  .
  .
  .
  P(T) = 1.0

- The E_{jt} matrix of unsorted residuals is used to calculate a JxJ correlation matrix ρ

- The ρ matrix is factored by the square root method to get the R matrix defined as:

  $R = \rho^{1/2}$

  such that

  $\rho = R \cdot R^1$

- A Jx1 vector of correlated standard normal deviates (CSND) is simulated using a Jx1 vector of independent standard normal deviates (ISND) where SND ~ Normal (0,1)

  $CSND_{Jx1} = R_{JxJ} * ISND_{Jx1}$

- The CSND vector is converted to a vector of correlated uniform deviates (CUSD) using the error function (ERF)

  $CUSD_{Jx1} = ERF\ (CSND_{Jx1})$

  ERF is available as an Excel function named NORMSDIST and is used individually for each $CSND_J$

- The final step is to simulate correlated deviates for each of the J random variables and use them to simulate random prices and yields for future periods T + t:

  $\tilde{Y}_{jT+t} = \hat{Y}_{jT+t} * (1 + EMP\left(s_j, P(s), CUSD_j\right))$

  where EMP is a function which uses the inverse transform method to simulate a random s_j value using the 0 to 1 stochastic $CUSD_j$ in the s_j, P(s) space. It should be noted that at this point the CUSD's can be used with the inverse transform to simulate random values for any distribution.

By applying the process described here the J simulated random variables will exhibit the same correlation as observed for the residuals. Student t tests are used to validate that the simulated random variables maintained their historical correlation at the alpha 0.05 level. Additionally, Student t tests are used to test if the $\tilde{Y}_{jT+t}$ means are statistically equal to the forecasted means of $\hat{Y}_{jT+t}$ at the alpha 0.05 level.