Final Report

DEVELOPING A GRAIN SORGHUM PRICING METHODOLOGY FOR CROP INSURNCE PROGRAMS

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Together with other major grain crops, grain sorghum enjoys four types of crop insurance programs offered by Risk Management Agency, USDA. They are Multiple Peril Crop Insurance Program (MPCI), Group Risk Plan (GRP), Crop Revenue Coverage (CRC) and Income Protection (IP), and Group Risk Income Protection (GRIP).

Grain sorghum CRC, GRIP and IP are market based programs. In the program, the price is valued at percentage of CBOT corn price, where the percentage is based on the ratio between January USDA estimated sorghum and corn prices each year (Collins). For the grain sorghum MPCI-APH plan, the established price election was based on USDA ERS projections at the previous year end but published before planting time. For example, the 2008 price was based on November 2007 projection and published in February 2008 in *USDA Agricultural Projections to 2017*. Some criticize the ERS model which is strongly linked to livestock feed for not considering the ethanol demand in recent year. (National Sorghum Producers).

In this final report, a new method of pricing sorghum for crop insurance programs is developed and recommended. The model and data used in the analysis are summarized and justified first in the following.

1. Data Used in the Analysis

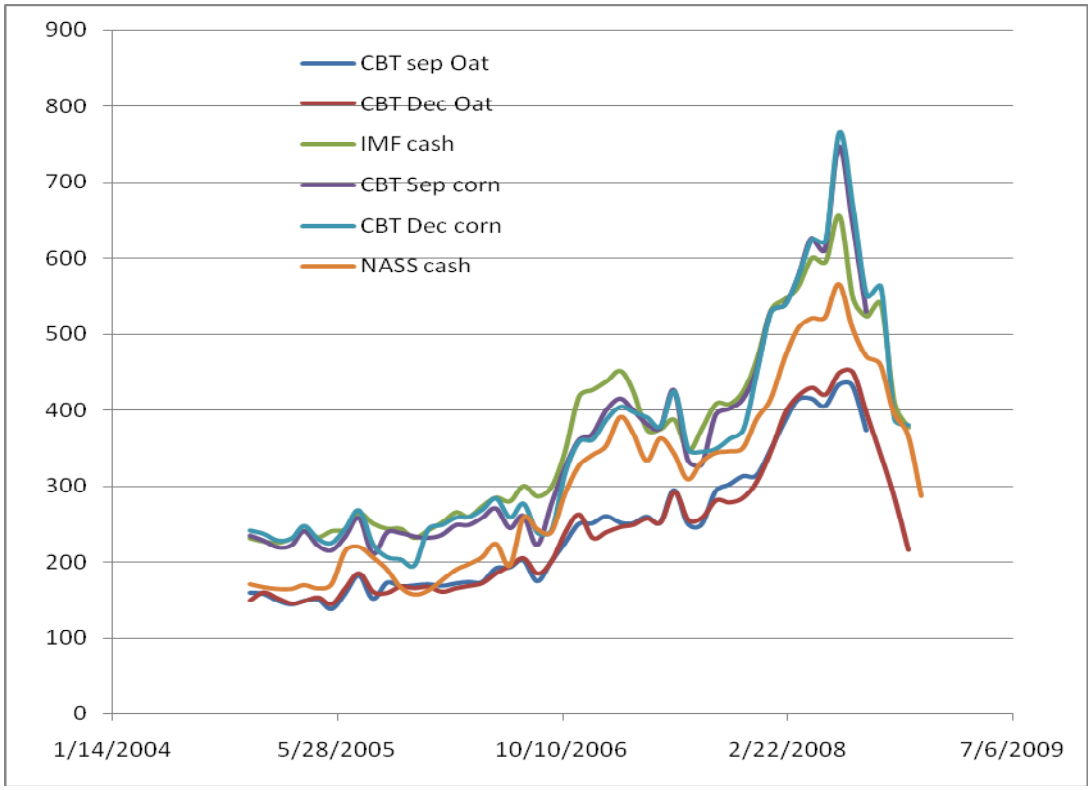
To come up with a pricing method that is transparent and best predict the harvest time market value of sorghum at the planting time, futures prices are the conveniently available sources. Futures prices represent the expected price from all players in the market when considering all available information about the demand and supply of the crop. Information such as crop acreage, input costs, price of substitutes, alternative ways of use, and technology is all reflected in the futures prices.

However, sorghum is not a traded commodity at any futures markets. Because sorghum has been used as a feed grain, its demand is closely related with corn. In recent years, the ethanol production has pulled the corn price high and fluctuating, this also affects the sorghum. In addition, oat is another feed grain that is related to sorghum and is traded in futures markets. In the past, USDA has used CBOT corn price only to calculate the sorghum price for the crop insurance. Here we use both corn and oat futures prices to examine which or what combination can predict the market sorghum better. Daily prices for the National Corn Index developed by Minneapolis Grain Exchange, a new instrument, is also used. Constrained by the availability of data, the NCI futures are for nearby contracts.

In order to check how the futures prices can predict the cash price, we need a good size of historical observations, more than the recent few years of annual cash prices. Therefore, we obtained monthly US sorghum prices represented by the Rotterdam FOB prices from the Gulf (published by IMF International Financial Statistics, measured in $/metric ton), and monthly data at national level as well as state level for all major grain sorghum growing states including AR, IL, KS, MT, NE, OR and TX (published by National Agricultural Statistics Service, NASS, measured in $/CWT).

All prices data are converted into cent/bu to match with the futures prices. We only use the most recent data from the middle of 2004 to the end of 2008.

The two national cash prices (IMF and NASS) and the four CBOT futures prices are plotted in the graph below. They all show very similar patterns. The oat futures prices are the lowest, NASS sorghum cash prices are next above it, and then the corn futures prices are even higher, which is very similar to the IMF FOB sorghum prices.



Date	IMF	Cents/bushel	NASS CASH Price	September Corn Futures	September Oat Futures	December Corn Futures	December Oat futures
11/15/2004	92.4	231	171.36	234.5	160	241.5	**149**
12/15/2004	90.7	226.75	167.44	228	158.5	237.25	**159.5**
1/15/2005	90	225	165.2	219	149.5	228.5	152
2/15/2005	92.3	230.75	165.2	221.75	144.5	231	145
3/15/2005	96.4	241	170.24	240.25	149.5	247.5	148
4/15/2005	93	232.5	165.76	221.25	151	230.25	153
5/15/2005	96.2	240.5	171.36	215	138.5	225.25	144
6/15/2005	97.1	242.75	215.6	233.75	159.75	244.5	165.5
7/15/2005	105.6	264	220.64	257.75	182.5	268	184.75
8/15/2005	100.1	250.25	206.64	210.5	152	223.25	160.5
9/15/2005	97.4	243.5	190.96	**238.5**	**173**	206.5	159
10/15/2005	97.4	243.5	167.44	**238**	**168.5**	203.5	167.25
11/15/2005	92.6	231.5	157.92	**233.5**	**169.5**	195.75	165.25
12/15/2005	96.6	241.5	162.96	**231.5**	**171**	**242.75**	**167**
1/15/2006	100.64	251.6	176.4	**235.5**	**169**	**248.75**	**160.5**
2/15/2006	106.1	265.25	190.4	**248.25**	**172**	**258.5**	**165**
3/15/2006	103.7	259.25	197.68	**248.25**	**174**	**259.25**	**168**
4/15/2006	109.4	273.5	207.2	**258**	**174**	**269.25**	**172**
5/15/2006	113.8	284.5	224.56	**270.5**	**192**	**283.75**	**184.75**
6/15/2006	111.9	279.75	196	**244.5**	**193.25**	**258.5**	**194.5**
7/15/2006	120	300	258.72	**260.75**	**202.75**	**276.75**	**204.5**
8/15/2006	114.4	286	243.6	**222**	**175**	**238.5**	**184.25**
9/15/2006	119.5	298.75	239.68	275.25	201	**241.75**	**200.5**
10/15/2006	138.2	345.5	289.52	323	225	**316.75**	**238**
11/15/2006	167.1	417.75	326.48	359.75	250	**358.25**	**262.25**
12/15/2006	170.6	426.5	341.04	368	251	361	231.5
1/15/2007	175.1	437.75	353.36	399.5	260.5	387.75	239
2/15/2007	180.6	451.5	390.88	415	252	404.5	245.75
3/15/2007	169.96	424.9	370.72	400.5	251	397.5	248.5
4/15/2007	149.52	373.8	333.76	382	260	390.25	257
5/15/2007	150	375	362.88	376.5	251.75	378.5	251.75
6/15/2007	154.79	386.975	342.72	426	294.75	424.25	292
7/15/2007	138.47	346.175	309.12	334.75	251	348.5	255.25
8/15/2007	150.28	375.7	332.08	328	249.5	345.25	258
9/15/2007	163.3	408.25	343.84	**393**	**293**	349	280.75
10/15/2007	163.19	407.975	346.08	**401.5**	**302**	362	278
11/15/2007	170.1	425.25	350.56	**414.5**	**313**	374.75	284.5
12/15/2007	187.01	467.525	388.08	**452.5**	**314**	**450.5**	**306**
1/15/2008	212.67	531.675	414.4	**528.25**	**347**	**529**	**346**
2/15/2008	218.49	546.225	467.6	**538**	**384**	**538**	**395**
3/15/2008	224.93	562.325	506.24	**573.25**	**413**	**575**	**418**
4/15/2008	240.28	600.7	520.8	**626.5**	**415**	**625.25**	**429**
5/15/2008	238.24	595.6	521.92	**611.25**	**405**	**622.5**	**420**

6/15/2008	262.19	655.475	565.6	**746.75**	**433**	**765**	**449**
7/15/2008	218.82	547.05	507.92	**648.25**	**432**	**666.75**	**449**
8/15/2008	209.34	523.35	470.4	**529.75**	**373.5**	**549.5**	**393**
9/15/2008	216.01	540.025	459.76			**562**	**339.75**
10/15/2008	163.63	409.075	396.48			**388**	**284**
11/15/2008	150.8	377	367.92			**380.25**	**215.5**
12/15/2008	138.6	346.5	287.28				

2. Econometric Analysis

Unit root tests are performed on each price series to examine their stationarity. We found most prices are non-stationary and first difference model is used for all analysis in the following. Seasonality is also tested and is not identified.

Several regression models are examined using cash prices as dependent variables and futures prices as independent variables as in the following equation.

$$(1) \qquad Cash_t = \beta_0 + \beta_1 CBOTCorn_t + \beta_2 CBOTOat_t + \beta_3 NCI_t + \sum_{j=4}^{k} \beta_j D_{jt} + \varepsilon_t$$

The dependent variable takes NASS national price, Gulf price, and NASS state level price for each of IL, KS, MT, NE, OR and TX. AR prices are reported sporadically and are excluded in this analysis. CBOT prices for December contracts and September contracts are used separately for the two national prices.

For the dummy variables D_j, several specifications are tested including yearly dummies with one representing each year to capture the systematic differences in any particular year. None of the yearly dummies for 05, 06, and 07, 08 being the default, is significant either individually or jointly. This is very good for the pricing method, because it means the patterns between futures prices and cash prices remain the same, irrespective to any specific years. Therefore, it is UNNECESSARY to adjust the pricing model used to estimate the parameters every year.

Contract switching dummies are also tested, where the dummy variables take the value one if during that particular period we switch to next year's contract for the futures prices; otherwise, zero. For example at September of each year, the futures prices are still the current year September contract prices, while at October the current contract expires and the futures prices are for next year's September contract. The September contract switching dummy variable will take value one in each October. Because we use the first difference data to fit model (1), any jump in prices during the contract switching month will be captured by this dummy. However, the results also indicate the switching dummy is not significant.

2.1 National prices

Regression results from alternative specifications are reported in the following tables. Table 1 reports the results for NASS national sorghum prices, and Table 2 reports for Gulf prices.

Table 1 NASS National Sorghum Prices

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Using CBOT December Contracts						
CBOT Corn	0.102	0.101		0.098		0.506***
CBOT Oat	0.041	0.034		0.034		0.130
NCI	0.513***	0.536***	0.607***	0.540***	0.607***	
D05	1.976					
D06	8.859					
D07	2.696					
Constant	-2.287	1.079	2.151			
N	47	47	50	47	50	47
R^2	0.656	0.644	0.600	0.644	0.597	0.583
Adjusted R^2	0.603	0.619	0.592	0.619	0.589	0.565
Using CBOT September Contracts						
CBOT Corn	0.160	0.143		0.157		0.569***
CBOT Oat	-0.001	0.008		0.024		-0.096
NCI	0.413**	0.438**		0.432**		
D05	-1.783					
D06	4.535					
D07	-2.684					
Constant	3.091	3.074				
N	47	47		47		47
R^2	0.550	0.538		0.549		0.484
Adjusted R^2	0.482	0.506		0.518		0.461

Table 2 Gulf National Sorghum Prices

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Using CBOT December Contracts						
CBOT Corn	0.359**	0.342**	0.340**	0.755***		
CBOT Oat	-0.105	-0.095	-0.095	0.003		
NCI	0.522***	0.548***	0.551***		0.795***	0.795***
D05	6.079					
D06	6.978					
D07	2.042					
Constant	-2.975	0.710			2.153	
N	47	47	47	47	50	50
R^2	0.829	0.823	0.824	0.777	0.744	0.741
Adjusted R^2	0.804	0.811	0.812	0.768	0.738	0.736
Using CBOT September Contracts						
CBOT Corn	0.402**	0.388**	0.403**	0.881***		
CBOT Oat	-0.442**	-0.432**	-0.414**	-0.554		
NCI	0.492***	0.508***	0.502***			
D05	1.756					
D06	5.545					
D07	-1.807					
Constant	1.855	3.237				
N	47	47	47	47		
R^2	0.699	0.690	0.693	0.625		
Adjusted R^2	0.653	0.668	0.672	0.608		

Overall, the best model, based on adjusted R^2 and the tests, that fits both NASS national and Gulf prices is to use the combination of CBOT December corn, oats, and NCI futures prices, without the constant. Because the models are estimated with first difference data, the insignificant constant terms indicates there is no significant linear time trend in the original prices data. The intercept of the original model is not able to be identified with the first difference data.

2.2 State Level Prices

The crop insurance sales closing date for grain sorghum is February 28 for AL, AR, AZ, CA, FL, GA, LA, MS, NC and SC, while March 15 for CO, DE, IA, IL, IN, KS, KY, MD, MO, ND, NE, NJ, NM, NY, OH, OK, PA, SD, TN, TX, VA and WI. In our dataset, AR is dropped because there are only a few observations reported occasionally, not enough for statistical analysis. MT and OR are also dropped because these states are removed from the grain sorghum crop insurance program in 2009.

All the rest states that we have cash prices reported by NASS, IL, KS, NE and TX, fall into the category of late closing. Nevertheless, we examine the explanatory effect from both September and December futures prices. The results are reported in Table 3.

Table 3 State Level Sorghum Prices

	Illinois		Kansas		Nebraska		Texas	
	Model 1	Model 2	Model 1	Model2	Model 1	Model 2	Model 1	Model 2
Using CBOT December Contracts								
CBOT Corn	0.105	0.105	-0.043	-0.050	0.103	0.097	0.015	0.009
CBOT Oat	0.572**	0.572**	0.192	0.192	0.328***	0.328***	0.065	0.064
NCI	0.187	0.186	0.654***	0.668***	0.354**	0.367**	0.404	0.416
Constant	-0.132		2.136		1.981		1.912	
N	46	46	46	46	46	46	46	46
R^2	0.308	0.309	0.615	0.618	0.751	0.751	0.308	0.314
Adjusted R^2	0.259	0.261	0.587	0.592	0.733	0.734	0.259	0.266
Using CBOT September Contracts								
CBOT Corn	-0.227	-0.215	0.289	0.300	0.144	0.152	-0.041	-0.023
CBOT Oat	0.405	0.418	0.195	0.208	0.343**	0.352***	0.146	0.167
NCI	0.470	0.464	0.306	0.301	0.380***	0.377**	0.410*	0.402**
Constant	2.560		2.399		1.687		3.806	
N	47	47	47	47	47	47	47	47
R^2	0.133	0.142	0.544	0.557	0.792	0.798	0.295	0.311
Adjusted R^2	0.073	0.084	0.512	0.527	0.778	0.784	0.246	0.264

IL, KS and TX all favor the model including December CBOT futures price, while only NE favors September contract prices. However, none of the CBOT futures prices is significant in any of the regression models. NCI and CBOT oat prices play important roles in explaining sorghum cash prices in these states.

2.3 The complete models using monthly data

Because the models were estimated using first difference data, we don't have the intercept of the model. For price prediction purpose, ignoring the intercept or restricted it to be zero will affect the predicted price levels. Here we can estimate the intercept by taking the difference between the actual cash price and the fitted value for each equation.

The final best fit models in terms of adjusted R^2 are reported in the following.

$$
\begin{aligned}
NASS &= 94.24 + 0.098 CBOTCornDec + 0.034 CBOTOatDec + 0.540 NCI \\
Gulf &= 97.56 + 0.340 CBOTCornDec - 0.095 CBOTOatDec + 0.551 NCI \\
IL &= 81.52 + 0.105 CBOTCornDec + 0.572 CBOTOatDec + 0.186 NCI \\
KS &= 62.79 - 0.050 CBOTCornDec + 0.192 CBOTOatDec + 0.668 NCI \\
NE &= 34.28 + 0.152 CBOTCornSep + 0.352 CBOTOatSep + 0.377 NCI \\
TX &= 170.38 + 0.009 CBOTCornDec + 0.064 CBOTOatDec + 0.416 NCI
\end{aligned}
\tag{2}
$$

2.4 Using harvest prices only

The above analysis utilizes the entire four years of monthly prices. In the following, only futures prices observed in spring months, January, February and March, which are also crop insurance sign-up time, are used to predict the harvest months cash prices which are September, October and November. This resembles the actual need of crop insurance pricing method. However, the trade off is we now have only 12 monthly observations left for the four years. Although collecting more years of prices can help with the econometric need, however, prices or many years old are not appropriate for representing current market.

Regression results are reported in Table 4. All equations have high R^2, which is partially due to the explanatory power of the futures prices and partially because of the low degree of freedom. The results confirm that CBOT December contract prices predict sorghum harvest cash prices better than CBOT September contract prices. They also confirm that NCI and CBOT oat prices are also very important in explaining sorghum prices. However, the signs and magnitudes of the estimated coefficients from Table 4 are not recommended to use because of the small sample size.

3. Recommended Pricing Methodology

The current sorghum crop insurance pricing method used by RMA is based on CBOT corn futures alone. A ratio between corn and sorghum prices is developed at spring time based on USDA's prediction of both corn and sorghum harvest prices of the current year. The harvest time sorghum price is determined by this ratio and spring time observed CBOT futures. The ratio itself is not transparent. In the following, a transparent pricing method is recommend based on the above analysis.

Instead of CBOT corn price, an index of futures price is recommended that CBOT corn, CBOT sorghum and MGEX National Corn Index are all considered. The procedure is supposed to be performed at the spring time before the crop insurance price is announced. Specific steps are listed in the following.

Table 4 Using Spring Futures Prices to Predict Harvest Cash Prices

	NASS	Gulf	Illinois	Kansas	Nebraska	Texas
Using CBOT December Contracts						
CBOT Corn	1.293	0.655	-0.182	1.528	1.385	1.261
CBOT Oat	3.323***	4.052***	4.563***	3.500***	3.210***	2.929***
NCI	-3.965***	-4.189**	-4.048***	-4.354***	-3.901**	-3.533**
Constant	-153.95**	-66.45	-71.011	-188.19**	-176.99**	-116.44
N	12	12	12	12	12	12
R^2	0.915	0.805	0.857	0.896	0.900	0.909
Adjusted R^2	0.883	0.732	0.803	0.857	0.862	0.875

Using CBOT September Contracts						
CBOT Corn	9.424***	11.341*	10.038**	10.600***	9.175**	7.354**
CBOT Oat	-2.993**	-4.339**	-4.202**	-3.357**	-2.811**	-2.146
NCI	-6.609***	-7.665*	-6.625**	-7.503***	-6.452**	-5.153**
Constant	-259.20*	-228.06	-194.82	-316.33**	-275.64**	-167.69
N	12	12	12	12	12	12
R^2	0.885	0.791	0.669	0.885	0.874	0.851
Adjusted R^2	0.841	0.712	0.545	0.842	0.827	0.795

Step 1: Collecting monthly NASS cash prices for the past 4 years at national level as well as state level for major sorghum growing states with sorghum crop insurance programs.

Step 2: Collecting monthly CBOT corn, oat prices and MGEX NCI for both December and September contracts for the past 4 years (Use daily price averages to present monthly prices).

Step 3: Performing multiple regression analysis, taking care of stationarity problem and correctly handling the intercepts.

- I recommend the regression is at the level of each state. National level regression is only for those states that don't have a cash price collected by NASS.
- The choice of December versus September futures contracts can follow the current RMA practice, ie, those states with the February closing date can use September prices, while those with the March closing date can use December prices.
- December contract is recommended for national prices.

Step 4: Recording prices for the identified contracts from the two futures market. Again, following the current practice and using average daily prices from mid December to mid January for September contracts and February prices for December contracts.

Step 5: Calculating the sorghum price using the regression estimates from Step 3 and the average prices from Step 4.

***An Example*:**

To calculate 2009 sorghum prices for Texas, we use regression results from equation (2). We record futures prices in February in Table 5. The sorghum price for 2009 is calculated as:

$$TX = 170.38 + 0.009 CBOTCornDec + 0.064 CBOTOatDec + 0.416 NCIDec$$
$$= 170.38 + 0.009 * 361.95 + 0.064 * 184.30 + 0.416 * 339.30$$
$$= 326.58$$

Table 5 February Observed Futures Prices

	MGEX NCI	CBOT Oat	CBOT Corn
2/2/2009	342.75	192.5	370.5
2/3/2009	333.75	187.5	361.75
2/4/2009	329.75	187	358.25
2/5/2009	344.75	193	371.25
2/6/2009	350.75	195	377.25
2/9/2009	350.75	196	377.5
2/10/2009	350.75	194.5	376.75
2/11/2009	345.75	188.5	368.5
2/12/2009	343.75	190.5	366.25
2/13/2009	341.75	184.5	363.25
2/16/2009	341.75	184.5	363.25
2/17/2009	327.75	176	349.25
2/18/2009	327.75	171.5	349.25
2/19/2009	332.75	171.5	353.25
2/20/2009	330.75	168.5	350.25
2/23/2009	332.75	177	351.75
2/24/2009	335.75	177	354.25
2/25/2009	345.75	181.5	363.75
2/26/2009	343.75	185	362
2/27/2009	332.75	184.5	350.75
Average	339.30	184.30	361.95

*These prices are not actual December contract prices, and they are listed for illustration purposes only.

4. Summary

The sorghum crop insurance pricing method recommended here is still based on futures prices. Different to the current practice, it uses an index of three futures prices, CBOT corn, CBOT oat and MGEX NCI. It is transparent in that all the data used for the analysis are from published sources, and the regression method is simple enough to be made available to the public.

Another difference between this one and the current practice is that we recommend the price is determined at state level if possible. This method is based on NASS published cash prices, and the calculated price will best resemble the NASS cash price.

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