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New Corn and Soybean Pricing Models and World Stocks-to-Use Ratios

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In a series of recent *farmdoc daily* articles we offered a new specification for the relationship between the marketing year ending stocks-to-use ratio and the marketing year average farm price for corn and soybeans. The new models were first presented in an April 6, 2016 article. We then used the models in an article of April 13, 2016 to make price forecasts for the 2016-17 marketing year based on alternative corn and soybean balance sheet projections. We next used the models in an April 22, 2016 article of to make projections of "new era" average prices and found that these were very consistent with earlier projections based on a simpler methodology. Finally, we explored the sensitivity of the new models to changing the functional form in an article of April 29, 2016. One issue we have not investigated to date is the use of world stocks instead of U.S. stocks in the pricing models. The logic for considering world stocks is straightforward. Since grain and oilseed markets are obviously global in nature, it follows that world stocks-to-use ratios may do a better job of predicting prices than only U.S. stocks-to-use ratios. In this article, we first review the new models introduced last month and then compare estimation results for models with U.S. stocks-to-use ratios versus models with world stocks-to-use ratios.

Review of New Ending Stocks and Price Models

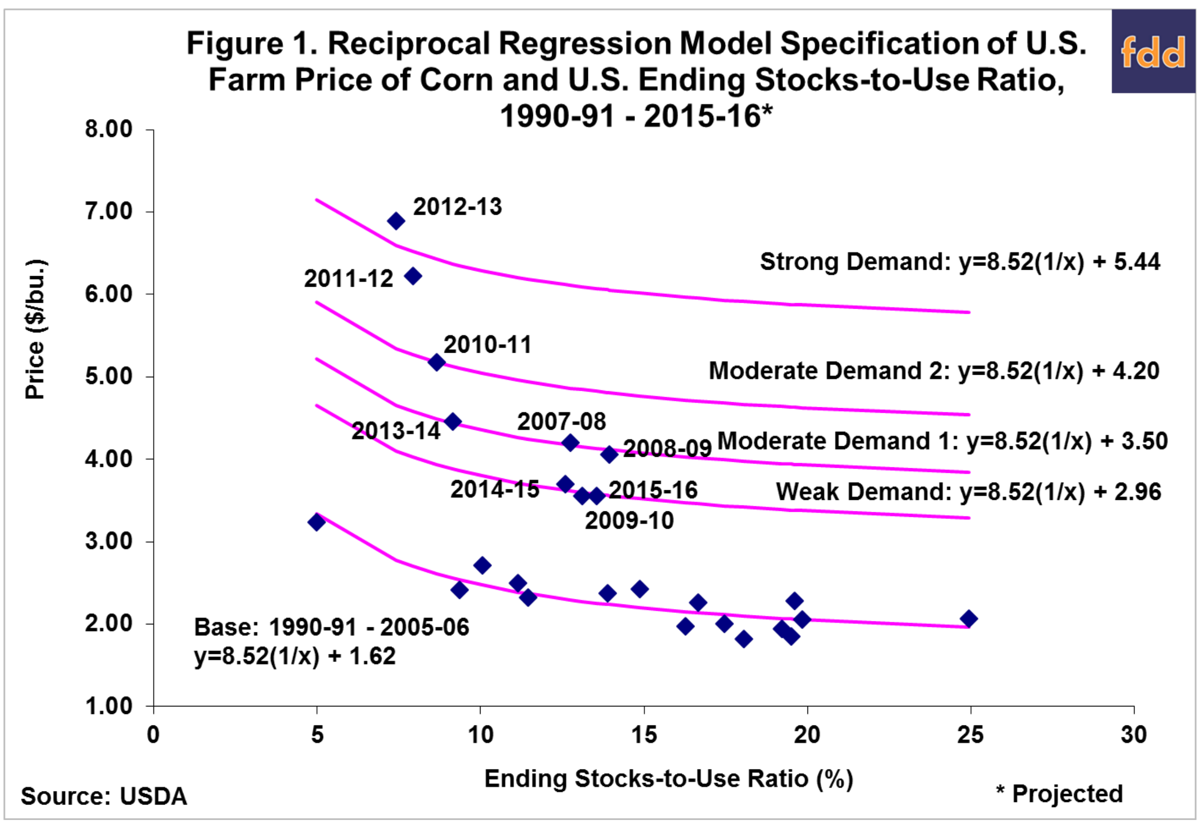
The marketing year ending-stocks-to use ratio is a widely used indicator of the supply and demand "tightness" of corn and soybean market conditions and is very commonly used to project prices. Tomek and Kaiser (2014, p. 378) classify price and ending stocks-to-use regression models as "price determination equations" rather than formal structural models of supply and demand. They point out the complexity of realistic structural models that have separate equations for supply and the various demand categories. As a result, analysts often turn to, "…graphs, tables, and simple regression models of price determination to summarize information." They also helpfully observe that, "The research objective may be to provide a forecasting tool, but more generally, the analysis helps the researcher depict current economic conditions relative to the historical evidence." The bottom-line is that these types of models, while useful in forecasting, cannot be directly derived (at least easily) from underlying structural and mathematical models of supply and demand.

In a previous article (*farmdoc daily*, April 6, 2016), we estimated a base reciprocal regression model of the U.S farm price of corn and soybeans and the ending stocks-to-use ratio for the period 1990-91 through 2005-2006, skipped 2006-07 as a transition year, and then estimated relationships after 2005-06 that are exactly parallel to the base period model. We selected the reciprocal functional form because it is simple and imposes the presumed non-linear relationship between price and the stocks-to-use ratio. As Tomek and Kaiser (2014, p. 379) note, "This accommodates the idea that, as current stocks approach zero (but cannot be less than zero), price must necessarily rise sharply to ration these stocks among competing demands." In our new model, we assumed the slope is unchanged between the base period and relationships after 2005-06, but the intercept varies in the latter period to reflect demand shifts that occurred after 2005-06. We further grouped the years after 2005-06 into four demand scenarios for corn (weak, moderate 1, moderate 2, and strong) and three demand scenarios for soybeans (weak, moderate, and strong).

The estimated pricing model of the relationship between the average marketing year price of corn and the ending stock-to-use ratio over 1990-91 through 2015-16 is presented in Figure 1. We used a reciprocal regression specification as follows:

Corn Price = a + b (1/Corn Stocks-to-Use Ratio) + c DW + d DM1 +e DM2 + f DS,

where DW is a dummy variable that takes on a value of 1 during weak demand years after 2005-06 and 0 otherwise, DM1 is a dummy variable that takes on a value of 1 during moderate demand 1 years after 2005-06 and 0 otherwise, DM2 is a dummy variable that takes on a value of 1 during moderate demand 2 years after 2005-06 and 0 otherwise, and DS is a dummy variable that takes on a value of 1 during strong demand years after 2005-06 and 0 otherwise. The intercept coefficient, a, in this reciprocal specification has the interesting interpretation as the estimated minimum price for the period under consideration. The coefficients on the dummy variables (c, d, e, and f) simply shift this estimated minimum price up or down by the magnitude of the dummy coefficient (in $ per bushel). The "slope" coefficient, b, does not have the usual interpretation of the change in price for a one-unit increase in the stocks-to-use ratio because of the reciprocal specification. Instead, at any given stocks-to-use ratio, the change in price for a one-unit increase in the stocks-to-use ratio is $-b/(\text{stocks-to-use ratio})^2$. The complete estimation results for the reciprocal model specification for corn can be found in Appendix Table 1. The reader is referred to our earlier article (*farmdoc daily,* April 6, 2016) for a more detailed discussion of the new model.



The estimated pricing model of the relationship between the average marketing year price of soybean and the ending stock-to-use ratio over 1990-91 through 2015-16 is presented in Figure 2. We again used a reciprocal regression specification:

Soybean Price = a + b (1/Soybean Stocks-to-Use Ratio) + c DA + d DW + e DM + f DS

where DA is a dummy variable that takes on a value of 1 during the Asian financial crisis years of 1999-00 through 2001-02 and 0 otherwise, DW is a dummy variable that takes on a value of 1 during weak demand years after 2005-06 and 0 otherwise, DM is a dummy variable that takes on a value of 1 during moderate demand years after 2005-06 and 0 otherwise, and DS is a dummy variable that takes on a value of 1 during strong demand years after 2005-06 and 0 otherwise. The complete estimation results for the soybean reciprocal model specification can be found in Appendix Table 2. The interpretation of the estimated model coefficients is the same as discussed above for corn.

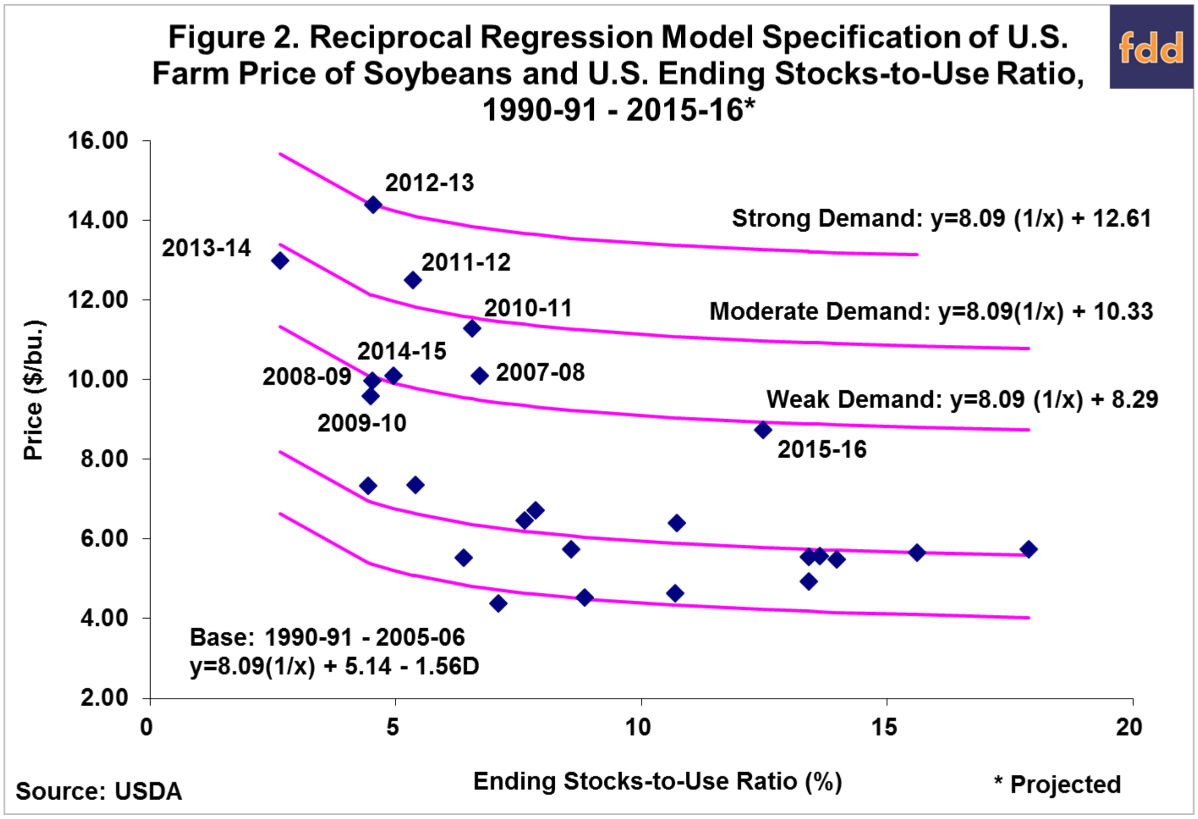
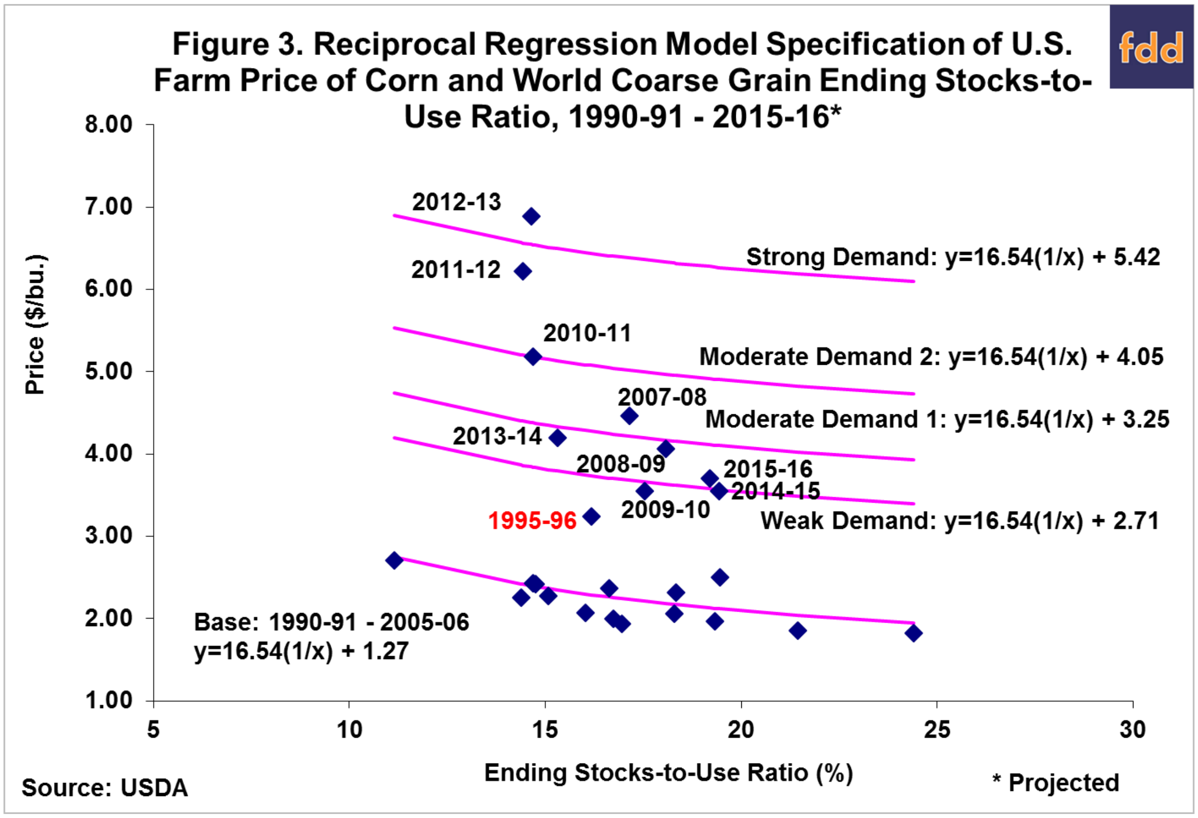
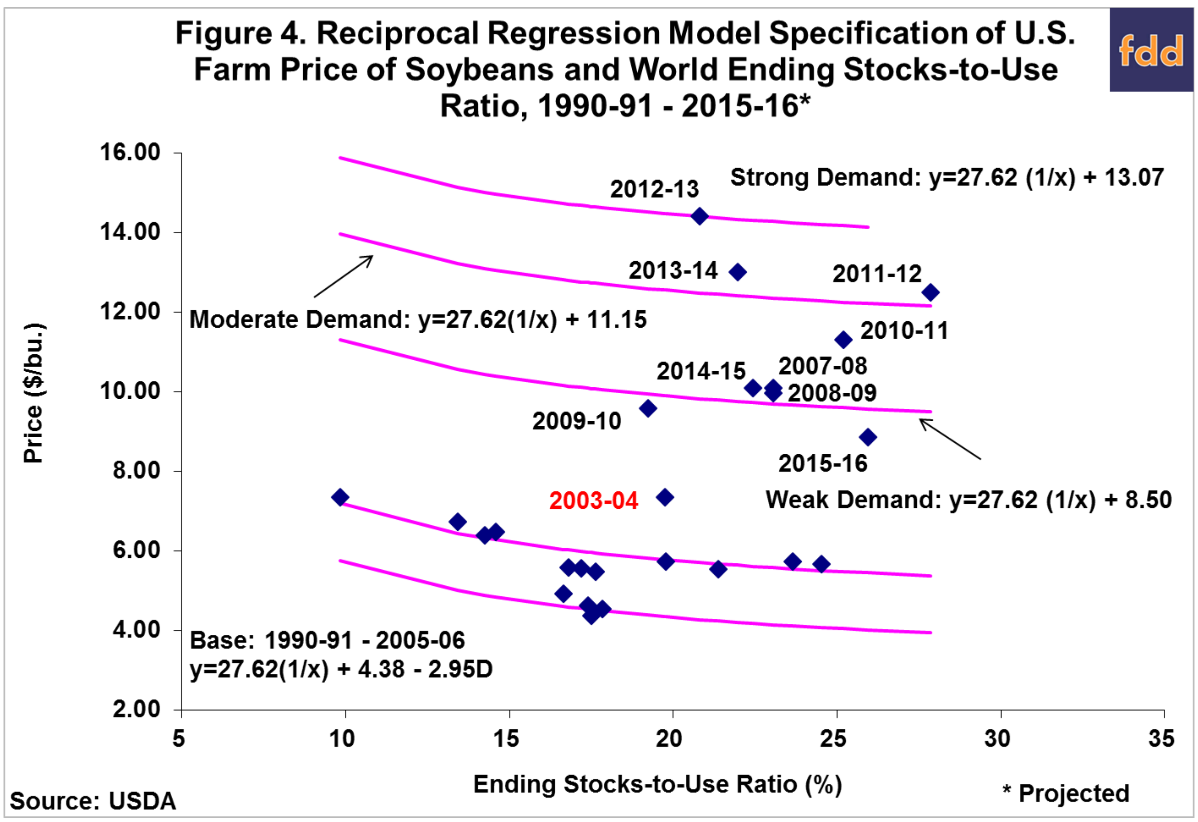


Figure 2. Reciprocal Regression Model Specification of U.S. Farm Price of Soybeans and U.S. Ending Stocks-to-Use Ratio, 1990-91 - 2015-16*

World Stocks-to-Use Ratios

Since U.S. corn and soybeans must compete in the world market with all other coarse grains and oilseeds, it could be argued that U.S. prices might better be explained by world stocks-to-use ratios. A long-term review of global stocks and corn and soybean prices can be found in this *farmdoc daily* article (March 11, 2016) by Carl Zulauf. We re-estimated the models presented in Figures 1 and 2 by substituting world coarse grains stocks-to-use ratios for U.S. stocks-to-use ratios in the case of corn and world soybean stocks-to-use ratios for U.S. stocks-to-use ratios in the case of soybeans. In order to make an exact comparison between the two models we used April 2016 WASDE estimates of prices, stocks, and consumption for 2015-16. Note that we imposed the exact same groupings of years in terms of strength of demand for both sets of models. The models with world stocks-to-use ratios are presented in Figures 3 and 4 for corn and soybeans, respectively. The complete estimation results for these alternative models can be found in Appendix Tables 3 and 4.





Since the exact same prices are used across the U.S. and world models, it is probably not too surprising that the model estimation results are similar. Visually, the main difference for corn is that the observation with world stocks-to-use for 1995-96 appears to belong to the weak demand group instead of the base group. In a similar fashion, the 2003-04 observation for soybeans with world stocks-to-use could be grouped as weak demand instead of the base. While neither observation has a major influence on the estimation results, it does serve to highlight how the switch from U.S. to world stocks-to-use ratios changes perspective on some years. From a more formal perspective, the fit is only marginally different between the specifications. As shown in the appendix tables, the R2 for the U.S. corn model is 0.99 compared to 0.96 for the world model, and 0.98 for the U.S. soybean model compared to 0.97 for the world model. Comparison of standard errors may be more revealing of the potential differences in predictability using the models because it is denominated in dollar per bushel terms. Recall that the standard error is simply the standard deviation of the estimation errors between actual and projected prices (points on the lines). As found in the appendix tables, the standard error for the U.S. corn model is $0.18 per bushel compared to $0.31 for the world model, and $0.49 for the U.S. soybean model compared to $0.60 for the world model. Whether these differences are seen as small or large is debatable, but, it is clear that the global supply and demand for coarse grains and soybeans is best captured in the export demand for U.S corn and soybeans, which in turn is reflected in the domestic stocks-to-use ratio.

So, what might explain the poorer fit of the world models compared to the U.S. models? The most likely explanation is problems created by aggregation of world stocks across different production periods. For example, since soybean production is large in both the U.S. and South America, with harvest separated by roughly six months, there is really not a distinct marketing year for soybeans. While corn production is still concentrated in the northern hemisphere, there has been substantial growth of production in recent years in Brazil. In this respect, world corn and soybean markets are becoming more similar to the wheat market, where there are substantial quantities produced in various parts of the world with a wide range of harvest dates. This creates measurement issues when aggregating ending stocks for the various production areas across the globe.

Implications

We recently developed new specifications for the relationship between the marketing year ending stocks-to-use ratio and the marketing year average farm price for corn and soybeans and used these new models to forecast prices for the 2016-17 marketing year as well as generate long-term average price projections. Here, we compare estimation results for models with U.S. stocks-to-use ratios to models with world stocks-to-use ratios. Since grain and oilseed markets are obviously global in nature, it follows that world stocks-to-use ratios may do a better job of predicting prices than only U.S. stocks-to-use ratios. We actually find that models with world stocks-to-use ratios have a marginally inferior fit compared to models with U.S. stocks-to-use ratios for both corn and soybeans. The most likely explanation is problems created by aggregation of world stocks across different production periods.

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Table A1. Reciprocal Regression Model Estimates for U.S. Farm Price of Corn and U.S. Ending Stocks-to-Use Ratio, 1990-91 - 2015-16*

Regression Statistics	
Multiple R	0.993
R Square	0.987
Adjusted R Square	0.983
Standard Error	0.179
Observations	25

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	45.685	9.137	283.606	0.000
Residual	19	0.612	0.032		
Total	24	46.297			

Variables	*Coefficients*	*Standard Errors*	*t Statistics*	*P-values*	*Lower 95% CI*	*Upper 95% CI*
Intercept	1.624	0.099	16.388	0.000	1.417	5.124
Stocks-to-Use Ratio	8.526	1.176	7.248	0.000	6.064	-0.578
Dummy Weak Demand	1.323	0.113	11.717	0.000	1.087	1.509
Dummy Moderate Demand 1	1.878	0.114	16.519	0.000	1.640	2.049
Dummy Moderate Demand 2	2.571	0.191	13.457	0.000	2.171	2.905
Dummy Strong Demand	3.817	0.150	25.516	0.000	3.504	4.092

*2015-16 projected based on April WASDE

Table A2. Reciprocal Regression Model Estimates for U.S. Farm Price of Soybeans and U.S. Ending Stocks-to-Use Ratio, 1990-91 - 2015-16*

Regression Statistics	
Multiple R	0.989
R Square	0.978
Adjusted R Square	0.972
Standard Error	0.488
Observations	25

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	198.865	39.773	167.260	0.000
Residual	19	4.518	0.238		
Total	24	203.383			

Variables	*Coefficients*	*Standard Errors*	*t Statistics*	*P-values*	*Lower 95% CI*	*Upper 95% CI*
Intercept	5.136	0.237	21.657	0.000	4.640	5.632
Stocks-to-Use Ratio	8.091	1.746	4.633	0.000	4.435	11.746
Dummy Asian Financial Crisis	-1.557	0.312	-4.984	0.000	-2.211	-0.903
Dummy Weak Demand	3.150	0.280	11.270	0.000	2.565	3.735
Dummy Moderate Demand	5.195	0.384	13.539	0.000	4.392	5.999
Dummy Strong Demand	7.479	0.541	13.831	0.000	6.347	8.611

*2015-16 projected based on April WASDE

Table A3. Reciprocal Regression Model Estimates for U.S. Farm Price of Corn and World Coarse Grain Ending Stocks-to-Use Ratio, 1990-91 - 2015-16*

Regression Statistics	
Multiple R	0.981
R Square	0.962
Adjusted R Square	0.952
Standard Error	0.305
Observations	25

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	44.530	8.906	95.728	0.000
Residual	19	1.768	0.093		
Total	24	46.297			

Variables	*Coefficients*	*Standard Errors*	*t Statistics*	*P-values*	*Lower 95% CI*	*Upper 95% CI*
Intercept	1.268	0.422	3.005	0.007	0.385	2.151
Stocks-to-Use Ratio	16.538	6.885	2.402	0.027	2.128	30.948
Dummy Weak Demand	1.447	0.197	7.327	0.000	1.033	1.860
Dummy Moderate Demand 1	1.985	0.192	10.343	0.000	1.584	2.387
Dummy Moderate Demand 2	2.785	0.319	8.731	0.000	2.118	3.453
Dummy Strong Demand	4.149	0.236	17.570	0.000	3.655	4.643

*2015-16 projected based on April WASDE

Table A4. Reciprocal Regression Model Estimates for U.S. Farm Price of Soybeans and World Ending Stocks-to-Use Ratio, 1990-91 - 2015-16*

Regression Statistics	
Multiple R	0.983
R Square	0.966
Adjusted R Square	0.957
Standard Error	0.603
Observations	25

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	196.706	39.341	108.285	0.000
Residual	19	6.903	0.363		
Total	24	203.608			

Variables	*Coefficients*	*Standard Errors*	*t Statistics*	*P-values*	*Lower 95% CI*	*Upper 95% CI*
Intercept	4.380	0.650	6.744	0.000	3.021	5.740
Stocks-to-Use Ratio	27.616	10.453	2.642	0.016	5.739	49.494
Dummy Asian Financial Crisis	-1.435	0.387	-3.704	0.002	-2.246	-0.624
Dummy Weak Demand	4.116	0.357	11.530	0.000	3.369	4.864
Dummy Moderate Demand	6.772	0.437	15.479	0.000	5.856	7.688
Dummy Strong Demand	8.692	0.638	13.626	0.000	7.357	10.027

*2015-16 projected based on April WASDE