The Forecasting Value of New Crop Futures: A Decision-Making Framework

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Abstract

The statistical forecasting efficiency of new crop corn and soybean futures is the topic of frequent academic inquiry. However, few studies address the usefulness of these forecasts to economic agents' decision making. Each year Central Illinois producers are faced with the decision to plant either corn or soybeans on marginal acreage. Agronomic concerns aside, these decisions hinge on the expected relative return of corn versus soybeans, which is largely a function of expected new crop prices. Do new crop futures prices reliably guide producers into the correct production decision? The results suggest that over the entire period of the analysis, futures markets provide only marginal decision-making information to the producer; however, more recent signals do appear to be useful. Further analysis explores several possible factors that could explain why the signals have improved so significantly since 1985.

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Introduction

The *Federal Agricultural Improvement and Reform Act of 1996* (*FAIR*), better known as the "Freedom to Farm Act”, gives U.S. agricultural producers virtually complete control over their production and planting decisions. That is, producers no longer must maintain a "base" acreage of a particular crop to remain eligible for government support programs. Thus, they are free to allocate their entire acreage (as opposed to just "flex" acres) as relative market prices dictate (Willot, *et al*.). The diminishing governmental influence on production decisions magnifies the importance of market prices, and futures prices in particular, in guiding scarce resources to their optimal use and heightens the research challenge posed by Hieronymus: “How well do futures markets perform as devices for planning economic processes?” (1993, p. 18).

There is considerable evidence that U.S. producers utilize futures prices as expected output prices when making production and planting decisions (e.g., Gardner; Eales, *et al*.), and it has been suggested that this is both a rational and desirable alternative to using USDA or extension service forecasts (Brorsen and Irwin). Stein demonstrates that if futures prices are unbiased forecasts of realized prices, then the residual misallocation of production resources and the subsequent social loss is unavoidable. Many researchers have tested Stein's unbiased null hypothesis by regressing the realized harvest time price against the planting time futures price and testing that the intercept and slope coefficient are zero and one, respectively (e.g., Kenyon, *et al*.). The results of this method are mixed, and the procedure is generally fraught with statistical troubles including concerns over data stationarity (see Zulauf, *et al*.) and statistical power (see Kahl and Tomek). Furthermore, unbiasedness does not guarantee that a forecast is either efficient or particularly useful (Granger and Newbold). Indeed, Tomek stresses that "the best available forecast today can be a poor one" (p. 33). Given this contention, it is worthwhile to investigate whether new crop futures forecasts, biased or not, provide useful decision-making information to row crop producers.

The following research employs a new method and data set to evaluate corn and soybean futures forecasts. The objective is to determine if new crop futures provide economically relevant information regarding producers' investment of acreage and resources into the production of corn versus soybeans.

Framework and Data

During the spring planting season, Central Illinois producers can sow acres in either corn or soybeans. Agronomic concerns aside, producers' planting decisions are based on the relative attractiveness of each investment. A corn/soybean producer has roughly the same fixed production cost on acreage regardless of whether corn or soybeans are planted. Thus, the crop with the greatest expected cash return (cash revenue less variable costs) is planted.

Here, we use average production costs and crop yields for a sample of Central Illinois corn and soybean producers from 1972 to 1996 (25 observations). The data are provided by the Farm Business and Farm Management Association (FBFM) at the University of Illinois, Urbana-Champaign.[1] Variable production costs are defined to include: fertilizer, pesticide, seed, drying/handling, non-land interest, machinery repair, fuel, and hire. Assuming that

[1]The FBFM receives production data from a sample of Central Illinois pure grain producers (i.e., no grain fed to livestock) who farm over 260 acres of high fertility type soil. The sample size varies from a low of 101 farms in 1983 to a high of 674 in 1996 with an average sample size of 520. The data set includes fixed and variable production costs, crop acreage, and crop yields. The presented work does not utilize data from individual producers. Rather, it focuses on the sample averages from 1972 to 1996 (25 observations).

Central Illinois producers know these costs at planting time, then they will utilize them in conjunction with expected cash revenue per acre to make planting decisions.

A producers' expected cash revenue per acre is a function of the expected output price times the expected quantity of production per acre. Here, the expected yield per acre is the *ex ante* forecast from a simple linear trend regression model estimated from 1962 forward. This is a simplistic specification of expected yields; but, it is consistent with models utilized by government and industry practitioners (Riley).[2]

It is assumed that producers utilize new crop futures in forming expected output prices. That is, the expected harvest-time price equals the new crop futures price plus the expected basis. Here, the expected basis equals the average harvest-time basis for the prior three years. This basis expectation is consistent with industry practice and prior academic studies (see Garcia and Sanders).

In this study, it is assumed that Central Illinois producers make planting decisions on the last day of March, and harvest occurs at the end of October. So, at planting (i.e., the end of March), producers use new crop futures prices (December corn and November soybeans) plus the harvest-time expected basis to determine their expected output price. The actual output price is the harvest-time (end of October) cash price represented by Central Illinois elevator bids to producers.[3]

As an example of calculating the expected revenue and expected cash return, consider the 1995 crop. At the end of March, December corn and November futures were trading at $2.62

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[2]Alternative yield specifications were examined, including log-linear trends, quadratic trends, and ARIMA specifications. None of these alternative specifications altered the presented results.

[3]Cash and futures price data were provided by the Office for Futures and Options Research, University of Illinois, Urbana-Champaign.

and $6.00 per bushel, respectively. Over the prior three years, the average end of October basis was -$0.20 per bushel for corn and -$0.21 per bushel for soybeans. So, the expected corn and soybean output prices were $2.42 and $5.79, respectively. The *ex ante* expected trend yield for Central Illinois producers was 158 bushels per acre for corn and 49.5 bushels per acre for soybeans. Thus, the expected revenue per acre for corn and soybeans were $382.36 and $286.61, respectively. Assuming producers know their production costs at planting time, then the expected cash return is computed as the difference between expected cash revenue and variable cash costs. In 1995, the variable cost of production for corn was $189 per acre, and it was $121 for soybeans. Therefore, the expected cash return was $193.36 and $165.61 per acre for corn and soybeans, respectively. For the purposes of this paper, we define the difference between expected corn and bean cash returns as the relative corn return. In this example, the expected relative corn return equals $27.75 per acre ($193.36-$165.61). The relative corn return is the variable of interest throughout the following study. If the expected relative corn return is greater (less) than zero, then the market is signaling producers to plant corn (soybeans).[4]

The expected relative corn return implied by the futures market is compared to the realized relative return at harvest time. Continuing with the 1995 crop, the Central Illinois harvest prices for corn and soybeans were $3.28 and $6.67, respectively. The actual yields were 128 bushels per acre for corn and 44 bushels per acre for soybeans. Thus, the actual cash returns were $230.84 and $172.48, resulting in an actual or realized relative return to corn of $58.36. So, in this case, the signal provided by the futures market was correct, and producers benefited by $58.36 for each acre planted in corn as opposed to soybeans. Does the futures market

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[4]Clearly, an evaluation of this signal is a joint test of the yield, basis, and price forecasts. Various alternative basis and yield forecasts were utilized, but none of them altered the results.

consistently provide the correct planting signal and thereby meaningful information to the decision-maker?

Method and Results

The following empirical work focuses on the expected and actual cash returns for the average corn and soybean producer in Central Illinois. In particular, the focus is on the market's forecast of relative corn returns and the information that this provides to producers. First, the characteristics and summary statistics of the data are examined.

Summary Statistics

The summary statistics for realized and expected corn and soybean cash returns are presented in Table 1. The average expected cash return for corn is $186.87 per acre and for soybeans $177.79 per acre.[5] A paired t-test fails to reject that these means are equivalent (10% level), i.e., the mean expected relative return to corn is not statistically different from zero. The mean actual returns are slightly lower for both corn and soybeans at $173.79 and $164.52, respectively. Again, a two-tailed paired t-test for a difference in these means fails to reject that they are equivalent; so, the mean actual relative corn return is not statistically different from zero.[6] Both the expected and actual returns are quite volatile year-to-year with roughly $216 separating the best and worst actual returns for corn and $112 for soybeans. Oddly, the expected

[5]Augmented Dickey-Fuller unit root tests for stationarity revealed that only the actual corn returns failed to reject the presence of a unit root at the 10% level. Using the Phillips-Peron test, all the series rejected the presence of a unit root at the 5% level. Hence, it is concluded the return series are stationary.

[6]Paired t-tests were also conducted for the difference between actual and realized returns for both corn and beans. For neither crop was there a statistically significant difference between the expected and actual return.

returns for corn are not materially less volatile than the actual returns, and for soybeans the expected returns are more variable than the actual returns.

Statistical Characteristics of the Forecast

The first test evaluates the new crop futures' forecast in a traditional sense. That is, the futures forecast for excess corn returns is tested for unbiasedness. Following a procedure similar to Zulauf, *et al*., the actual relative returns are regressed on the market's forecast.

$$ACTUAL_t = \alpha_1 + \beta_1 EXPECTED_t + \epsilon_{1t} \tag{1}$$

Where, $ACTUAL_t$ = actual harvest time relative corn returns in year t, and $EXPECTED_t$ = expected relative corn returns in year t. So, the actual relative corn return is regressed against the market's forecast for relative returns. The market's forecast is unbiased if we cannot reject the joint null hypothesis, H_0: α_1=0 and β_1=1, using an F-test.

Estimation of equation (1), and use of misspecification tests indicated some degree of parameter instability and a statistical reduction of the residual variance after 1985. As a result, equation (1) was re-estimated after dividing the data into two periods 1972-1985 and 1986-1996. The separation of the data reflects the periods before and after the introduction of the 1985 farm legislation which marked the beginning of the decline of government intervention in agricultural markets through a reduction in target prices, loan rates, and government stocks (1985 Farm Bill), and later through the introduction of more flexible acreage policies (1990 Farm Bill). The regression results are presented in Table 2, and the underlying data are displayed graphically in Figure 1. The findings are clear, and the differences in the two periods are rather surprising. For the entire data set, the findings show that the forecasts are unbiased but rather poor estimates of subsequent relative returns, suggesting that they provide relatively little information as to the actual relative corn returns.[7] Examination of the results by periods indicates that the overall poor forecast performance is primarily due to the early set of observations. During the first period, although it is not possible to reject the null hypothesis of an unbiased forecaster, the R^2 is practically zero. In contrast, during the second period, the variability in the actual relative returns is rather highly associated with the variability in expected relative returns.

Information Content of the Forecast

Essentially, producers must decide among two alternative investments, corn and soybeans, based primarily on output price forecasts provided by the futures market. Henriksson and Merton (H-M) develop a nonparametric test for evaluating if these type of forecasts provide economically useful information regarding the relative performance of investments. The H-M procedure tests if producers should modify their probability beliefs, and thus production, based on the new crop futures forecasts (Merton). Notably, the test does not require any assumptions about the distribution of returns nor the pricing of risk.

The market signal is defined by the binary variable, SIGNAL = 1 if expected relative corn returns > 0, and = 0 otherwise. This is compared to the realized harvest time returns defined by the binary variable, FINAL = 1 if the actual relative corn returns > 0, and = 0 otherwise. Presumably, if SIGNAL =1, then producers plant corn instead of beans, and if FINAL =1, then this was the correct decision. Conversely, if FINAL = 0, then this was not the

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[7]Equation (1) was also estimated in differences, where, the dependent variable was the year-to-year change in ACTUAL, and the independent variable was the market's expected change ($EXPECTED_t$ - $ACTUAL_{t-1}$). With this specification the R-squared was greater, and we again could not reject that the forecast was unbiased.

correct decision. The H-M test evaluates the statistical significance of this binary signal with Fisher's test for independence in a 2 by 2 contingency table (see Cumby and Modest) or equivalently in the following regression (Breen, Glosten, and Jagannathan).

$$SIGNAL_t = \alpha_2 + \beta_2 FINAL_t + \epsilon_{2t} \tag{2}$$

The null hypothesis that the market signal contains no economic or statistical information, $\beta_2=0$, is tested with a two-tailed t-test. Rejecting the null hypothesis and finding that $\beta_2>0$ suggests that new crop futures provide economically meaningful information to producers concerning the planting of corn versus soybeans.

Following a strategy similar to that used for equation (1), the data were split into two periods, and three equations were estimated, one for the entire data period and one for each of the subperiods. The estimation results are presented in Table 3. Again the results are rather striking. For the entire period, the estimated β_2 is 0.233 which implies that 62% of the market signals are correct where the percent correct equals $(1+\beta_2)/2$ (see Breen, *et al.*). However, this success rate is not statistically significant (p-value = 0.252).[8] For the entire period, the null hypothesis ($\beta_2=0$) cannot be rejected, suggesting that the forecast does not provide statistically significant information to producers. The results again suggest that the ability of the market to correctly identify production and marketing opportunities improved dramatically. During the 1972-1985 period, the market provided little information to producers. During the 1986-1996 period, β_2 was highly significant and 90% of the market signals were correct.

[8]The H-M test was also conducted with a Fisher's exact test and a Logit model. None of these tests rejected the null hypothesis at conventional significance levels.

The forecasting ability also is examined with the regression test proposed by Cumby and Modest (C-M). Unlike the H-M test, C-M test is not independent of the distribution of relative returns. That is, the C-M test is influenced if the market provides the correct planting signal in years when it is especially rewarding to plant a particular crop. The C-M test is conducted by regressing the actual relative corn returns against the binary variable indicating the market's signal to produce corn or beans. As in equation 1, define the variable ACTUAL = realized relative corn returns, and define the variable SIGNAL as in equation (2), then the following model is estimated.

$$ACTUAL_t = \alpha_3 + \beta_3 SIGNAL_t + e_{3t} \tag{3}$$

The C-M test is basically a difference in means test. If $\beta_3 > 0$, then the mean actual relative corn return conditioned on the market signal ($\alpha_3 + \beta_3$) is greater than the unconditional relative return (α_3). The null hypothesis that the signal has no statistical ability to guide resources into the most rewarding endeavor ($\beta_3 = 0$) is tested with a two-tail t-test.

The estimation results for equation (3) using the three different definitions of the data as previously discussed are presented in Table 4. For the entire data set, the mean unconditional relative return to corn is -\$3.62 per acre (α_3) , and the relative return when the market is signaling to plant corn is \$16.51 per acre ($\alpha_3 + \beta_3$). Although, the per acre relative return for corn is greater when the market signals to plant corn versus beans, the difference is not statistically significant (p-value = 0.353). Thus, for the entire data set, the null hypothesis is not rejected, and again it is concluded that the expected relative return does not provide statistically meaningful information in guiding resources into the production of corn versus soybeans.

Dividing the data set, and performing the same analysis again identifies the difficulty the market had in forecasting realized relative returns during the first period, and its improvement during the second period. The first period is associated with an insignificant statistical relationship, and a loss in relative returns per acre when the market is signaling to plant corn. However, during the second period, R^2 increases dramatically, β_3 is statistically significant, and the improvement in relative returns when the market signals to plant corn is $19.20 per acre.

Discussion and Further Analysis

The improvement in the futures market's ability to identify subsequent returns is likely attributable to several factors. First, the relative forecasting ability of the futures market improved marginally during the second period. While the ability of the corn futures market to forecast harvest prices declined modestly in terms of R^2 from 0.262 to 0.254, the ability of the soybean futures market to forecast harvest prices increased in terms of R^2 from 0.164 to 0.24. On a relative basis (i.e., the ratio of corn to soybean prices), the forecast ability of the markets increased substantially with the R^2 increasing from 0.01 to 0.275.[9] It is interesting to note that even with this relatively low level of forecast ability, futures signals identified correct acreage decisions during the second period with a high degree of regularity. Second, during the later period there existed a higher degree of correspondence between the corn and soybean forecast errors of local yield and local basis. Correlation coefficients of the difference between expected and realized corn and soybean yields for the first and second periods were 0.737 and 0.914. Similarly, correlation coefficients for the difference between expected and realized corn and soybean local basis for the first and second periods are 0.606 and 0.787. This higher

[9]Regressions not shown.

correspondence suggests a more concomitant movement of realized returns, increasing the likelihood that an effective relative signal would correspond to the actual situation. Third, national level corn and bean yields and their deviations from expectations were more highly correlated during the second period. The correlation coefficients between the change in corn and bean national yields for the first and second period were 0.782 and 0.969. The correlation coefficients between the deviations from an expected yield for corn and soybeans defined in terms of a combined forecast of last year's yields and a ten-year moving trend forecast also demonstrated a similar pattern, 0.807 and 0.963 for the first and second periods. This higher correspondence suggests a more consistent pattern of futures price changes.

Finally, the relative effect of national inventories may have been more uniform during the second period. Previous research has documented the effect of inventories on the forecast ability of futures markets (Tomek and Gray). Not only do futures markets associated with inventories demonstrate a closer correspondence between prices at planting and harvest because of the supply of storage and arbitrage, but large inventories make price less susceptible to shocks in supply and demand (Tomek). Here, we suggest that the size of inventories and their co-movement also may be affecting the market's response to unexpected supply and demand shocks. During the second period, the level of stocks for both corn and soybean increased, and their relative movement (particularly in terms of stock to end-use ratios) became more similar. Median level of stocks increased during the second period for corn and soybeans by 294 and 110 million bushels. Median values of corn stock to end-use ratio decreased from 21 to 19.6% while the median bean stock to end-use ratio increased from 12.1 to 13.6%. Correlation coefficients between corn and bean stock to end-use ratios for the two periods also demonstrated a more uniformly consistent pattern of relative stock movement during the second period, increasing from 0.199 (not statistically significant at the 25% level) to 0.783. In all likelihood, the higher level of stocks and their more concomitant movement lead to the higher level of relative forecast accuracy and may have resulted in smaller, more corresponding movements in prices to unexpected shocks in supply and demand.

To examine the effect of stocks on unexpected corn and soybean price movements during the two periods in more detail, regressions were specified to explain the percentage error between planting and harvest futures prices for each commodity as a function of the percentage error in estimated production and the percent stock to end-use ratio. Estimated production was specified as the product of USDA planting intentions in March and expected yields defined as a composite forecast with equal weighting of a ten-year moving trend forecast and yields in the previous year. The USDA final output estimate was used as final production. The equations were estimated using a seemingly unrelated framework to account for the potential correlation in the error terms of the two relationships (Table 5). F-tests for structural change between the two periods for both crops lead to a rejection of the null hypothesis of parameter constancy with p-values for the F(3,38) distribution of 0.039 and 0.022 for the corn and bean equations, respectively. The results of the estimation suggest that larger than expected production reduces the forecast error in futures prices. In part, because of lower stock levels, the effect of production errors are larger in soybeans than corn, and larger during the first period. Interestingly, the effect of production errors also appears more similar during the second period, with elasticities of -0.615 for corn and -0.716 for soybeans. The direct effect of the stock to end-use variable also appears to change between the two time periods. During the first period, increasing the stock to end-use ratios reduced the differences between planting and harvest futures prices, with the effect being about twice as large in the soybean market. During the second period, the direct effect of the stock to end-use ratios was relatively small on the difference between the prices in soybeans, and virtually nonexistent for corn. Thus, we find smaller, more uniform price forecast errors in response to errors in expected production when stocks are larger and more similar in their movement.

Summary and Implications

This research strives to evaluate the ability of new crop futures prices to guide resources into the most profitable endeavor. Producer planting flexibility provided by *FAIR* makes the markets' performance in this role increasingly important. The research moves beyond traditional tests of bias and seeks to more fully describe the decision-making value of new crop futures forecasts to agricultural producers.

The presented research examines the market's ability to guide resources into the production of corn versus soybeans for Central Illinois producers. Focusing on relative corn returns, returns to corn minus returns to soybeans, the research leads to the following conclusions. First, the futures market's relative return forecast is confounded by considerable uncertainty in price and yields. Second, the futures market's forecast of the relative corn returns, in general, is an unbiased forecast. Third, the futures market's planting-time forecast of relative corn returns provides little information to Central Illinois producers over the entire 1972-1996 period. A producer following these signals would not have achieved statistically greater returns per acre than a producer not following the signals. Fourth, after 1985, following the implementation of the 1985 farm legislation, the market signals improved. That is, from 1986-

1996, a producer responding to the futures market's signals would have been correct 90% of the time and would have benefitted with higher per acre returns.

The results indicate that in more recent years production signals have become more accurate in terms of net returns. The improvement in the use of the market was influenced by a modest improvement in the forecast ability of futures markets. Perhaps, more importantly, during the second period, forecast errors in local yields, in local basis, and in futures prices of corn and soybeans appear to be more uniform in their movement. These factors suggest a more concomitant movement in realized returns which undoubtedly increased the likelihood that the relative signal would correspond to the actual returns. Because of the importance of local yields and basis fluctuations, the findings suggest that the ability of the futures market to provide appropriate production signals needs to be examined for specific locations and production characteristics. This becomes increasingly important when one considers that soil quality, costs per acre, and the degree of correlation between changes in local yields and prices also may differ substantially across locales. Further, the findings indicate that larger and more uniform movements in relative stocks enhance the predictive ability of these markets. As we move into an era of reduced government participation in agriculture and reduced stocks, monitoring of the relative level of stocks in order to assess the likelihood that expected returns are adequate forecasts of realized returns will become increasingly important. Finally, with the reduction of loan rates in the 1985 legislation, government inventories have declined over time, especially relative to total inventories, and the private sector has assumed a larger responsibility for managing stocks. It appears that in recent years private stock managers and the market in general have performed reasonably well at providing planting signals to Central Illinois corn and soybean producers. In a future environment of possible increased yield and price uncertainty and an enhanced flexibility of producers to allocate their resources under the *FAIR* program, it will be interesting to see if the market continues its recent performance of providing adequate planting signals to producers.

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Table 1. Summary Statistics for Expected and Actual Cash Returns

	Corn		Soybeans	
	Expected	Actual	Expected	Actual
Mean*	186.87	173.79	177.79	164.52
Maximum	297.40	282.10	242.58	225.40
Minimum	75.80	66.54	86.13	113.30
Std. Deviation	51.26	54.42	37.94	30.13

*All numbers are in dollars per acre. Cash returns are calculated as cash revenue per acre less variable cash costs.

Table 2. Test for Bias

$$ACTUAL_t = \alpha_1 + \beta_1 EXPECTED_t + \epsilon_{1t}$$

	Coefficients			
Sample	α_1	β_1	R^2	F-stat.
1972-1996	4.9025 (0.478)*	0.4803 (1.581)	0.098	1.4635** (0.252)
1972-1985	21.0320 (1.085)	-0.1133 (-0.201)	0.003	1.9513 (0.185)
1986-1996	-0.0598 (-0.009)	0.9376 (4.736)	0.714	0.0498 (0.952)

*T-statistics in parenthesis.
**The F-statistic tests the joint null that α_1=0 and β_1=1. The p-value is in parenthesis.

Table 3. Henriksson-Merton Test

$$SIGNAL_t = \alpha_2 + \beta_2 FINAL_t + \epsilon_{2t}$$

Sample	Coefficients α_2	β_2	R^2
1972-1996	0.5000 (3.253)*	0.2333 (1.176)	0.057
1972-1985	0.8000 (3.564)	-0.2444 (-0.873)	0.059
1986-1996	0.2000 (1.500)	0.8000 (4.431)	0.686

*T-statistics in parenthesis.

Table 4. The Cumby-Modest Test

$$ACTUAL_t = \alpha_3 + \beta_3 SIGNAL_t + e_{3t}$$

Sample	Coefficients α_3	β_3	R^2
1972-1996	-3.6233 (-0.213)*	20.1333 (0.948)	0.038
1972-1985	27.0040 (0.996)	-12.5851 (-0.372)	0.011
1986-1996	-41.9075 (-3.556)	61.1061 (4.136)	0.665

*T-statistics in parenthesis.

Table 5. Seemingly Unrelated Regressions of Percentage Error between Planting and Harvest Futures Prices

	1972-1996	1972-1985	1986-1996
Corn			
Constant	-.058 (-1.26)*	.029 (0.26)	-.115 (-2.61)
% Production Error	-.807 (-5.27)	-1.018 (-4.13)	-.615 (-4.50)
Stock to end-use	-.210 (-1.39)	-.651 (-1.94)	.013 (0.10)
R^2	.508	.566	.690
Soybean			
Constant	.015 (0.23)	.132 (1.26)	-.123 (-1.94)
% Production Error	-1.055 (-5.40)	-1.322 (-4.71)	-.716 (-3.78)
Stock to end-use	-.215 (-0.48)	-1.051 (-1.31)	.542 (1.39)
R^2	.528	.616	.611
System R^2	.642	.699	.743

*T-statistics in parentheses.

Figure 1. Actual vs. Expected Relative Corn Returns
1972-1996, Crop Years