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Practitioner's Abstract

Using 1971-2000 data, we examine the accuracy of corn and soybean production forecasts provided by the USDA and two private services. All agencies improved their forecasts as the harvest progressed, and forecast errors across the agencies were highly correlated. Relative accuracy varied by crop and month. In corn, USDA's forecasts ranked as most accurate in all periods except in August during recent times, and improved more markedly as harvest progressed. In soybeans, forecast errors were very similar with the private agencies ranking as most accurate in August and September and making largest relative improvements in August during recent times. The USDA provided the most accurate October and November forecasts.

***Key Words**: corn, soybean, production forecasts, USDA, private services*

Introduction

In industrial production, final output is known with a high degree of certainty when inputs are employed. However, agricultural crop production is characterized by great variability in output corresponding to the employed input factors. The variability often is associated with changes in the stochastic factors affecting agricultural production (e.g., precipitation, temperature), and can make the forecasting of crop production a challenge. Uncertainty about final crop production is resolved only as the growing season progresses and more information about crop conditions and crop yields becomes available. Crop reports that accurately estimate the size of production before harvest therefore can play an important role in the process of uncertainty resolution.

For corn and soybeans, crop forecasts are provided by the National Agricultural Statistics Service (NASS) of the U.S. Department of Agriculture (USDA) as well as by private information services or agencies. Researchers that have investigated the accuracy of these predictions most frequently have either focused on evaluating the individual accuracy of USDA forecasts (Clough, 1951; Gunnelson et al., 1972) or, more recently, on indirectly analyzing the relative forecast accuracy of public and private agencies by measuring the reactions of corn and soybean cash and futures prices to the release of the respective reports (Milonas, 1987; Sumner and Mueller, 1989; French et al, 1989; Fortenberry and Sumner, 1993; McNew and Espinosa, 1994, Garcia et al., 1997). Results from this research suggest that USDA forecasts improve in successive months during the crop year, and over time up to 1970. It also appears that USDA and private information services are providing rather similar information, particularly in more recent periods.

Here, we re-evaluate the relative accuracy of corn and soybean production forecasts provided by the USDA and two private services. Our re-evaluation differs from recent research in several important dimensions. First, instead of focusing on an indirect assessment of differences in forecast accuracy by examining price reaction, we evaluate the performance of crop forecasts directly. The direct method of examining differences in crop forecast performance reduces the likelihood that findings may be influenced by noisy movements in price, a problem that emerges particularly in research that examines the effect on prices of differences between USDA and private crop forecasts. Commonly, only a small portion of realized price change is associated with the differences in forecasts, underscoring the large number of factors that can influence price, and the difficulty in drawing inferences about the accuracy of crop forecasts using this method. A direct approach also is well suited for identifying the suspected underlying dynamic changes in forecast performance. Second, we examine differences in forecast performance by individual private services as opposed to an average of the private forecasts. This is important because accuracy of the private services may change through time, and an assessment of their relative performance may make users more aware of their attractiveness. Further, the USDA and private information services examined in this study use very different methods of collecting and interpreting information. The USDA provides a highly systematic method of determining plantings and yields, while the other services use less rigorous sampling procedures. To date, little research has focused on the difference in these procedures and their effect on forecast performance. Hence, our analysis sheds light on the relative merits of the procedures used to develop crop production forecasts. Finally, an extended and updated data set containing 30 years of observations is available, allowing for a more detailed analysis, the use of relatively powerful statistical procedures, and permitting an assessment of whether previously identified patterns in crop production forecasts have continued.

Literature Review

Previous studies that analyze the accuracy and value of production forecasts for corn and soybeans most frequently either evaluate the accuracy solely of USDA crop reports or infer the relative forecast performance of the USDA and other agencies from the reports' impacts on the mean and variance of commodity cash and futures prices[1]. Clough (1951) evaluated corn forecasts by the Department of Agriculture for the period 1919-1950. He found that the uncertainty was reduced as crop size was re-assessed each month. While there were substantial decreases in uncertainty by the August and September reports, the October and November revisions were fairly close to the December "final" estimates. The data used in his study did not indicate a trend in changing forecast accuracy over the time period analyzed. Gunnelson et al. (1972) evaluated the accuracy of USDA crop production forecasts for seven row crops, including corn and soybeans, for the period 1929-1970. Over the time period analyzed, they found that the accuracy of USDA crop forecasts increased. The authors also noted that subsequent revisions of initial production forecasts became more accurate as the growing season progressed.

Garcia et al. (1997) compared the accuracy of USDA, Leslie, and Sparks production forecasts for corn and soybeans for the period 1971-1992 and found little differences with the exception of corn, where USDA forecasts appeared to be more accurate during the early stages of the period. They further concluded that the two private information services have improved their relative forecasting accuracy in August over time. However, a detailed analysis of forecast accuracy and its changes over time were not provided.

Based on the notion that efficient markets incorporate new information immediately into prices, other researchers have investigated the informational value of USDA corn and soybean production forecasts by their impact on the mean and variance of cash and futures prices. Milonas (1987) analyzed the impact of the release of USDA corn, wheat, and soybean production forecasts on the cash prices of corn, wheat, soybeans, soybean oil, and soybean meal for the period 1966-1984. He found significant market reactions to the reports and further noted that first crop forecasts produced larger price reactions than subsequent revisions. Sumner and Mueller (1989) investigated the impact of USDA reports for corn and soybeans on futures prices for the period 1961-1982. They found evidence that USDA crop forecasts affect the respective futures prices. French et al. (1989) examined corn and soybean crop reports over 1969-1981, and found that the unanticipated component of USDA forecasts explained a significant amount of the variation in corn and soybean futures prices immediately following release of the reports. Garcia et al. (1997) measured corn and soybean futures price reactions and also concluded that the USDA production forecasts have substantial informational value.

In contrast, Fortenbery and Sumner (1993), who examined the reactions of futures markets to releases of USDA production forecasts for corn and soybeans in three periods (1969-1989; 1969-1982; and 1985-1989), reported finding no evidence of larger than average price movements for the period 1985-1989. The authors concluded that USDA crop forecasts may no longer contain new information. They provided and tested three different hypotheses to explain their findings. First, prices for corn and soybeans were at or near government support levels during the period 1985-1989 and therefore did not react to the release of crop forecasts. Second, a diminishing U.S. share of the world export market may have resulted in a smaller price impact of the release of USDA crop forecasts. However, the authors could statistically support this hypothesis only for soybeans, but not for corn. Third, they proposed that the introduction of options on corn and soybean futures may have provided market participants with different means of adjusting their positions in the futures market and price reactions may therefore no longer be observable in the futures market. Given the brief period 1985-1989, they suggested further research to determine the validity of their proposed explanations and the sensitivity of their results to the data period studied. McNew and Espinosa (1994) obtained results consistent with Fortenbery and Sumner (1993). Focusing on the period 1985-1991, they did not find evidence that USDA corn and soybean production forecasts influence the level of futures prices. The authors argued that despite these findings the USDA corn and soybean production forecasts have economic value because the reports significantly reduce the uncertainty prevailing in the market and thus validate the expectation of the market regarding the crop size.

Data

Crop production forecasts for corn and soybeans provided by the USDA and two private information services, Conrad Leslie and Sparks Companies, Inc., are analyzed for the 30-year period 1971-2000. Production forecasts are provided in August, September, October, and November of each year. The private information agencies make their predictions about crop size available to their customers 5 to 7 days prior to the publication of the USDA report. The USDA releases the "final" crop production estimate in January of the following year after harvest is completed. Following Clough (1951) and Garcia et al. (1997), the January estimates are used for final crop production. Most market participants consider these January estimates as the most relevant and assign little value to census based revisions in later years.

The USDA provided corn and soybean production forecasts in all months during the period evaluated. Leslie did not issue reports in November 1989, August 1990, and November 1992. Sparks did not provide forecasts in November 1972. With the exception of these cases, the resulting data series included 30 observations for each crop, information agency, and month a report was released. Years in which no forecasts were issued were deleted only when direct statistical comparisons among the forecasts required paired observations.

Forecasting Methods

USDA

The USDA uses a highly elaborate and well-documented procedure to generate its crop production forecasts. At different stages of the production process, forecasts of total acres and yields/acre by crop must be developed. For corn and soybeans the USDA generates production forecasts based on estimates of planted acreage, and two types of yield indications, a farmer-reported survey and objective measurements (NASS/SMB Staff Report SMB 98-01, 1998). The planted acreage figures are obtained using a survey of farmers during the first two weeks of June. These acreage estimates are used in subsequent production forecasts unless acreage figures, which are monitored through the growing season, indicate a change.

The farmer-reported yield survey is conducted primarily by Computer Assisted Telephone Interviewing (CATI), but some data are collected by mail and by face-to-face interviews. The farmers are randomly selected from a list frame, and asked monthly for a subjective prediction of their final corn and soybean yields. The list frame is a non-complete set of all corn and soybean farmers. The list changes through time, reflecting farming arrangements. The objective yield survey is based on an area-frame random sampling design, where the survey samples are selected from respondents to the USDA's June Agricultural Survey in the major producing states. The sample fields are then selected with a probability proportional to their size. The objective yields are obtained from two independently located plots in each randomly selected field. Physical counts and measurements of the number of plants and production per plant are conducted. Yields per acre are generated for the field after standardizing for moisture content and harvest loss. Objective yield indications are derived from models based on observations over the last five years for the corresponding months compared with end of season yields. Separate monthly models are constructed by maturity stage so forecast adjustments are automatically made for early or late growing seasons.

It is important to note that accuracy of the objective yields indications can change through the growing season. Early in the season the yield indications are influenced by assumed relationships between plant counts and fruit numbers, and an assumed fruit weight adjusted for moisture content and harvest loss. As the season progresses, fruit counts become known. At the end of the season, plots are harvested, and yields are calculated based on actual grain weights, and harvest losses.

The yield forecasts are developed monthly from August to November. The data on yields are collected during the last week of the previous month and the first few days of the survey month, and hence yield forecasts reflect crop conditions at the beginning of the survey month. The crop production forecasts are based on the assumption of normal growing conditions for the remainder of the season as reflected by historical records.

The subjective and objective yield indications are combined in a multistage process employing statistical and judgmental techniques. This procedure is conducted independently in each state. The state results then are aggregated and adjusted by USDA statisticians to generate national production forecasts.

Conrad Leslie

Conrad Leslie[2] employs a method to generate crop production forecasts that is based completely on a survey conducted by mail. The objective of the survey is not to forecast USDA estimates, but the actual size of the crops. The resulting corn and soybean production reports are obtained based on a statistical model that incorporates at least two components, the yield information from the conducted survey and the USDA acreage estimates. The exact model is confidential.

The yield estimates are “based on 1,250 ‘card’ reports received from elevator managers, processors, grain dealers and milling correspondents – a base which differs from that often used in other estimates” (Leslie-ADM Investor Services, 1999). Most of the respondents, however, are grain elevator managers because “these observers are very sensitive to changing conditions in their operating areas …” (private correspondence with Conrad Leslie, 1999). The questions asked in the survey include: during the growing season, compared to normal, how would you rate the condition of the crop? (The response is in terms of percentage of normal, with normal being defined as no damage from weather, insects, etc.); and near harvest, what do you think the yield is in your reporting district? In predicting corn and soybean production, Leslie further “utilizes the latest available government acreage estimates for harvest” (private correspondence with Conrad Leslie, 1999).

Sparks Companies, Inc.

Sparks Companies, Inc.[3] was formed in 1977 from what was previously Cook Industries, Inc., a grain merchandizing-exporting firm. The company also employs a model that calculates crop production as the product of acreage and yield. Sparks uses the USDA acreage estimates, which they adjust “under specific circumstances”. The yield forecasts are obtained based on three types of information: a yield survey, which is the dominant source; observations in the field; and any other relevant information available.

The yield survey is conducted by mail. The population surveyed consists of individuals with knowledge about agriculture: county extension agents, bankers, farmers, grain elevator managers, and input suppliers. The information about the number of questionnaires distributed is confidential, but the response rate is above 50%. Using these subjective assessments of yields, the U.S. yield forecasts are generated based on the area-specific yield responses weighted by crop reporting district acreage.

In the largest crop growing states, data from field observations also are collected by "crop scouts" according to a pre-determined sampling plan. The plan involves driving through an area, stopping at fixed distance intervals, assessing the field, and conducting physical counts. No particular farms are surveyed. An objective yield is calculated based on these field observations.

Sparks also uses any other relevant information that is available and believed to be reliable. This information may involve subjective opinions from professional and non-professional contacts, such as USDA weekly crop condition reports. The survey yields and the objective yield as well as the other information obtained are then combined in a very "flexible model" that generates the final crop production forecasts.

Empirical Methods

Four measures of accuracy are employed to evaluate the forecasts provided by the three reporting agencies. Two measures are defined using percent forecast errors, $p_{t,i} = \frac{A_t - F_{t,i}}{A_t}$, and two using absolute forecast errors, $e_{t,i} = A_t - F_{t,i}$, where A_t denotes the actual crop production defined as the January USDA estimate and $F_{t,i}$ denotes the forecast in year t and month i. The following accuracy measures are computed for each commodity and forecasting service.

Mean absolute percentage error: $MAPE = \frac{1}{T}\sum_{t=1}^{T} | p_{t,i} |$

Root mean squared percentage error: $RMSPE = \sqrt{\frac{1}{T}\sum_{t=1}^{T} p_{t,i}^2}$

Mean absolute error: $MAE = \frac{1}{T}\sum_{t=1}^{T} | e_{t,i} |$

Root mean squared error: $RMSE = \sqrt{\frac{1}{T}\sum_{t=1}^{T} e_{t,i}^2}$

The differences in the accuracy measures between the forecasts from the three agencies are evaluated using the Modified Diebold Mariano (MDM) test proposed by Harvey et al. (1997). The procedure involves specifying a cost-of-error function, g(e), of the forecast errors e and testing pair-wise the null hypothesis of equality of expected forecast performance for the services. The test statistic, which Harvey et al. indicate should be compared with the critical values from the Student's *t* distribution with (T – 1) degrees of freedom, is computed for one-step ahead forecasts as

$$MDM = \sqrt{\frac{T-1}{\frac{1}{T}\sum_{t=1}^{T}\left(d_t - \bar{d}\right)^2}}\,\bar{d} \ ,$$

where $d_t = g(e_{t,i,1}) - g(e_{t,i,2})$, $\bar{d}$ is the average difference for the period, and the null hypothesis is $E(d_t) = 0$. For example, when testing for significant differences of the MAPEs of two forecast agencies, $g(e_{t,i,1}) = p_{t,i,1}$ is the absolute percent forecast error of agency 1, $g(e_{t,i,2}) = p_{t,i,2}$ is the absolute percent forecast error of agency 2, and $d_t = p_{t,i,1} - p_{t,i,2}$ is the difference between the respective absolute percent forecast errors at time t.

Harvey et al. (1997) demonstrate that the size of the *MDM* test is quite similar to the nominal significance levels for the number of forecasts used in our analysis, a finding that is insensitive to the degree of contemporaneous correlation between forecast errors, and departures from normality. They argue that these characteristics of the test are important as researchers attempting to differentiate between forecasts are often faced with a limited number of correlated forecasts that possess occasional very large errors. Further, for the degree of contemporaneous correlation in forecast errors in our sample, the power of the test is rather substantial and declines only marginally with departures from normality (Harvey et al., 1998). Harvey et al. (1997) identify other advantages of the *MDM* test, including: its applicability to multiple-step ahead forecast horizons, its non-reliance on an assumption of forecast unbiasedness, and its applicability to cost-of-error functions other than the conventional quadratic loss. They conclude by asserting that the *MDM* test constitutes the "best available" method for determining the significance of observed differences in competing forecasts.

To examine how forecast behavior has changed through time in more detail, the individual forecast accuracy measures also are aggregated on a cumulative and a rolling basis and are graphed. The cumulative measures are obtained by successively adding each year to the previous set of observations. Hence, the effect of any one year on the cumulative measure declines as the number of observations increase. The cumulative measure will smooth graphs and provide an overall indication of directional changes in forecast accuracy. The rolling measures are computed as 5-year moving averages of the respective accuracy measures. The rolling measures display larger variability than the cumulative measures and are sensitive to poor predictions in a single year. The cumulative measures provide a description of overall patterns in forecast accuracy, while the rolling measures provide substantial information on more short-run changes in forecast behavior.

Results and Discussion

The first section compares the forecast errors of the crop estimates released in August, September, October, and November for each crop separately, between both crops, and between the earlier and later periods, independent of which agency has generated the forecasts. This evaluation will permit identifying possible common patterns underlying the crop forecast errors. The next section focuses on evaluating the relative performance of the individual forecasting agencies.

General Patterns in Crop Forecasts

The measures for evaluating the forecast accuracy of corn and soybean production estimates by USDA, Leslie, and Sparks, are presented in Tables 1 and 2. The measures are calculated for the entire period 1971-2000, and for the subperiods 1971-1984 and 1985-2000. The length of the two subperiods was chosen based on earlier research by Fortenbery and Sumner (1993) who found that corn and soybean futures did not react to the release of USDA crop production reports after 1984, and by Garcia et al. (1997) who, testing this hypothesis, also found a decline in the reaction of corn and soybean futures prices to the release of the USDA crop report starting in the years surrounding 1984.

Within each crop, the changes in prediction errors in successive months (August, September, October, and November) reflect the resolution of the crop uncertainty. In general, the error measures decline in successive months for both commodities and periods. This result is not surprising, as uncertainty about future crop production is resolved as the harvest progresses, and is consistent with earlier findings by Gunnelson et al. (1972) and Sumner and Mueller (1989) who note that production forecasts become more accurate in later months.

Between the two crops, forecast accuracy is best evaluated using the percentage-based error measures, because the sizes of the corn and soybean crops are significantly different. With the exception of the September USDA forecast during 1985-2000, the percentage forecast errors for corn tend to be larger than for soybeans in August, September, and October, independent of the period analyzed. The pattern becomes less pronounced in November.

Between the two periods, it is difficult to determine an overall pattern of changing forecast accuracy. August MAPEs and RMSPEs for corn and soybeans are smaller during the second period, with the largest declines registered in corn. November corn also registered slightly smaller MAPEs during the second period. In contrast, during the second period the errors in the September and October corn forecasts are larger than those for the early period for all agencies with the exception of Sparks' October MAPE. The findings for the other months for soybeans also are mixed, with some agencies improving their forecasts in specific months, but declining in others. These findings may reflect the high degree of variability in crop production over the entire period.

For both crops, the errors in the production forecasts provided by the three agencies are highly correlated. As an example, the correlation coefficients for the August corn and soybean forecasts are displayed in Table 3. In light of the similar magnitude of the forecasts errors for many periods (Table 1 and 2), this result suggests that the forecasting agencies either all overpredict or underpredict by a similar amount. One explanation for such a strong relationship is that Leslie, and Sparks rely heavily on the USDA acreage numbers in generating their crop production forecasts, so that the differences between the crop production forecasts result primarily from differences in forecasted yields.

Relative crop forecast performance

In the following section, forecast rankings and statistical findings are complemented by cumulative and rolling accuracy measures to identify structural breaks in accuracy and to refine the evaluation. The cumulative measures will incorporate changes more slowly, while the rolling measures react immediately to changes in forecast accuracy. The discussion centers on the MAPEs as the measure for forecast accuracy. The results using the other error measures yield similar results and lead to comparable conclusions.

The *MDM* test was employed to explore the statistical significance of the forecasts provided by the reporting agencies within the two subperiods, 1971-1984 and 1984-2000. Because of the limited number of observations, in addition to the statistical tests which can have limited power, we examine the patterns in forecast accuracy as differences may have economic significance.

Corn

The forecast performance of the agencies varied by month (Table 1). In August, USDA's MAPE for the entire sample period is smaller than that of either private agency. During the early period, the USDA provided the most accurate forecasts with a mean absolute percentage error (MAPE) of 5.33%, followed by Leslie and Sparks with MAPEs of 6.14% and 6.94%, respectively. In this early period, the MAPEs were found to be significantly different between Sparks and Leslie ($p = 0.036$) and between Sparks and the USDA ($p = 0.010$), reflecting the lower accuracy of the earlier Sparks' corn estimates. In the later period, the USDA improved its accuracy, reducing its MAPE by 0.27 percentage points while Leslie reduced its MAPE by 1.21 percentage points. Sparks displayed the largest increase in accuracy, reducing its MAPE by 2.33 percentage points, and surpassing both Leslie and the USDA in predictive accuracy. During the later period, no statistically significant differences among the services were encountered, underscoring the improvement in forecast accuracy of Sparks relative to Leslie and the USDA.

As reflected in the cumulative and rolling accuracy measures, Sparks' improvement occurred during two major periods. Starting in 1983 to 1991, Sparks improved relative to Leslie as its cumulative MAPE declined relative to Leslie's (Figure 1a). By 1991, the difference between Sparks' and Leslie's cumulative MAPEs had become almost zero. The relative improvement is also reflected in the rolling MAPEs (Figure 1b) where Sparks' declined at a faster rate than Leslie's MAPE. Hence, 1983-1991 was a period of improved forecasts by the private agencies, and a time of increasing correspondence in their forecast errors. Beginning in 1992, the differences between the cumulative MAPEs of the private agencies and the USDA decrease, while the differences in the cumulative MAPEs of the private agencies remained close to zero (Figure 1a). This relationship is also displayed in Figure 1b, which shows that the private forecasts have improved relative to the USDA and are now marginally more accurate. The past decade marks the improvement in the accuracy of the private services' August forecasts relative to the USDA.

In September, the USDA's MAPE for the entire sample, and for the individual periods are only marginally smaller than that of Leslie (Table 1), with Sparks possessing the largest MAPEs a result of a few poor forecasts in the early 1980's (Figures 2a and 2b). Each agency's forecast accuracy decreased from the early to the later period, however, the improvements in the MAPEs were very small. Figure 2b also shows that after 1990, there are essentially no differences in corn forecasts. These findings suggest that the three agencies provide about equally accurate forecasts in both subperiods. The statistical analysis, yielding no significant differences between the three agencies during the two subperiods, confirms this conclusion.

The USDA forecast accuracy dominates the private agencies in October and November, particularly after 1990. The USDA had the lowest MAPE followed by Leslie and Sparks over the entire period with no change in the ordering in the separate periods (Table 1). During the early and the later periods, Sparks and the USDA forecasts differ in October ($p = 0.003$ and 0.027, respectively) and in November ($p = 0.001$ and 0.035, respectively). Sparks and Leslie also differ in October ($p = 0.013$) and in November ($p = 0.006$) during the early period, but not during the later period. These findings indicate an improvement of Sparks relative to Leslie in October (Figures 3a and 3b) and an improvement of Leslie relative to Sparks in November (Figures 4a and 4b). Further, in October and November Leslie also differed from the USDA in the later period ($p = 0.009$ and $p = 0.083$), but not in the early period, indicating an improvement of the USDA relative to Leslie.

Overall, the USDA's forecasts rank as most accurate in September, October, and November, and August of the early period, followed by Leslie and Sparks. However, in August during the later period, the private forecasting agencies, particularly Sparks, have improved their forecast accuracy and appear to provide marginally superior predictions of final corn production. In September, while the USDA ranks as the most accurate forecaster, there are virtually no differences in the magnitude of the forecast errors, particularly in recent years. The USDA forecasts dominate in October and November. It appears that with successive monthly forecast the USDA becomes relatively more accurate than the private agencies, particularly during the past decade.

Soybeans

The results for soybeans differ to some extent from those for corn, but there are also important similarities. The rankings of the agencies according to forecast accuracy change across months and subperiods due to the small differences among the individual forecasts in each year, and are reflected in the small differences in the calculated MAPEs. For example, for the entire period, the minimum and maximum differences in MAPE between the most accurate and least accurate forecast for each month were 0.29

percentage points between USDA and Leslie in August, and 0.63 percentage points between Leslie and Sparks in September. Consequently, none of the forecast error measures for the agencies were significantly different during any period in the analysis. Despite the small magnitude of the differences in the MAPEs, several patterns emerge.

During the early period, the USDA's August forecasts displayed marginally smaller MAPEs than those of either Leslie or Sparks (Table 2). Hence, the USDA provided the most accurate forecasts in August during 1971-1984. Over the later period, the forecast errors of all agencies decreased further. The private agencies were able to achieve the largest improvement in accuracy with Leslie improving its MAPE by 1.07 percentage points and providing the most accurate forecasts, and with Sparks improving its MAPE by 0.84 percentage points making its estimates more accurate than the USDA's. Similar to corn, both private agencies provided moderately more accurate forecasts than the USDA during 1985-2000. The cumulative and rolling accuracy measures also demonstrate this development (Figures 1c and 1d).

In September, Leslie recorded the smallest MAPEs followed by the USDA and Sparks and independent of the time period analyzed. In contrast to corn where the USDA provided the best September forecasts, Leslie as private agency consistently provided the most accurate forecasts for soybeans. In October and November, as harvest progresses, the USDA begins to dominate the forecasts, a pattern also reflected in corn. In October, the USDA improved forecast accuracy most dramatically by reducing its MAPE 0.66 percentage points from the early to the later subperiod. In November, all three agencies improved the forecast accuracy, with the USDA providing the most accurate forecasts independent of the period analyzed.[4] On balance, the forecast accuracy tended to improve through time for all agencies, with Leslie and the USDA generally providing the most accurate forecasts. Similar to corn, the USDA's accuracy in August during the later period declines relative to the other agencies.

Summary and Discussion

The accuracy of corn and soybean production forecasts was evaluated for Leslie, Sparks and the USDA. In general, percentage forecast errors are larger for corn than for soybeans, and forecast accuracy improves in successive months of the crop year as the uncertainty over the size of the harvest is resolved. Forecast errors are highly correlated across the three agencies, and in conjunction with similar absolute errors, this indicates that the agencies over- and under-predict production by about the same amount.

Our findings also indicate that forecast errors have not been declining monotonically over time. There has been an improvement over time across the three agencies in forecasting production of corn and soybeans in August, and in forecasting corn production in November. However, September production forecasts for corn and soybeans have declined in accuracy across the three agencies, while the forecasts for other months have demonstrated more mixed results. The decline in September production forecast accuracy across agencies and crops, as further evidenced in the rolling forecasts centered around 1995, suggests the presence of related-weather phenomena that affected all production forecasts simultaneously.

Direct comparisons of the relative forecast accuracy of the three agencies indicated that performance varied by crop and month. In corn, USDA forecasts ranked as the most accurate during all periods except in August from 1985-2000. Here, both Sparks and Leslie have improved during the later period and have marginally surpassed the accuracy of the USDA production forecasts. In September, USDA forecasts were marginally more accurate, while in October and November the USDA forecasts dominated, although the percent absolute error for all the agencies was relatively small. With the exception of the August forecast during the later period, Leslie provided more accurate forecasts than Sparks. In soybeans, the differences in forecast accuracy were rather small, but patterns did emerge. In August, all agencies improved their forecast accuracy from the early to the later period. Similar to corn, USDA forecasts ranked first in the early period, with the private agencies offering marginally better forecasts in the later period. The USDA soybean forecasts improve in successive months relative to the private agencies and were most accurate in October and November. With the exception of the November forecasts in the later period, Leslie provided more accurate forecasts than Sparks. While many of the differences in forecasts discussed above were not large in magnitude, patterns exist which could result in economically more meaningful decisions particularly during periods of reduced inventories.

With regards to convergence of the agencies' forecasts, the most evidence is found in August for corn and soybeans. August forecasts, which are arguably the most important for setting the level of crop production, and affect price and marketing decisions most, have been converging for the last ten years. These findings are not entirely consistent with the results of previous studies by Fortenbery and Sumner (1993) and McNew and Espinoza (1994) that found no reaction of futures prices to the release of USDA crop forecasts after 1985, well before the convergence in forecast accuracy. Nevertheless, our results are consistent with the reduced corn price reaction in more recent years identified by Garcia et al (1997).

Confidentiality associated with the methods of generating the private agency predictions makes a complete assessment of the effects of the procedures on their production estimates difficult. Still, several points seem apparent. The similarity in the forecasts across years and their improvement within the year indicate that each agency has identified salient and highly related information affecting final production. Some of the similarity over time may reflect a process where both private agencies use primarily the USDA estimates of acreage in their production calculations. However, forecast improvements within the crop year also indicate that, regardless of the procedure used, as the final yields becomes more precise, the agencies are able to reflect the changes appropriately. Overall, the results suggest that the three agencies are doing a reasonable job of estimating the production prospects in advance of crop maturity.

Yield forecasts, which are the most important source of forecast differences, can be composed of subjective and objective components. When objective and subjective yields are highly consistent and accurate, then yield forecasts will be similar regardless of the source of or weight placed on the individual components. However, as the accuracy of the subjective and objective yield measurements differ, the overall accuracy of the yield forecast will be affected by the magnitude of the difference and the weights placed on the components. Here, the agencies differ in the use of and procedures for developing subjective and objective yield measurements. USDA forecasts are calculated based on a highly systematic subjective survey of producers and a repeated rigorous objective assessment of crop development. Sparks uses a somewhat less rigorous objective assessment procedure, complemented by a subjective survey of a more broadly defined sample of the crop-producing sector. In contrast, Leslie uses only a subjective survey of market participants. In this context, our findings that the private agencies have improved their accuracy in both August corn and soybeans relative to the USDA suggest that during the period of most uncertainty, when the distributions of objective yields are not well established, gains in forecast accuracy may be achieved by subjective sampling of a wider variety of market participants or by discounting the rather diffuse objective yield figures. As harvest develops, and objective yields become relatively more precise, the value of repeated location-specific sampling procedures employed by the USDA that are designed to evaluate this component of overall yields increases.

Another possible explanation for the improved forecast accuracy of the private agencies in August is the introduction of USDA Crop Condition reports in 1984/85. These reports make information that was previously only available to the USDA about the progress of crop development publicly accessible. This information is especially important for the early forecasts as little objective data about the final yields exist and may have assisted the private agencies in refining their accuracy. Further, the relative cost of information technology and computing power has decreased dramatically over the period analyzed. Hence, the resource gap between the USDA and the private agencies has narrowed, allowing the private agencies to include more data and perform more complex analysis. In this context, future technological developments combined with declining costs for information such as satellite images may lead to further improvements in forecast accuracy for all agencies.

From a crop forecast-generating perspective, the improved performance by the private services in August during the most recent years, and the ability of the private services to generate relatively accurate forecasts in soybeans suggest that it might be useful for USDA to investigate expanding the scope of their subjective yield analysis to incorporate more completely a wider range of market and industry participants. Such a strategy, if proved effective, might lead to improved predictions and perhaps eventually to a reduction in resources used to generate the monthly forecasts.

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Endnotes

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[1] A second study by Bailey and Brorsen (1998) examined USDA forecast accuracy of hog and cattle production. Their analysis, which did not make comparisons between private and USDA forecasts, suggested that the USDA forecast accuracy had improved and the forecast error variability declined.

[2] Conrad Leslie now works in a relationship with Archer Daniels Midland, Inc.

[3] The material in this section is based on private communication with Don Frahm of Sparks.

[4] In November, we deleted the Leslie and USDA soybean predictions as Sparks did not issue a forecast. This year was associated with an extremely large percentage error in soybeans experienced by the other agencies and changed the relative rankings. Our other findings were not sensitive to the small number of nonexistent forecasts by the agencies.

Table 1. Accuracy Measures and Rank for Corn Production Forecasts

Date	Period	Agency	MAPE Percent (r)	MAE mil bu (r)	RMSPE Percent (r)	RMSE mil bu (r)
August	1971-2000	USDA	5.19 (1)	356.4 (1)	7.47 (1)	475.2 (2)
		Leslie	5.51 (2)	367.2 (2)	7.92 (2)	472.3 (1)
		Sparks	5.69 (3)	371.7 (3)	8.46 (3)	501.3 (3)
	1971-1984	USDA	5.33 (1)	306.1 (1)	8.22 (1)	426.7 (1)
		Leslie	6.14 (2)	357.6 (2)	9.12 (2)	481.6 (2)
		Sparks	6.94 (3)	402.9 (3)	9.89 (3)	528.3 (3)
	1985-2000	USDA	5.06 (3)	400.3 (3)	6.75 (2)	514.0 (3)
		Leslie	4.93 (2)	376.1 (2)	6.59 (1)	463.5 (1)
		Sparks	4.61 (1)	344.4 (1)	6.98 (3)	476.4 (2)
September	1971-2000	USDA	4.04 (1)	287.2 (2)	5.10 (1)	366.0 (1)
		Leslie	4.10 (2)	284.4 (1)	5.61 (2)	380.1 (2)
		Sparks	4.60 (3)	321.7 (3)	6.00 (3)	408.6 (3)
	1971-1984	USDA	3.68 (1)	224.4 (2)	4.23 (1)	256.0 (1)
		Leslie	3.71 (2)	220.9 (1)	4.70 (2)	269.1 (2)
		Sparks	4.30 (3)	265.4 (3)	5.17 (3)	315.7 (3)
	1985-2000	USDA	4.35 (1)	342.1 (2)	5.76 (1)	440.2 (1)
		Leslie	4.43 (2)	340.0 (1)	6.30 (2)	455.5 (2)
		Sparks	4.87 (3)	370.9 (3)	6.64 (3)	475.2 (3)
October	1971-2000	USDA	2.57 (1)	185.4 (1)	3.43 (1)	245.4 (1)
		Leslie	3.02 (2)	213.0 (2)	3.87 (2)	271.8 (2)
		Sparks	3.36 (3)	235.6 (3)	4.19 (3)	286.2 (3)
	1971-1984	USDA	2.42 (1)	156.6 (1)	2.84 (1)	188.1 (1)
		Leslie	2.80 (2)	174.6 (2)	3.35 (2)	211.7 (2)
		Sparks	3.47 (3)	218.4 (3)	3.85 (3)	241.4 (3)
	1985-2000	USDA	2.70 (1)	209.0 (1)	3.87 (1)	286.3 (1)
		Leslie	3.20 (2)	246.6 (2)	4.27 (2)	315.1 (2)
		Sparks	3.27 (3)	250.8 (3)	4.46 (3)	320.2 (3)
November	1971-2000	USDA	1.24 (1)	86.3 (1)	1.65 (1)	108.6 (1)
		Leslie	1.59 (2)	105.5 (2)	2.22 (2)	137.5 (2)
		Sparks	1.90 (3)	129.8 (3)	2.42 (3)	156.7 (3)
	1971-1984	USDA	1.40 (1)	91.8 (1)	1.66 (1)	111.3 (1)
		Leslie	1.64 (2)	105.1 (2)	1.93 (2)	125.6 (2)
		Sparks	2.19 (3)	140.2 (3)	2.37 (3)	154.2 (3)
	1985-2000	USDA	1.10 (1)	81.5 (1)	1.65 (1)	106.1 (1)
		Leslie	1.53 (2)	105.9 (2)	2.47 (2)	148.5 (2)
		Sparks	1.66 (3)	121.4 (3)	2.46 (3)	158.8 (3)

Note: MAPE, mean absolute percentage error; MAE, mean absolute error; RMSPE, root mean squared percentage error; RMSE, root mean squared error. The figures in parentheses are ranks.

Table 2. Accuracy Measures and Rank for Soybean Production Forecasts

Date	Period	Agency	MAPE Percent (r)	MAE mil bu (r)	RMSPE Percent (r)	RMSE Mil bu (r)
August	1971-2000	USDA	4.93 (3)	96.5 (3)	5.96 (2)	119.7 (2)
		Leslie	4.64 (1)	89.5 (1)	5.69 (1)	110.7 (1)
		Sparks	4.75 (2)	95.4 (2)	6.13 (3)	127.0 (3)
	1971-1984	USDA	5.10 (1)	83.3 (1)	6.41 (1)	105.7 (1)
		Leslie	5.19 (2)	85.0 (2)	6.46 (2)	106.5 (2)
		Sparks	5.20 (3)	88.9 (3)	6.72 (3)	117.2 (3)
	1985-2000	USDA	4.78 (3)	108.1 (3)	5.53 (2)	130.7 (2)
		Leslie	4.12 (1)	93.7 (1)	4.87 (1)	114.5 (1)
		Sparks	4.36 (2)	101.1 (2)	5.56 (3)	135.1 (3)
September	1971-2000	USDA	3.92 (2)	79.4 (2)	4.64 (1)	97.6 (2)
		Leslie	3.49 (1)	67.9 (1)	4.65 (2)	92.8 (1)
		Sparks	4.12 (3)	81.6 (3)	5.15 (3)	103.9 (3)
	1971-1984	USDA	3.37 (2)	57.5 (2)	4.11 (1)	70.9 (2)
		Leslie	3.28 (1)	53.1 (1)	4.38 (2)	67.3 (1)
		Sparks	3.78 (3)	62.1 (3)	5.13 (3)	83.4 (3)
	1985-2000	USDA	4.39 (2)	98.5 (2)	5.06 (2)	116.0 (2)
		Leslie	3.67 (1)	80.8 (1)	4.88 (1)	110.4 (1)
		Sparks	4.41 (3)	98.7 (3)	5.12 (3)	119.0 (3)
October	1971-2000	USDA	2.50 (1)	47.6 (1)	2.95 (1)	56.5 (1)
		Leslie	2.60 (2)	51.8 (2)	3.14 (2)	63.3 (2)
		Sparks	2.94 (3)	57.7 (3)	3.57 (3)	70.8 (3)
	1971-1984	USDA	2.85 (2)	48.9 (2)	3.21 (2)	56.3 (2)
		Leslie	2.39 (1)	41.8 (1)	3.03 (1)	53.5 (1)
		Sparks	3.01 (3)	49.9 (3)	3.69 (3)	62.2 (3)
	1985-2000	USDA	2.19 (1)	46.6 (1)	2.70 (1)	56.7 (1)
		Leslie	2.78 (2)	60.6 (2)	3.23 (2)	70.9 (2)
		Sparks	2.88 (3)	64.6 (3)	3.46 (3)	77.6 (3)
November	1971-2000	USDA	1.33 (1)	24.9 (1)	1.59 (1)	29.3 (1)
		Leslie	1.61 (3)	30.4 (3)	2.02 (3)	37.6 (3)
		Sparks	1.47 (2)	27.5 (2)	1.91 (2)	34.2 (2)
	1971-1984	USDA	1.67 (1)	28.7 (1)	1.92 (1)	32.9 (1)
		Leslie	1.82 (2)	31.8 (3)	2.14 (2)	37.8 (2)
		Sparks	1.86 (3)	30.7 (2)	2.40 (3)	39.3 (3)
	1985-2000	USDA	1.04 (1)	21.9 (1)	1.27 (1)	26.0 (1)
		Leslie	1.42 (3)	29.1 (3)	1.90 (3)	37.5 (3)
		Sparks	1.16 (2)	24.9 (2)	1.39 (2)	29.3 (2)

Note: MAPE, mean absolute percentage error; MAE, mean absolute error; RMSPE, root mean squared percentage error; RMSE, root mean squared error. The figures in parentheses are ranks.

Table 3. Correlations of Relative and Absolute Forecast Errors for the August Corn and Soybean Estimates by USDA, Leslie, and Sparks

		Relative Forecast Errors			**Absolute Forecast Errors**		
		USDA	Leslie	Sparks	USDA	Leslie	Sparks
Corn	USDA	1			1		
	Leslie	0.93	1		0.90	1	
	Sparks	0.96	0.98	1	0.94	0.96	1
Soybeans	USDA	1			1		
	Leslie	0.94	1		0.94	1	
	Sparks	0.94	0.95	1	0.94	0.95	1

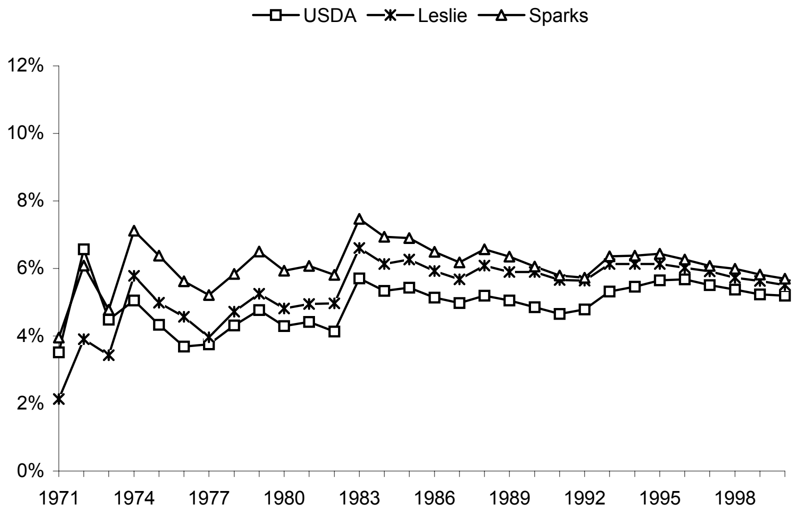

Figure 1a. Corn cumulative MAPEs, August

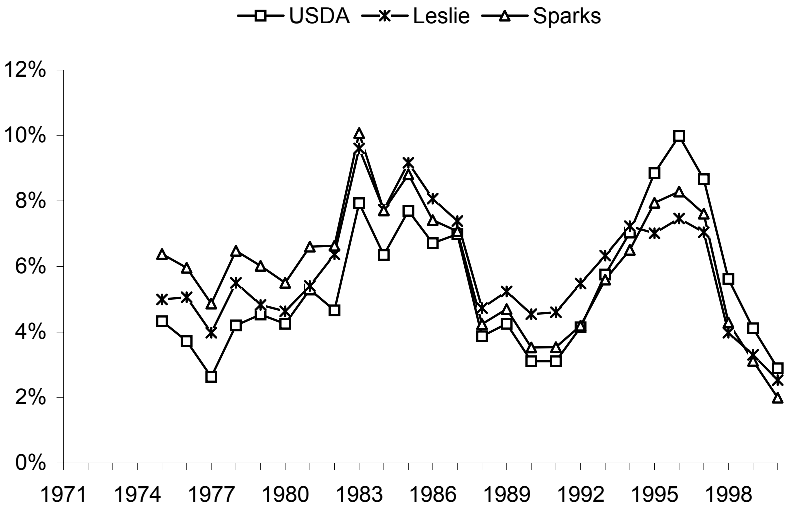

Figure 1b. Corn rolling MAPEs, August

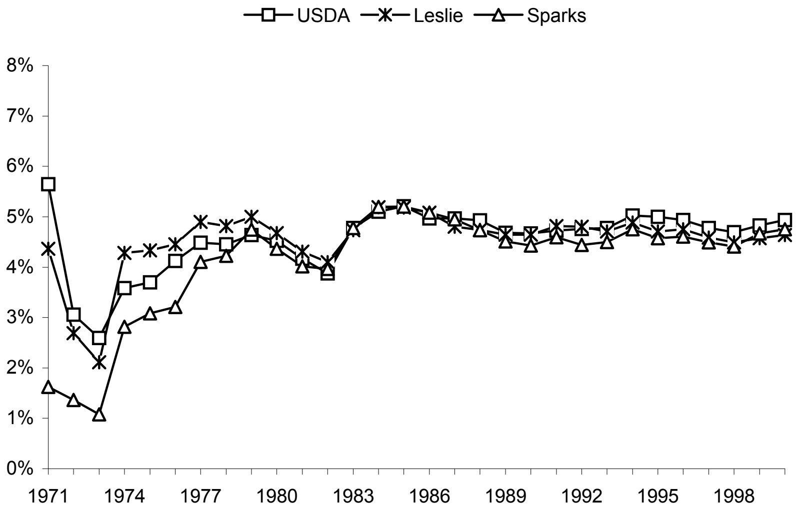

Figure 1c. Soybeans cumulative MAPEs, August

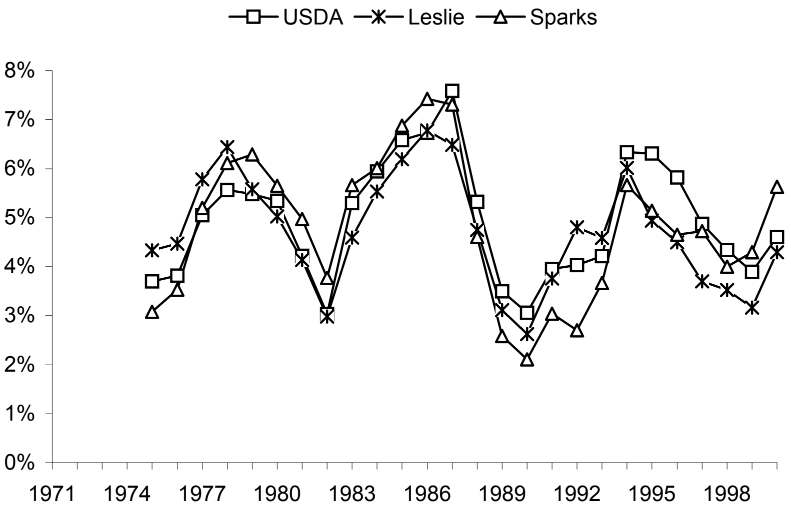

Figure 1d. Soybeans rolling MAPEs, August

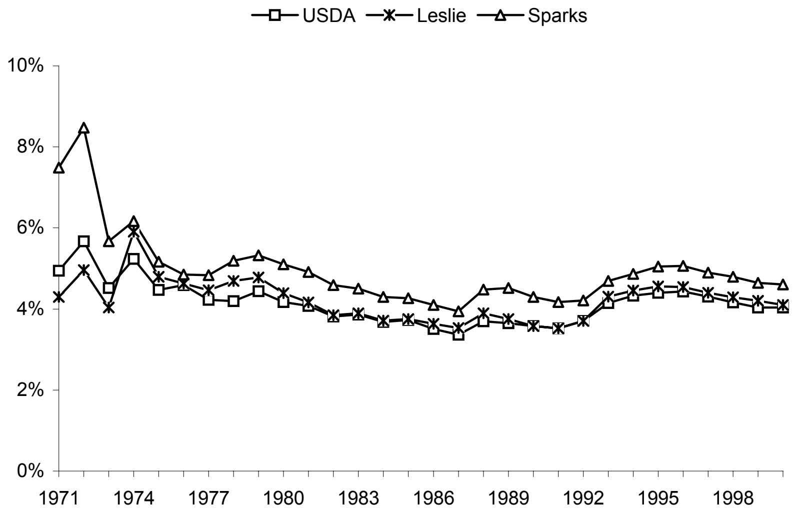

Figure 2a. Corn cumulative MAPEs, September

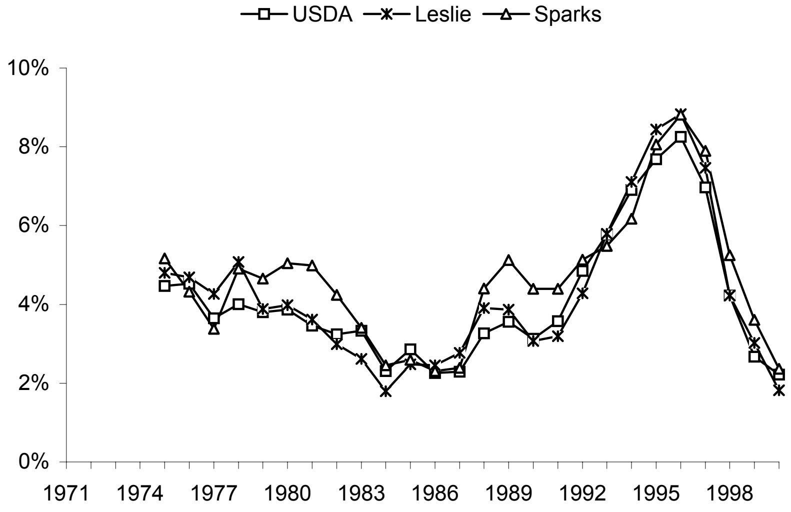

Figure 2b. Corn rolling MAPEs, September

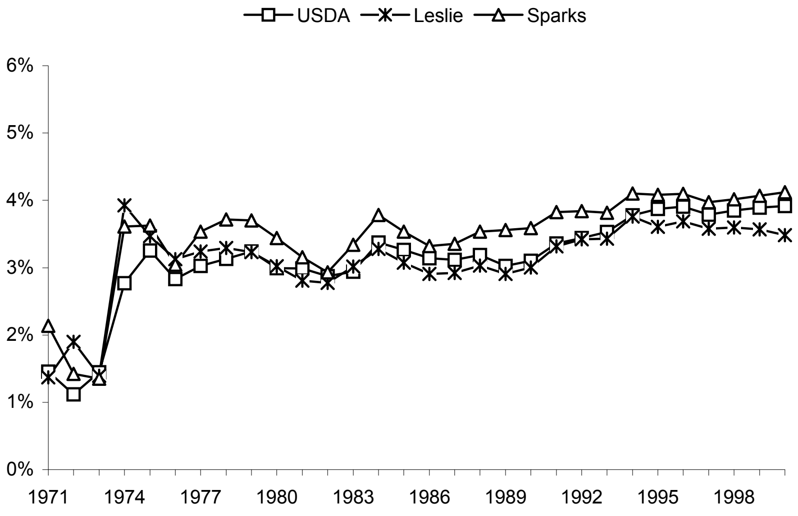

Figure 2c. Soybeans cumulative MAPEs, September

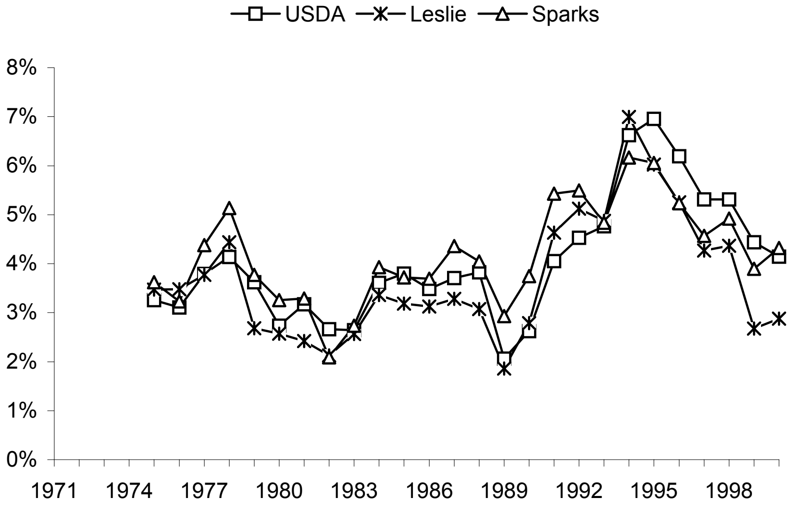

Figure 2d. Soybeans rolling MAPEs, September

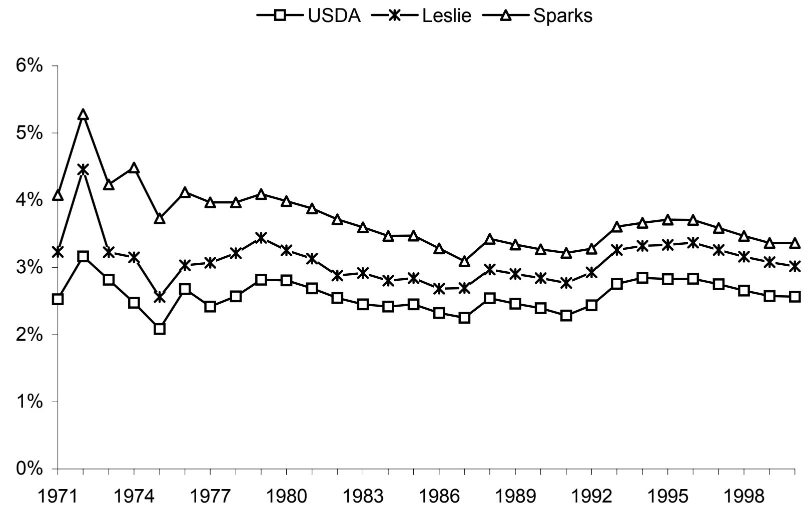

Figure 3a. Corn cumulative MAPEs, October

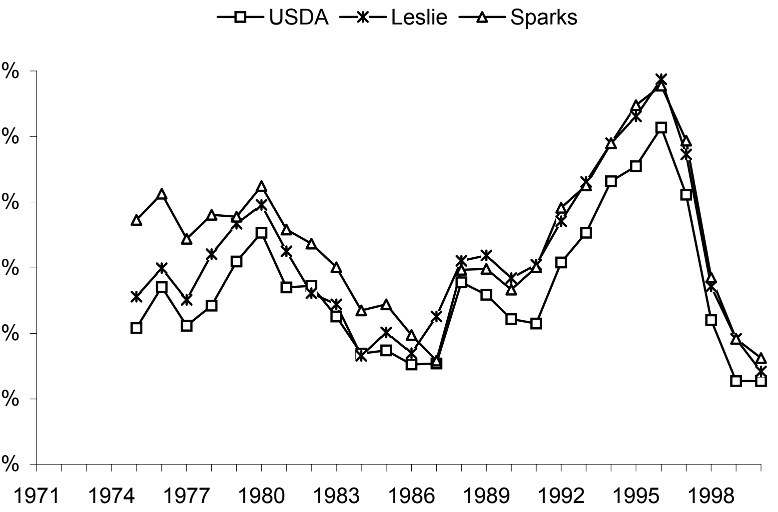

Figure 3b. Corn rolling MAPEs, October

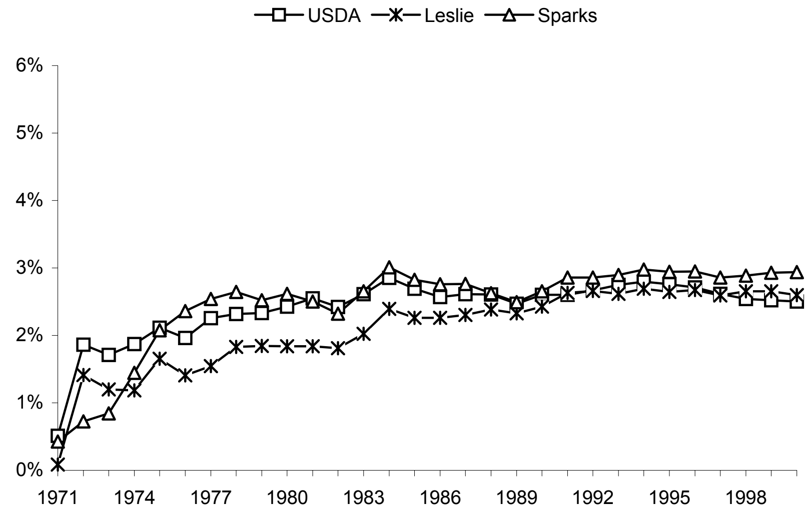

Figure 3c. Soybeans cumulative MAPEs, October

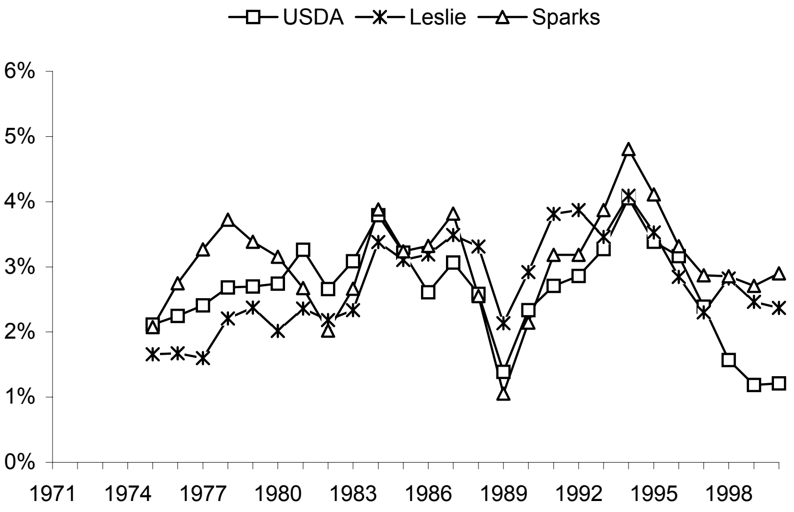

Figure 3d. Soybeans rolling MAPEs, October

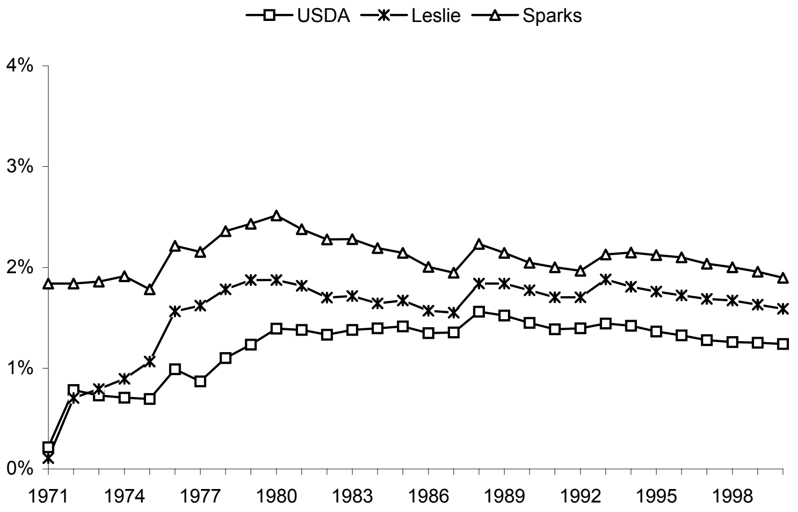

Figure 4a. Corn cumulative MAPEs, November

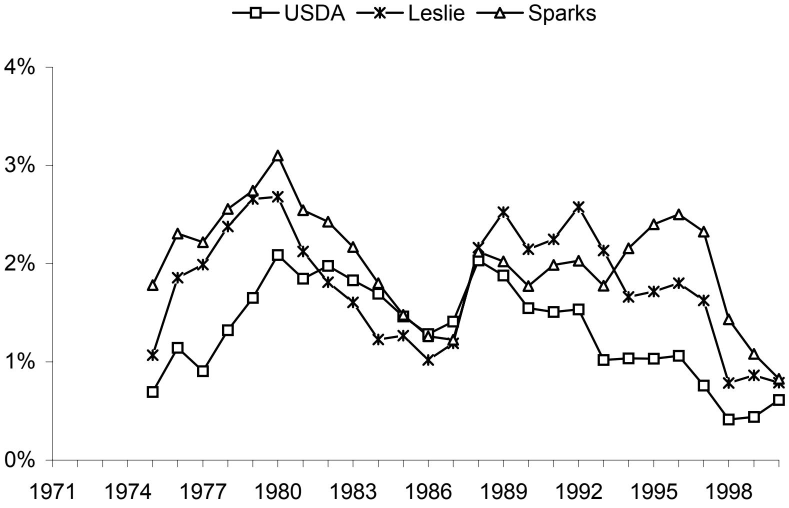

Figure 4b. Corn rolling MAPEs, November

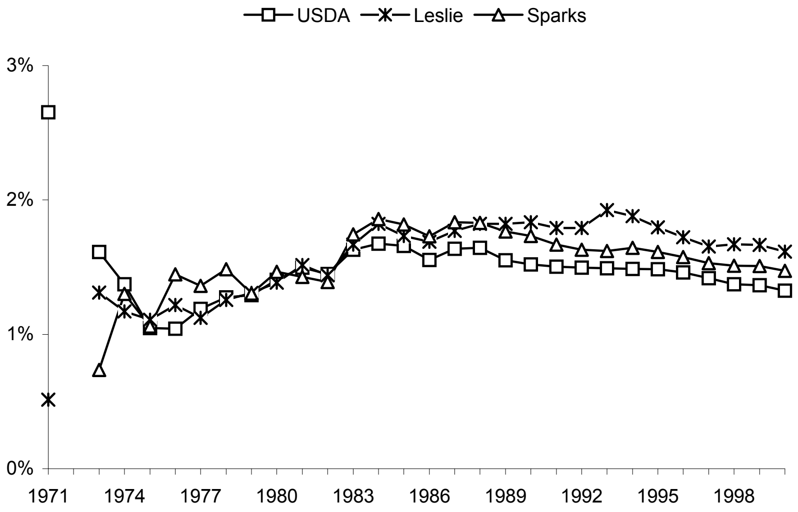

Figure 4c. Soybeans cumulative MAPEs, November

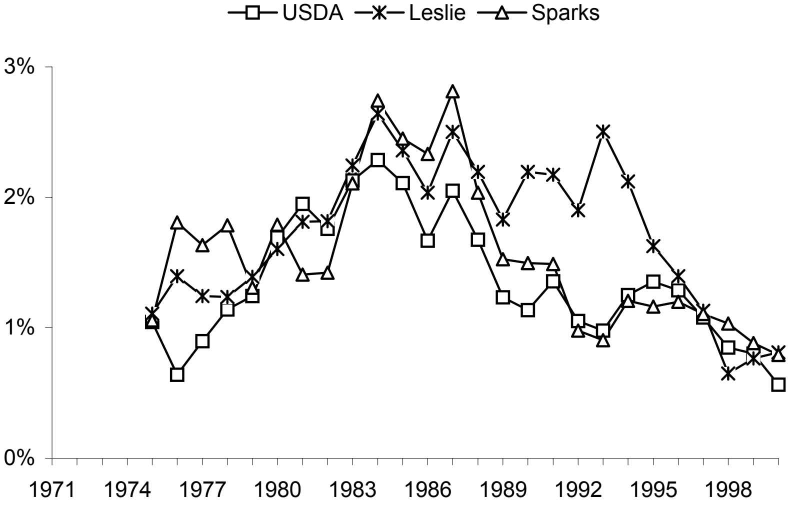

Figure 4d. Soybeans rolling MAPEs, November