Reliability of the fertilizer expenditure forecast by USDA/ERS Farm Income and Wealth Statistics

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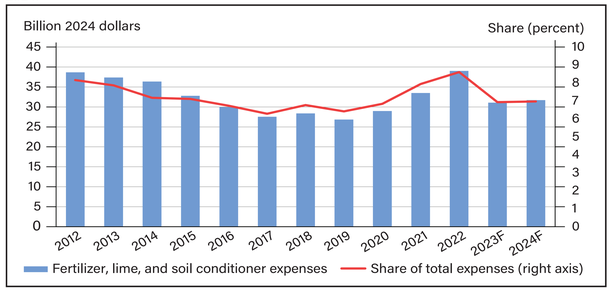
Introduction

Spending on fertilizer, lime, and soil conditioners (FLSC) in the U.S. agricultural sector has been highly volatile. According to USDA, Economic Research Service (ERS) Farm Income and Wealth Statistics, FLSC expenditures decreased 31 percent from $38.7 billion in 2012 to $26.8 billion in 2019. They then increased 45 percent from 2019 to reach a record high $39.0 billion in 2022, in inflation adjusted dollars. Forecasts point to an expected decline in FLSC spending in 2023 and 2024 (figure 1).

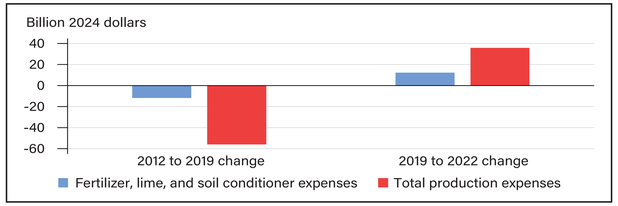
Figure 1
Calendar year estimates and forecasts for fertilizer, lime, and soil conditioner (FLSC) expense, 2012-2024F



Note: F=forecast. Values are adjusted for inflation using the U.S. Bureau of Economic Analysis Gross Domestic Product Price Index (BEA API series code: A191RG) rebased to 2024 by USDA, Economic Research Service.
Source: USDA, Economic Research Service, Farm Income and Wealth Statistics. Data as of February 7, 2024.

FLSC spending is the third largest expense category (in net farm income calculations for the U.S. agricultural sector). Furthermore, the increase in FLSC expenses amounts to 34 percent of the increase in total expenses from 2019 to 2022 (figure 2).

Figure 2
Change in fertilizer, lime, and soil conditioner expenses relative to change in total production expenses



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The volatility of FLSC expenses complicates the forecasting task, and it has implications for the quality of farm income forecasts. USDA releases short-term forecasts and historical estimates of financial indicators (including net farm income and FLSC spending). The forecasts are for the current calendar year. The initial forecast is released in February. Three forecast revisions follow, including revision in February of the following year, when forecasts are published for the previous and current calendar years. The first official estimate is published in August/September of the following year, when more complete data are available (figure 3). The forecasts provide insights to the financial health of the U.S. agricultural sector and are widely used. Evaluating and improving the forecast methods is a part of USDA/ERS data quality standards.

Objectives

We evaluate the method used by USDA/ERS to forecast FLSC expenses. Specifically, we examine the relative contribution of fertilizer price changes and crop acreage changes to changes in fertilizer expense estimates (objective 1) and summarize the historical reliability of FLSC expense forecasts (objective 2).

Methods

Sector FLSC expense forecast in calendar year t, $\boldsymbol{FLSCExpense}_t^F$, is generally based on the latest survey-based FLSC estimate, $\boldsymbol{FLSCExpense}_{t-1}^e$. The estimate is adjusted using proxies for the expected FLSC price change and quantity (based on crop area):

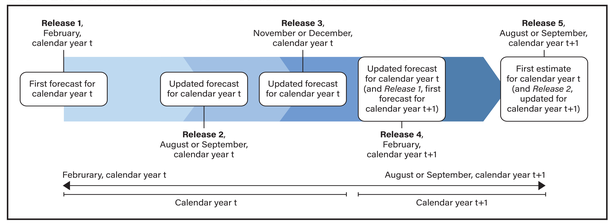
$$\boldsymbol{FLSCExpense}_t^F = \boldsymbol{FLSCExpense}_{t-1}^e \times \frac{\boldsymbol{FertilizerPPI}_t^F}{\boldsymbol{FertilizerPPI}_{t-1}^e} \times \frac{\boldsymbol{CropAcres}_t^F}{\boldsymbol{CropAcres}_{t-1}^F} \quad (1)$$

where $\boldsymbol{FertilizerPPI}$ is the price paid index (PPI) for fertilizer totals. Annual values are calculated as the average of monthly PPI data taken from USDA/NASS (for year t-1).

For forecast year t, all available monthly data are taken from USDA/NASS, and the remaining monthly PPI values are forecasted using the Holt-Winters method (based on all available monthly data starting in 1990).

$\boldsymbol{CropAcres}$ in equation (1) is the acreage for 13 major crops (plus hay), calculated from USDA/NASS data (for year *t-1*) or projected by USDA/ERS commodity analysts (for forecast year *t*).

Figure 3
USDA/ERS Farm Income And Wealth Statistics: Release Schedule



Note: Due to the data collection lag, complete data for the past calendar year are not generally available in February, and therefore, Release 4 is still referred to as a "forecast." Release 5 is the first release referred to as an "estimate" because of its reliance on more complete data, for example, from USDA's National Agricultural Statistics Service surveys and USDA's Agricultural Resource Management Survey.
Source: USDA, Economic Research Service.

Equation (1) implies that the year-to-year change in FLSC expense (in percent) is equal to the sum of percent changes in the price and quantity variables (assuming small changes in all variables):

$$ln\left(\frac{\boldsymbol{FLSCExpense}_t}{\boldsymbol{FLSCExpense}_{t-1}}\right) = \alpha + \beta_1 ln\left(\frac{\boldsymbol{FertilizerPPI}_t}{\boldsymbol{FertilizerPPI}_{t-1}}\right) + \beta_2 ln\left(\frac{\boldsymbol{CropAcre}_t}{\boldsymbol{CropAcre}_{t-1}}\right) \quad (2)$$

For objective 1, we develop a linear regression model (2) using the estimates, $\boldsymbol{FLSCExpense}_t^e$ from USDA/ERS, and USDA/NASS PPI and acreage data (1990-2022), and accounting for the error term's autocorrelation. We then test the hypotheses if α=0, β_1=1, or β_2=1 (using t and F tests). The analysis is completed using proc *autoreg* in SAS.

For objective 2, the reliability of the FLSC expense forecast is measured as the deviations of the forecasts from the first official estimate in release 5 (in percent and absolute percent):

$$\boldsymbol{PDiv}_{tk} = \frac{\boldsymbol{FLSCExpense}_t^{F,k} - \boldsymbol{FLSCExpense}_t^{e,5}}{\boldsymbol{FLSCExpense}_t^{e,5}} \quad (3)$$

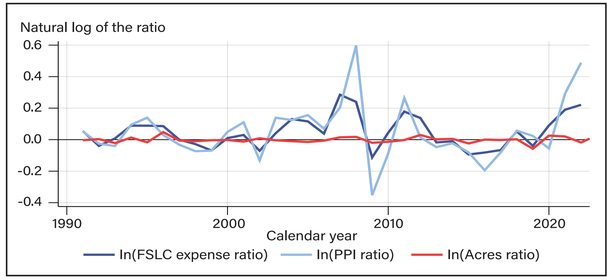
$$\boldsymbol{APDiv}_{tk} = |\boldsymbol{PDiv}_{tk}| \quad (4)$$

Where *k* refers to the forecast release (1-4). Descriptive statistics are calculated for 2014-2022 based on the publicly available data for historical USDA/ERS forecast releases.

Results

Figure 4 shows the value of the dependent and independent variables used in regression model (2) (objective 1). While the crop acreage changes little from year to year, changes in fertilizer PPI and FLSC expenses are more sizeable, especially in 2008-2009 and 2020-2022.

Figure 4
Variables used in regression model



Source: developed by the authors using data from USDA/ERS Farm Income and Wealth Statistics, and USDA/NASS.

Regression analysis is summarized in Table 1:

- Estimated model explains approximately 78 percent of the variation in the dependent variable (R-squared);
- H0: α=0 was rejected (see t-test in Table 1);
- H0: β1=1 was rejected (F value = 124.80);
- H0: β2=1 failed to reject (F value = 0.74).

Table 1
Regression model: Estimation Results

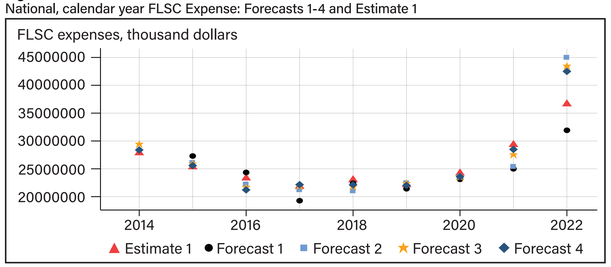
Model performance			
SSE	0.072	DFE	29
MSE	0.002	AIC	(98.181)
Durbin-Watson	2.016	Total R-square	0.777

Parameter estimates				
Variable	Estimate	St. error	t Value	Pr > |t|
Intercept	0.027	0.009	2.910	0.007
ln(PPI_ratio)	0.448	0.049	0.080	<0.0001
ln(Acres_ratio)	1.412	0.477	2.960	0.006

Source: Estimated by the authors.

For objective 2, figure 6 illustrates the FLSC forecast evolution over the forecasting horizon, for 2014-2022. The four forecasts are generally close to the first official estimate (published in release 5), with more significant deviations in 2021 and 2022. Furthermore, the expense forecasts are frequently below the estimated values.

Figure 5
National, calendar year FLSC Expense: Forecasts 1-4 and Estimate 1



Source: developed by the authors using USDA/ERS Farm Income and Wealth Statistics.

Table 2 shows that for the four forecasts developed for each calendar year in 2014-2022, the mean and median (absolute) percent deviation declines between forecast 1 (produced at the beginning of the forecast year) and forecast 4 (the last forecast, produced after the forecast year *t* ends).

Table 2
Percent Deviation and Absolute Percent Deviation for Forecasts 1-4

	Percent deviation				Absolute percent deviation			
	Forecast 1	Forecast 2	Forecast 3	Forecast 4	Forecast 1	Forecast 2	Forecast 3	Forecast 4
Number of years	8	8	9	9	8	8	9	9
Mean	-5.5	-1.5	-0.9	-0.9	8.1	7.6	5.7	4.9
Median	-4.7	-3.6	-2.4	-2.4	6.1	4.7	5.2	3.5

Source: developed by the authors using USDA/ERS Farm Income and Wealth Statistics - historical releases.

Conclusions

- The national FLSC expense forecasts are generally reliable;
- The forecasts' reliability improves over the forecasting cycle;
- Year-to-year changes in FLSC expenses are highly correlated with the changes in fertilizer PPI and crop acreage which is important for the forecasting process.

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