NCCC-134
APPLIED COMMODITY PRICE ANALYSIS, FORECASTING AND MARKET RISK MANAGEMENT

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Tatiana Borisova, Carrie Litkowski,
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Suggested citation format:
Borisova, T., C. Litkowski, and O. Mandalay. 2022. "An Examination of the USDA Net Cash Farm Income Forecast Reliability using a New Archival Farm Income Dataset: A Case Study of the 2020 Forecasts and Estimates." Proceedings of the NCCC-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management.
[http://www.farmdoc.illinois.edu/nccc134].

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Tatiana Borisova, Carrie Litkowski, and Okkar Mandalay[1]

Paper presented at the NCCC-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management, 2022

Disclaimer: The findings and conclusions in this presentation are those of the authors and should not be construed to represent any official U.S. Department of Agriculture (USDA) or U.S. Government determination or policy. This research was supported by the USDA, Economic Research Service.

[1] Tatiana Borisova: Agricultural Economist, Carrie Litkowski: Farm Income Team Lead, and Okkar Mandalay: Agricultural Economist, Farm Economy Branch, Resource and Rural Economics Division, Economic Research Service, U.S. Department of Agriculture. Address all correspondence to Tatiana Borisova at Tatiana.borisova@usda.gov .

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Abstract

USDA Economic Research Service (ERS) releases short-term forecasts and estimates of farm sector income three times a year, informing the public on the financial health of the U.S. agriculture sector. This paper presents the new data archive of ERS's farm sector income forecast and estimate releases and analyzes how forecasts and estimates for a calendar year change over time. We also examine the reliability of the net cash farm income (NCFI) forecasts for the calendar year 2020, the first year of the COVID-19 pandemic. We found that the fourth release of the 2020 NCFI forecast, published in February 2021, was less reliable than the initial forecast, published in February 2020, contrary to the historical evidence where the reliability of ERS calendar year forecasts tends to improve with each release.

Key words: farm sector income, short-term forecast, estimate, archive, reliability, absolute percent error, COVID-19, net cash farm income.

Acknowledgements. The data archive discussed in this paper was developed with assistance by all members of the USDA/ERS Farm Economy Branch. We also acknowledge the contribution to the archive development by Tait Militana, formerly a USDA/ERS Pathways Intern.

Introduction

As one of the 13 principal federal statistical agencies in the United States (U.S.), the United States Department of Agriculture Economic Research Service (USDA ERS) produces forecasts and estimates of the U.S. farm sector income and finances three times a year. Forecasts are projections for the current calendar year.[2] Estimates are released about nine months after the end of the calendar year, primarily based on survey and administrative data. ERS releases include forecasts and estimates of net farm income and net cash farm income and their components, including commodity cash receipts, Government direct farm program payments, and production expenditures.

[2] Note that the last forecast for a calendar year is released in February of the following year. Also, in this paper, we use the words "released" and "published" interchangeably.

ERS data and analysis are used by USDA and other farm sector stakeholders, including lenders, agribusinesses, farm organizations, and others, to inform their perspectives on the financial health of the U.S. agricultural economy. The U.S. Congress, the Secretary of Agriculture, and numerous public and private entities rely on ERS farm income forecast and estimates for a variety of uses – from aiding in the development of legislation and USDA programs to helping states assess their local farm economies.

Given the importance of this ERS data product, the forecast reliability has been periodically reviewed by USDA (e.g., McGath et al., 2009). Information on forecast updates and revision history is documented on the ERS website, along with complete data files from each release since August 2014 (ERS 2022a, ERS 2022b). However, this history does not allow for a long-term analysis of the forecast reliability. To address this gap, in April 2022, ERS released a new data file with farm income forecasts and estimates beginning with February 1977 release (ERS 2022c).

This paper describes the archive, starting with background information on how the ERS forecasts and estimates are revised or evolve over time. We discuss absolute percent error for forecasts and estimates and then examine the special case of the reliability of the 2020 net cash farm income forecasts released during the first year of the COVID-19 pandemic.

USDA/ERS Farm Income and Wealth Statistics Data Archive

ERS Forecasts and Estimates: Background

To understand how an archive of data from prior releases of the ERS Farm Income and Wealth Statistics could be useful, it can be informative to first understand how the ERS farm income data changes (or evolves) across time. Data is released by ERS three times a year: usually in early February, late August/early September, and late November/early December, in coordination with other key USDA data releases, including the World Agricultural Supply and Demand Estimates (WASDE). The values of the farm sector financial indicators can vary significantly throughout the forecasting cycle. Notably, as the year progresses, each new release incorporates incrementally more observed information gathered via surveys and other means into the forecast model.

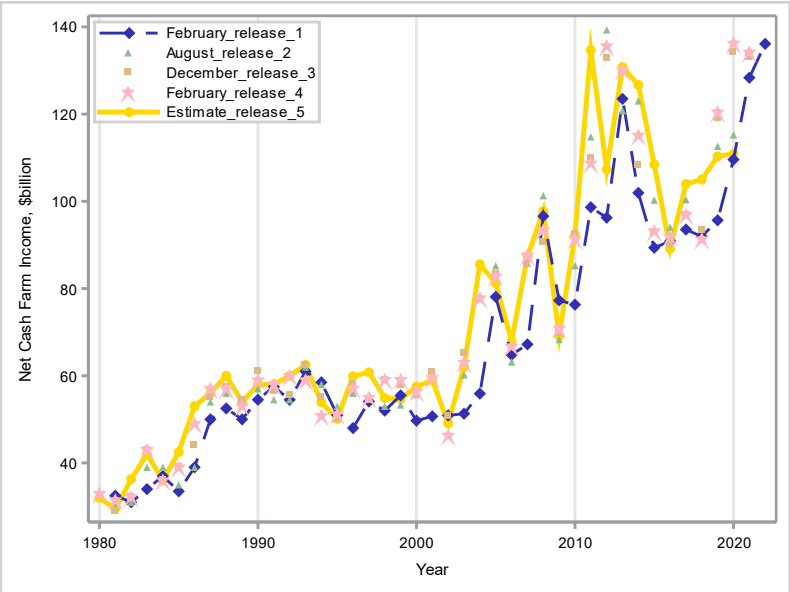
The first U.S. level forecast for any given calendar year is released in February of that year. This February release also updates the forecast for the prior calendar year.[3] The late August/early September release converts the prior year's U.S. farm income forecasts to estimates, adds State-level farm income estimates,

[3] Even though the calendar year is over, the economic indicators remain in "forecast" status.

and updates the current year's forecast. The late November or early December release updates the current year's forecast again. Historical estimates are open to revisions in all releases.

The ERS forecasts are largely based on projections which may be updated as frequently as monthly, such as the WASDE commodity price and production projections which are used in forecasting farm sector cash receipts (or sales). Other data is released incrementally throughout the year, such as USDA's National Agricultural Statistics Services (NASS) monthly indexes of the price paid by farmers which are used in forecasting production expenses (or costs). The ERS estimates are largely based on survey data from NASS and data from other agencies collected through the administration of programs to farmers. An important source for the estimates is the Agricultural Resource Management Survey (ARMS). Note that estimates and forecast values can change markedly among releases, as illustrated on Figure 1.

*Figure 1. Calendar Year U.S. Net Cash Farm Income: Four Consecutive Forecasts and the First Official Estimate**



* On this graph, the horizontal axis indicates calendar years, and the vertical axis shows NCFI forecasted or estimated for each calendar year. The initial forecast is released in February of the calendar year (Release 1, the blue dashed line with diamond markers). The forecast is then revised at the end of August or early September (Release 2) and in late November or early December (Release 3). The final forecast is released in February of the following year (Release 4), and the estimate follows in August/September (Release 5, golden line). Generally, the estimated values in Release 5 are higher than the initial forecast in Release 1.

Source: ERS calculation using "Historical Farm Income and Wealth Statistics Releases, February 1977 to Most Recent Vintage," USDA, Economic Research Service, Farm Income and Wealth Statistics. Data as of April 22, 2022.

Study Motivation

In 2018, ERS commissioned a panel of external experts to evaluate the quality and accuracy of ERS Farm Income and Wealth Statistics forecasts and provide recommendations for improvement. In their 2019

consensus study report, one of the panel recommendations was that "ERS should provide an archived history of farm income forecast data by each component (cash receipts, government payments, expenses, etc.) going back as far as possible" (p. 12, Katchova et al., 2019). ERS assembled an archive for the panel to use in their evaluation of the farm income forecasts. The panel believed that making the archive publicly available "would allow for more transparency of ERS farm income forecasts and estimates and would provide opportunities for researchers and stakeholders to better understand the farm income forecasts and estimates" (p. 12, Katchova et al. 2019).

Following their recommendation, ERS has assembled a data set of U.S.-level, calendar year estimates and forecasts from previous Farm Income and Wealth Statistics data releases starting with the February 1977 release. The purpose of this archive was to compile data values from prior releases of the farm income and wealth statistics into a single, easy to use file. This file would enable anyone to evaluate the accuracy and reliability of the ERS farm income data. It was posted on the ERS Farm Income and Wealth Statistics Data Product page on April 22, 2022.

Farm Income Measures Included in the Archive

The archive includes data on total cash receipts, net cash farm income, and net farm income. We include these three measures because each shows a different aspect of farm income. Cash receipts measure the amount of income received from sales of agricultural commodities (both crops and animal/animal products). They reflect both the prices received by farmers for their commodities as well the level of production. Cash receipts are the largest source of gross income for the farm sector.

Net cash farm income (NCFI) is a measure of farm sector profitability and is calculated as gross cash income minus cash expenses. It can also be calculated as follows:

$$NCFI = Cash\ Receipts + Direct\ Government\ Payments + Cash\ Farm\ Related\ Income - Cash\ Production\ Expenses \quad (1)$$

Net farm income is a broader measure of profitability that also incorporates noncash items, including changes in inventories, economic depreciation, and gross imputed rental income. It reflects "the share of value added to the U.S. economy created through the use of production factors (land, capital, labor, and management) belonging to farm equity owners" (p. 1, McGath et al., 2009):

$$Net\ Farm\ Income = Value\ of\ Crop\ and\ Animal\ Production + Farm\ Related\ Income + Direct\ Government\ Payments - Production\ Expenses \quad (2)$$

The value of crop and animal/animal products production is different from cash receipts in that it reflects production in the year in which it was produced rather than the year in which it was sold. It also accounts for the value of agricultural production that is consumed on the farm. Net farm income also accounts for non-cash farm related income and non-cash production expenses. Specifically, it includes the gross imputed rental value of farm dwellings as part of farm related income and includes expenses associated with operator dwellings as well as non-cash employee compensation and a measure of economic depreciation (capital consumption).

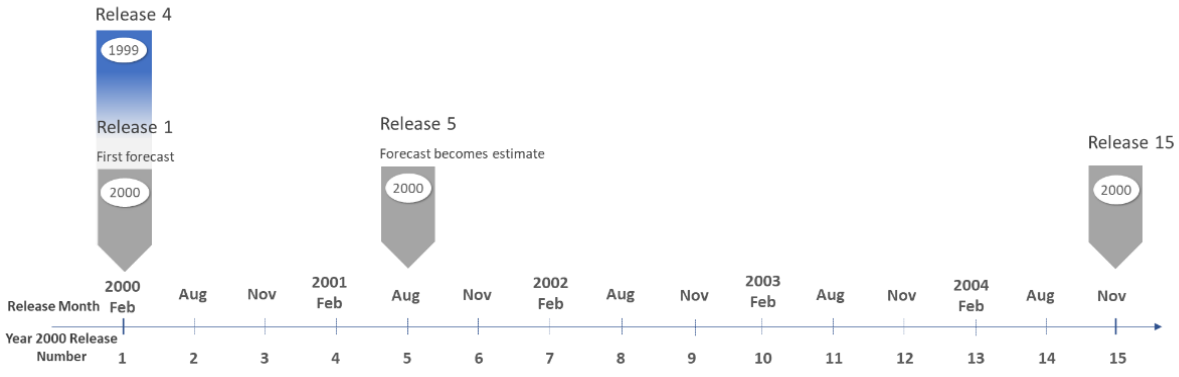
These three measures are not complete measures of farmers or farm households' well-being. Other factors may affect economic returns from farming to farm households (Prager et al., 2018). Also, many farm households supplement their income with off-farm employment which contributes to their well-being.

Scope of the Data

For the three measures, the archive includes the first forecast values and the values from the subsequent 14 releases. This encompasses releases over five years for each calendar year. In the archive, the cash receipts and net farm income data starts with the February 1977 release and net cash farm income data starts with the February 1981 release. The archive contains U.S. level, calendar year data only.

Figure 2 below presents the release numbering in the archive using calendar year 2000 as an example. Release 1 represents the initial forecast for the year, and it was published in February 2000. The forecast was then updated in Releases 2 through 4. The first estimates of farm income were published in August 2001 (Release 5), which was nine months after the end of the calendar year being estimated. The estimates can be further revised – up to and beyond Release 15. The archive includes up to release 15 because availability of data past release 15 was limited in the historical records.

Figure 2. Release numbers example – Year 2000



Every release also includes forecasts or estimates for the prior calendar years. For example, at the time of the first forecast for calendar year 2000 (Release 1) on February 2000, an updated forecast for the calendar years 1999 (Release 4) was also published along with estimates for 1997 (Release 7), 1996 (Release 10), and 1995 (Release 13).

Data Sources and Quality Control

The data in the archive was compiled from a variety of sources. Data from releases starting with August 2014 were retrieved from the "All Data" CSV files posted on ERS Wealth and Statistics data page (ERS 2022c). For each release, there is a separate file with all the data from that release.

For releases prior to August 2014, we had to build the archive from other available sources such as ERS publications. From February 1975 to December 2002, the ERS Agricultural Outlook (AO) reports featured tables with select farm income forecasts and estimates. Farm income data was also available from the Agricultural Income and Finance Situation and Outlook (AI) reports which were published intermittently from December 1984 to December 2011 before being renewed in 2022. We were not able to access the contemporaneous farm income releases prior to the first AO report in 1975, despite the fact that measures of cash receipts, net cash farm income and net farm income go all the way back to 1910.[4]

The data from AO and AI were gathered using a scraping program with the data from the reports being assigned to particular release. Data not available in the AO nor AI reports were retrieved from ERS internal documents such as briefing documents and spreadsheets. Another source was the archive.org aka Wayback Machine which saved many of ERS farm income data pages as they were released. Despite these sources, we are not able to locate all data items from every release. Some of the data quality control methods used to verify the data included summing of the accounting subcomponents to the aggregates for the years with more complete data and individually checking outstanding numbers. The review also includes checking that the variables were conceptually consistent across time.

Missing Data and Other Challenges

Missing data points in the archive may indicate that data was not released at the time or that we could not locate the data. For example, some releases are not covered by the AO and AI, or the Wayback Machine. Furthermore, to be consistent with the present ERS accounting format, the archive only includes calendar

[4] In the earlier publications of USDA reports, farm income data was presented in varying formats with varying levels of detail. Some versions of the reports used monthly format or year-to-date, while others showed quarterly. To be consistent with the present ERS accounting format, only data values available in the annual format were used in the archive. Therefore, net farm income and net cash farm income data prior to 1977 and 1981 releases (respectively) are missing. Based on the available records, the archive includes net farm income and cash receipts data starting with the 1974 calendar year (Release 10, February 1977) and net cash farm income data starting with the 1977 calendar year (Release 15, November 1981).

year, annual values. In the earlier publications of USDA reports, only monthly, quarterly, or year-to-date farm income data was presented. Data from such reports is listed as missing.

Missing data are discussed in detail in the "Readme" file attached to the archive, which also lists other data challenges, such as the following:

- For releases prior to August 2014, data were assumed to be released three times a year in February, August, and November. However, there may be instances where there were more or fewer than 3 data releases in a year and/or where new or updated data were not released in those months.
- Where possible and as needed, the data values were adjusted to ensure the data items remained conceptually consistent over time.
- Between 1981 and 1996, ERS released interval forecasts rather than point forecasts. For those years, the mid-point of the interval was used in the archive.
- Differences in the level of precision across releases may suggest revisions to values when the differences are only due to rounding.

Despite these complications, the archive is the best source of the long-term history of ERS farm income releases for cash receipts, net cash farm income, and net farm income currently available to the public. Below, the case study illustrates how the archive was used to examine farm income forecast reliability.

Using the Archive to Measure Forecast Error

Forecast accuracy and reliability analysis can be guided by questions of special importance to the users. The ERS farm income forecast users may ask whether the forecast is generally reliable or if it was reliable during a particular period. We use the new data archive (ERS 2022c) to answer the first question examine the specific case of the recent economic recession associated with the COVID-19 pandemic.

ERS Farm income forecast reliability has been examined in several published reports and peer-reviewed studies. For example, Dubman et al. (1993) report an average 16 percent downward bias in the initial NCFI forecast for the eight years prior to their study. Similarly, Isengildina-Massa et al. (2019, 2021) finds an 11 percent bias in the initial NCFI forecast. The forecasting error decreases as additional production and price information becomes available during the forecast cycle (USDA 1988; Dubman et al. 1993; McGath et al. 2009; Isengildina-Massa et al., 2019, 2021), yet the negative bias in NCFI forecast is statistically significant even for Release 4 (Isengildina-Massa et al. 2019, 2021). Bora et al. (2020) explains the downward bias by the asymmetric loss function, with USDA being averse to overpredicting incomes early in the forecast cycle. Bora et al. (2020) suggests that forecasts produced by government agencies tend to be conservative or cautious because policy-making may require the analysis of worst-case scenario or because the forecasts

are developed to trigger or avoid specific actions from the forecast users (e.g., avoid private debt accumulation in response to overly optimistic GDP forecast).

While some of the existing studies examine revisions in the NCFI forecasts, we did not find any study examining revisions to the NCFI estimates. The estimates can be revised for several years after the initial release to account for new Census of Agriculture data, for example. To begin answering the question about the impacts of the estimate revisions on the forecast error measurements, this paper discusses absolute percent error for forecasts and estimates over the five-year time span. We also add to the existing literature with the data analysis for 2020, the first year of the COVID-19 pandemic.

Existing studies offer various forecast error measures, such as unit, percent, and absolute percent forecast error. Median and mean errors can be used, including arithmetic, square root, geometric, symmetric, and other definitions of the sample mean (e.g., Makridakis 1993, Hyndman and Koehler 2006, Kim and Kim 2016). We use absolute percent forecast error in this paper. This measure focuses on the relative forecast error, which is important given the fivefold increase in NCFI, from $25.3 billion in 1977 to $136.1 billion in 2022, in nominal terms. The absolute measure also prevents negative and positive errors from canceling out when calculating the mean, making this measure more sensitive to forecast deviations from the estimates.[5]

Using index *i* to indicate the forecast release number (*i*=1, 2, 3, and 4), and *t* to refer to the calendar year for which the forecast or estimate is developed, the absolute percent error, $|e_{ti}|$, is the difference between the forecast, F_{ti}, and the estimate, S_{tj}, divided by the estimate:

$$|e_{ti}| = \left|\frac{F_{ti} - S_{tj}}{S_{tj}}\right| \qquad (3)$$

Note that index *j* refers to the releases that include the official *estimates* rather than the *forecasts*: $j \geq 5$, *t* is the calendar year forecasted or estimated.

As mentioned above, estimates can be periodically revised. Therefore, the absolute percent error for the estimates can also be calculated as follows:

$$|e_{tk}| = \left|\frac{S_{tk} - S_{tj}}{S_{tj}}\right| \qquad (4)$$

[5] Future studies can expand the analysis presented in this paper by considering other measures of the forecast error, such as percent error, absolute deviations, and others.

where index *k* refers to releases containing estimates for the calendar year *t* (*k*>4). Since the archive contains 15 releases for each calendar year, one can calculate absolute percent revision by comparing each estimate with Release 15 (*j*=15).

For the sample of the absolute errors, the outliers are defined using the interquartile range (IQR) as follows:

$$\text{Outlier} < Q1 - 1.5*IQR;\ \text{Outlier} > Q3 + 1.5*IQR \qquad (5)$$

where Q1 refers to the first quartile, Q3 refers to the third quartile, and IQR is the difference between Q3 and Q1. The analysis is completed in SAS Enterprise Guide and Stata (StataCorp 2021; SAS Institute Inc. 2020).

Two sub-sections below present the initial analysis of the NCFI forecast reliability for (a) all releases available in the archive, and (b) 2020 NCFI forecast releases, focusing on the first year of the unprecedented COVID-19 pandemic.

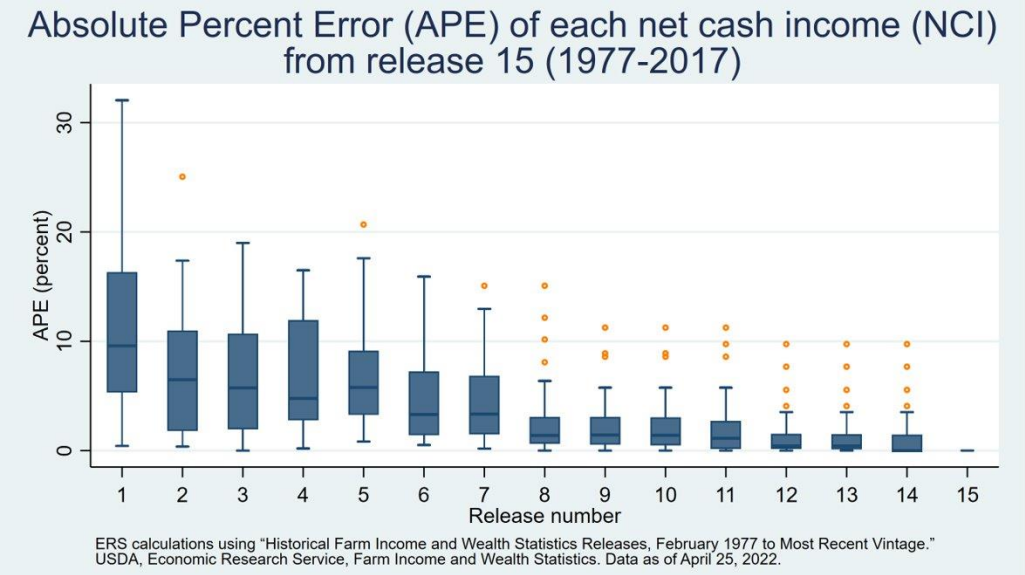
Forecast Reliability: Complete NCFI History Available in the Archive

Absolute percent errors are calculated for each release for all calendar years included in the archive. For each calendar year, forecasts and estimates are compared with the estimate in Release 15, the last release included in the archive. Release 1 is generally the least reliable among the four forecast releases, with a maximum forecast error exceeding 30 percent (Figure 3). At the same time, MAPE for Release 1 is 12.1 percent, and approximately half of the historical data shows an absolute error of less than 10 percent (See the median in Figure 3). Release 1 is generally published in February of the calendar year when little information is known, and many of the input data are forecasts themselves. Further, significant changes in NCFI are often observed from year to year. Therefore, a MAPE of 12.1 percent may be reasonable.[6] The forecast error decreases rapidly in subsequent releases. For example, Release 4 – the last forecast before the first official estimate – has a MAPE of 6.5 percent relative to Release 15.

While the estimates can be revised after Release 5 (see Figure 3 and Table 1), MAPE converges to zero toward Release 15. Note that while Release 15 is a more final number, it also could be revised in later releases. Convergence of MAPE toward later releases also indicates that estimation models are generally consistent. These results may differ slightly if longer series of releases were used, for example Release 20. However, data availability is severely limited past Release 15.

[6] Our literature search did not result in a benchmark forecast error that can be used to evaluate the forecast reliability across various forecast models.

*Figure 3. Absolute Percent Error for NCFI Forecasts and Estimates from Release 15**



* This boxplot figure displays the absolute percent error (APE) of each release, measured as the difference from Release 15. Median APE are indicated by the solid line in the boxes. Orange dots are the outliers. This figure shows that the median APE decreases with each consecutive forecast (see Releases 1-4), and even for the initial forecast in Release 1, the median APE is less than ten percent. For the estimates (i.e., Releases 5-15), the APE converges to zero toward Release 15.

Source: ERS calculation using "Historical Farm Income and Wealth Statistics Releases, February 1977 to Most Recent Vintage," USDA, Economic Research Service, Farm Income and Wealth Statistics. Data as of April 22, 2022.

Table 1. NCFI Mean Absolute Percent Error from Release 15, by Release

Release Number	NCFI Mean Absolute Percent Error, MAPE (Percent)
1	12.1
2	7.7
3	6.5
4	6.5
5	6.7
6	5.0
7	4.8
8	2.6
9	2.3
10	2.3
11	1.9
12	1.4
13	1.4
14	1.2

Source: ERS calculation using "Historical Farm Income and Wealth Statistics Releases, February 1977 to Most Recent Vintage," USDA, Economic Research Service, Farm Income and Wealth Statistics. Data as of April 22, 2022.

Forecast Reliability During COVID-19 Pandemic

At the start of the COVID-19 pandemic, its effects on the economy and the agricultural sector were largely unknown. While the SARS-CoV-2 virus was declared a public health emergency on January 21, 2020 (CDC 2022), the months of March and April of 2020 were the first periods of economic recession when the gross domestic product (GDP) plummeted (FRED 2022a, 2022b), evoking a strong government response to stimulate the economy. Six major laws approved by the U.S. Congress (including economic impact payments to the households),[7] the Federal Reserve Bank's actions, and other efforts helped mitigate the economic decline (CRS 2021). Economic growth resumed in May 2020, and by January 2021, the GDP returned to the pre-pandemic levels (FRED 2022b).

The pandemic led to rapid changes in the agricultural sector, including supply chain disruptions and demand changes for certain commodities. Other factors affecting agriculture in 2020 included unexpected domestic and international pest and disease pressures, weather, and government policies (Litkowski and Law, 2021). Direct Government payments to farmers doubled in 2020 relative to 2019, offsetting both higher production expenses and lower commodity cash receipts (ERS 2022d).

ERS's first farm income forecast for 2020 (Release 1) was published on February 5, 2020, and given this release date, it did not include any information on the potential pandemic impacts (Litkowski and Law, 2021). This original forecast for NCFI in 2020 was $109.59 billion, and it was close to the first estimate for 2020 published on September 2, 2021, with only a 1.18 percent absolute percent error[8] (Table 2). In contrast, Release 2 – published in September 2020 – had an error of 3.91 percent relative to the September 2021 estimate. The forecast error increased further in subsequent releases, reaching 22.86 percent in Release 4 (Table 2).

We then compare 2020 NCFI forecast errors with those observed historically in the archive. The reliability of NCFI forecasts in Releases 1 through 4 is first evaluated by comparing the forecasts with the first official estimate in Release 5. Among the releases, mean and median forecast errors are highest for Release 1 (Table 3).[9] Release 1 mean absolute percent forecast error is 11.63 percent (with the 95 percent confidence interval for the population mean of $11.63 \pm (2.024 \times 8.14 / \sqrt{39}) =$ [8.99 percent, 14.27 percent]). The last NCFI

[7] Page 2 of CRS (2021) lists the six major laws approved by the U.S. Congress: "the Coronavirus Preparedness and Response Supplemental Appropriations Act 2020 (P.L. 116-123); the Families First Coronavirus Response Act (P.L. 116-127); the Coronavirus Aid, Relief, and Economic Security (CARES) Act (P.L. 116-136); the Paycheck Protection Program and Health Care Enhancement Act (P.L. 116-139); the Consolidated Appropriations Act, 2021 (P.L. 116-260); and the American Rescue Plan Act of 2021 (P.L. 117-2)." For the discussion of one of the bills (CARES Act) and the USDA's Coronavirus Food Assistance Program (CFAP) targeted to farm operations, see Giri et al. (2021).

[8] The absolute percent error is measured as the difference from the first 2020 estimate (Release 5, September 2021).

[9] We used Kuiper and other tests implemented in the SAS *npar1way* procedure to test if forecast errors are drawn from the same distribution.

forecast is Release 4, on average, 5.64 percent off the first official estimate, with the 95 percent confidence interval for the population mean being in the interval of $5.64 \pm (2.024 \times 5.54 / \sqrt{40})$ [3.87 percent, 7.41 percent].

Table 2. 2020 NCFI forecast, Unit Error, Percent Error, and Year-to-Year Change Direction, by Release

Release	Release Month	Forecast or Estimate	Net Cash Farm Income ($billion)	Unit Error ($billion)*	Absolute Percent Error (percent)*	Direction of NCFI Change between 2019 and 2020
1	Feb. 2020	Forecast	$109.59	$1.30	1.18%	Decrease
2	Sept. 2020	Forecast	$115.23	$4.34	3.91%	Increase
3	Dec. 2020	Forecast	$134.12	$23.23	20.95%	Increase
4	Feb. 2021	Forecast	$136.24	$25.35	22.86%	Increase
5	Sept. 2021	Estimate	$110.89	-	-	Increase

* Unit error ($billion) and absolute percent error (percent) are calculated using September 2021 (Release 5).

Source: ERS calculation using "Historical Farm Income and Wealth Statistics Releases, February 1977 to Most Recent Vintage," USDA, Economic Research Service, Farm Income and Wealth Statistics. Data as of April 22, 2022.

Table 3. Descriptive Statistics for the Absolute Percent Forecast Error, compared with Release 5

Release	Historical Observations												2020 Calendar Year
	N	Mean	St.D.	Std. Err.	Min	5th Percentile	Q1	Median	Q3	95 Percentile	Max	Upper Outlier Fence	
1	39	11.63	8.14	1.30	0.86	1.16	4.52	10.71	17.34	26.77	34.66	36.57	1.18
2	39	7.71	7.78	1.05	0.80	0.93	2.90	5.79	8.33	29.85	34.66	16.48	3.91
3	39	5.89	5.69	0.91	0.00	0.00	1.79	3.65	8.24	18.47	23.75	17.92	20.95
4	40	5.64	5.54	0.88	0.00	0.00	1.76	4.55	8.14	16.70	26.37	17.71	22.86

Source: ERS calculation using "Historical Farm Income and Wealth Statistics Releases, February 1977 to Most Recent Vintage," USDA, Economic Research Service, Farm Income and Wealth Statistics. Data as of April 22, 2022.

Table 3 also identifies the 5th and 95th percentiles and the upper outlier fences for the historical samples. For Releases 2, 3, and 4, the upper outlier fences are generally comparable – between 16 percent and 18 percent. Forecasting errors exceeding these boundaries are classified as outliers. Lower outlier fences are not reported in Table 1 since they are negative and not relevant for the absolute percent forecast error. However, one can look at the values for the lower 5 percent of the sample to identify "rare" observations. For example, for Release 1, only five percent of observations have the absolute percent forecast error of 1.16 percent or smaller.

The 2020 NCFI absolute percent error is also presented in Table 3. For Release 1, the 2020 NCFI forecast was very close to the first estimate (Release 5), and the forecast error is near the 5th percentile of the

historical sample. Only two years show smaller errors: 1991 (the error of 0.86 percent) and 2008 (the error of 1.16 percent). In turn, the absolute percent error in Release 2 was 3.91 percent. Out of 39 years in the archive, 16 years (or 41.03 percent) had Release 2 forecast errors smaller than that value. Next, the 2020 NCFI forecasts in Releases 3 and 4 were more than 20 percent off the estimate published in Release 5. Such sizable forecast errors are outliers. The only year when the forecast errors were even higher was 2012, with the Release 3 error of 23.75 percent and Release 4 error of 26.37 percent.[10]

As shown in Table 2, Release 1 incorrectly predicted the direction of change of NCFI in 2020 from 2019. We examine the reliability of predicting the direction of year-to-year change, and find that historically, Release 1 correctly indicates the direction of change more than two-thirds of the time. The reliability of predicted direction increases in later releases, with Releases 3 and 4 correctly predicting more than 80 percent of the time (column (2) in Table 4).

Table 4. Percent of forecasts with correct direction of year-to-year change (as compared with Release 5)

Release	All years	Years with NCFI decline	Years with NCFI increase
(1)	(2)	(3)	(4)
1	69.23 (N=39)	93.75 (N=16)	52.17 (N=23)
2	76.32 (N=38)	87.50 (N=16)	68.18 (N=22)
3	84.62 (N=39)	93.75 (N=16)	78.26 (N=23)
4	84.21 (N=38)	86.67 (N=15)	81.61 (N=23)

NCFI values are rounded to $billions before the analysis to avoid incorrect conclusions due to precision change. Source: ERS calculation using "Historical Farm Income and Wealth Statistics Releases, February 1977 to Most Recent Vintage," USDA, Economic Research Service, Farm Income and Wealth Statistics. Data as of April 22, 2022.

The reliability of the year-to-year change predictions depends on the NCFI trend. For example, when the estimates indicate NCFI decline, Release 1 accurately predicts the decline 93.75 percent of the time (see column (3) in Table 4). When NCFI increases, Release 1 accurately indicates this trend 52.17 percent of the time (see column (4) in Table 4). This confirms the conclusion drawn by past studies that the USDA forecast tends to be conservative, frequently underpredicting the NCFI (Kuethe et al., 2018; Bora et al., 2020; Isengildina-Massa et al., 2021).[11] Therefore, incorrect initial prediction of year-to-year change direction for 2020 NCFI is generally in line with the history of the forecasts.

[10] To examine how the forecast reliability depends on the Release from which the estimate is selected, we calculated the absolute percent errors using Release 7 – the latest release of 2020 NCFI at the time of this conference paper. First, the revision between Release 5 and Release 7 was 5.40 percent, which is in the fourth quarter of the historical sample, but not an outlier. Next, when Release 5 is replaced with Release 7 in the absolute error calculations, the error increases for Release 1 but shrinks for Releases 2–4. Release 4 stands out, however, with the forecast error falling in the 95th percentile.

[11] Sensitivity analysis was conducted replacing Release 5 with Release 7 estimates to assess the actual year-to-year change direction. The frequencies of correct predictions remain generally similar to those reported in Table 4.

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Overall, the analysis showed that the reliability of the NCFI forecasts for 2020 was comparable with that observed historically despite a substantial increase in Federal Government assistance. The exception was Release 4, which showed a relatively large absolute percent forecast error of 22.86 percent when compared to the first official estimate (Release 5), or 16.22 percent when measured against the third estimate (Release 7). This error was in the 95th percentile of the sample of historical forecast errors, and it was an outlier when Release 5 was used in the analysis.

The comparison of NCFI forecast error by component between Releases 1 and 4 helps in understanding the drivers of the significant error in Release 4.[12] As shown on Figure 4A, the 2020 NCFI forecast error was approximately –$1.3 billion in Release 1, benefitting from *offsetting* forecast errors in cash receipts and direct Government payments (overpredicted by $27.3 billion and underpredicted by $30.7 billion, respectively). Release 1 was not able to capture significantly higher Government program payments because programs were enacted after the release. The results of the pending legislations are generally difficult to forecast. Additionally, it is not a goal of the ERS farm income forecasts to try to predict farm policy.[13]

In turn, for Release 4, the 2020 NCFI error at $25.3 billion was attributed to *compounding* errors. Cash receipts were overpredicted by $13.2 billion while expenses were underpredicted by $11.7 billion (see Figure 4B). The first official estimate of the 2020 reduced cash receipts forecasted by Release 4 by almost four percent. One can expect that the reduction in anticipated cash receipt should correlate with a decline in expenses to reflect farmers' adjustments to the market conditions. In the case of 2020, however, despite the lower cash receipt levels there was no reduction in spending detected in Release 5 (as compared with Release 4), and despite the reduction in cash receipts there was no drop-off in spending. It is likely that the high levels of government payments made any requirement to economize less compelling.

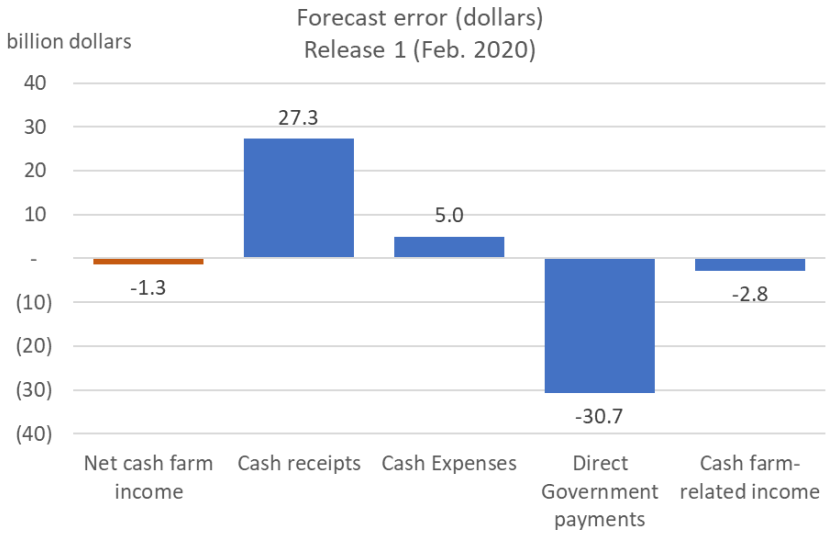
The cash receipts forecasts did show significant improvement between Release 1 and Release 4, with approximately a $14.1 billion reduction in the forecast error (in dollar terms). The cash expenses forecast error, however, increased significantly by Release 4 with cash expenses forecast lower than what they

[12] While the archive (ERS, 2020c) did not allow the analysis of what was driving the forecast errors, such examination is possible with the "All Data".csv files on the ERS website for releases starting with August 2014 (ERS 2022b).
[13] Two characteristics of 2020 NCFI Release 1 made it different from much of the history. First, past studies identified persistent *underestimation* in crop and livestock cash receipts as the key source of the negative bias in Release 1 (Isengildina-Massa et al., 2019 and 2021). In contrast, 2020 Release 1 *overestimated* total cash receipts. Secondly, even though Government payments are usually underpredicted (Kuethe et al. 2021), the impact of the underprediction is minute: forecast errors in Government payments are usually small contributors to the total NCFI forecast error (Isengildina-Massa et al. 2019). Nonetheless, in 2020, the underprediction in the Government payments in Release 1 had a significant impact on NCFI forecast error (likely more significant than the historical average).

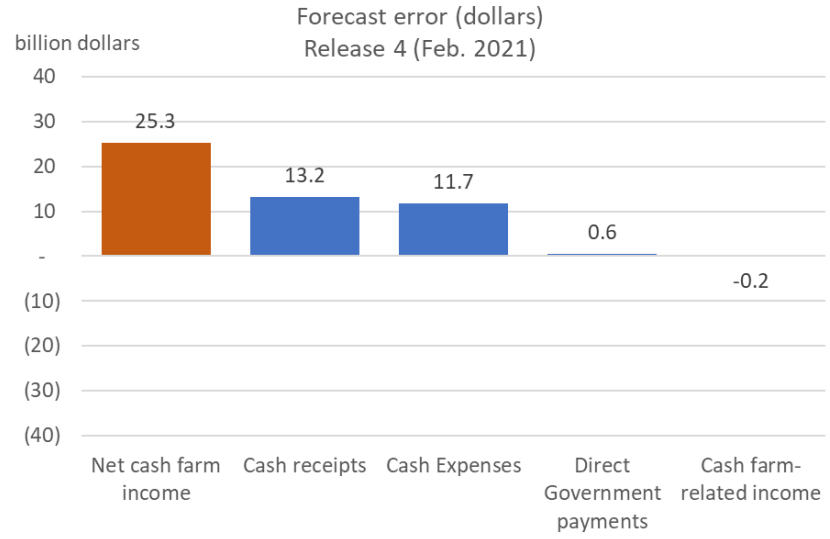
would be estimated at in Release 5. Releases 4 is consistent with Isengildina-Massa et al. (2019, 2021) that found that crop cash receipts and expense forecast error as the most significant drivers for NCFI forecast error in Release 4. However, overprediction of total cash receipts and an increase in expense forecast error in Release 4 are different from the results reported in past studies.

Figure 4. Errors by component help explain differences in 2020 forecast performance by release number.

A. 2020 forecast: Release 1 (Feb. 2020), off-setting errors



B. 2020 forecast: Release 4 (Feb. 2021), compounding errors



The forecasts are compared with Release 5 estimate. Source: ERS calculation using "Historical Farm Income and Wealth Statistics Releases, February 1977 to Most Recent Vintage," USDA, Economic Research Service, Farm Income and Wealth Statistics. Data as of April 22, 2022

Overall, based on this initial analysis, the 2020 NCFI forecast error seems to have different drivers than those typically observed in that: 1) reliability did not improve in later forecast releases, 2) cash receipts were overpredicted, 3) and Government payments were grossly underpredicted in Release 1.[14] Adding cash receipt and expense history into the archive, and examining the methodology used in their forecast along with other NCFI components could provide an important avenue for improving NCFI forecast reliability.

Conclusion

This study presents a new ERS data archive with U.S. calendar year estimates and forecasts from previous Farm Income and Wealth Statistics data releases (ERS 2022c). This product was developed in response to the ERS panel recommendation (Katchova et al., 2019), and it is intended to increase transparency of ERS farm income forecasts and estimates, provide opportunities for researchers and stakeholders to better understand the forecasts and estimates, and to allow for farm income forecast reliability research.

In this paper, we applied this archive to examine the USDA farm sector income forecast reliability during the COVID-19 pandemic. The analysis shows that the direction of NCFI change between 2019 and 2020 was forecast correctly in three out of four USDA forecast releases. Further, the 2020 NCFI forecasts were overall reliable, that is, reasonably close to the official 2020 NCFI estimate, with the exception is Release 4 (the last forecast), which resulted in an unusually large forecast error, driven by the compounding errors in cash receipts and expenditures.

This analysis is one example of research that can be done using the data in ERS (2022c). Other research questions can include the following:

- How has the reliability of the forecasts varied across time periods?
- How much do the revisions to the WASDE projections impact the reliability of the farm income forecasts?
- How reliable are the farm income forecasts when looking at year-to-year growth rates?

The data archive and its supporting documentation can be found at ERS Farm Income Wealth and Statistics Data Product page at https://www.ers.usda.gov/data-products/farm-income-and-wealth-statistics.aspx. The farm income team may update the archive later to add data for other components of farm income and other farm sector financial measures.

[14] 2020 NCFI also showed usual forecast characteristics, such as under-estimated governments and cash-receipts-and-expenses driving the NCFI.

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