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SOURCES OF ERRORS IN USDA'S NET CASH INCOME FORECASTS

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SOURCES OF ERRORS IN USDA'S NET CASH INCOME FORECASTS

This study evaluates the accuracy of net cash income (NCI) forecasts and its components in order to track down the main sources of errors in NCI forecasts over 1986-2017. Specifically, we examine the bias as well as the correlation between errors in net cash income forecasts and in forecasts of its components for each forecasting horizon. Our findings suggest that long term NCI forests underestimate the official estimate. Crop receipts forecasts appear to be the main source of this bias as underestimation in crop receipts persists throughout the forecasting cycle. The main contributors to NCI forecast errors are errors in expenses and in crop and livestock receipts. Errors for all components except farm related income tend to decline over the forecasting cycle. There is not much evidence of forecast errors becoming larger or smaller over time. These findings identify potential areas for improvement in USDA's NCI forecasts.

Key words: crop receipts, forecast accuracy, livestock receipts, net cash income forecasts, production expenses, USDA

Introduction

USDA's farm income estimates are the official measures of the farm sector's contributions to the national economy and play an important role in the development of agricultural policy (Schnepf, 2016). These forecasts have been released by USDA since 1910 and serve as one of the main indicators of the economic well-being of the farm sector. As such, these forecasts have been described as some of the USDA's most cited statistics (McGath et al., 2009). Furthermore, these forecasts serve as an input in various USDA models as well as U.S. GDP estimates (McGath et al., 2009). Given the important role of these forecasts, it is imperative to ensure that they are accurate and reliable.

However, very little research has been devoted to evaluating farm income forecasts. McGath et al. (2009) provide a brief and informal summary of the variation in net farm income forecasts and their components. A recent study by Kuethe, Hubbs, and Sanders (2018) provides a detailed analysis of net farm income forecasts, but leaves out its components that add up to net farm income. One of their main findings suggests that there is a downward bias in the initial forecast released in February of the year prior to the estimate release year, 18 months before the official estimate is first released in August of the following year. They also find that the updated forecasts, released 12 to 6 months before the official estimate, are inefficient as they tend to over-react to new information.

The goal of this study is to evaluate the accuracy of net cash income (NCI) forecasts and its components in order to track down the main sources of errors in NCI forecasts over 1986-2017. Specifically, we examine the bias as well as the correlation between errors in net cash income forecasts[2] and in forecasts of its components for each forecasting horizon. Additionally, we

[2] Net cash income is the difference between gross cash income and cash expenses, which are components measured on cash basis. NCI does not include non-monetary income, capital consumption, and changes in inventories that are part of the net farm income. Our focus on the net cash income is driven by data availability.

evaluate how the size of forecast errors changes across the forecasting horizon and over time. The findings of this study identify potential areas for improvement in USDA's NCI forecasts.

Data

Our study examines the accuracy of USDA's NCI over 1986 through 2017, including the forecast errors in its main components (crop receipts--CR, livestock receipts--LR, cash farm-related income--FRI, total direct government payments--GP, and cash expenses--EXP). These forecasts are released within an income statement that follows an accounting equation:

(1) *Net cash income = (Crop receipts + Livestock receipts + Cash farm-related income + Total direct government payments) – Cash expenses = Gross Cash Income – Cash expenses.*

where gross cash income is also referred as GCI.[3] Even though additional sub-categories are released for farm-related income as well as cash expenses, these data are not available for the entire period of study and therefore are not included. All data are obtained from USDA-ERS archives. All values are forecasts on a calendar year basis. McGath et al. (2009) meticulously describe the economic model underlying each component and the aggregate net cash income forecasts used since 1986. Figure 1 shows the official NCI estimates during 1986-2017. There is a clear upward trend in nominal net cash income likely due to inflation. In order to remove this trend, all income forecasts and estimates are adjusted for inflation using the chain-type GDP price index with 2012 as the base year (Federal Reserve Bank, 2019).

These forecasts follow a fixed-event format; in each forecasting cycle a series of *h*-period (months) ahead forecasts are available for the same terminal event at time τ (when the estimate is released) for year *t*. Forecasts are released in February (*h*=18), August (*h*=12), and November (*h*=9) of the previous year and in February (*h*=6) of the terminal event year. The forecasting cycle is finalized with the release of the first official estimate (final, terminal event) in August. Thus, the final estimate for component *j* for terminal year *t* is denoted as $F_{\tau,t}^{j}$ and the *h*-period ahead forecasts are $F_{\tau-h,t}^{j}$ for *h* = {6, 9, 12, 18} and *j* = {NCI, CR, LR, FRI, GP, EXP}. Figure 2 demonstrates this forecasting cycle and illustrates that when the first forecast for year *t* is made in February, an estimate for the previous year *t*-1 is not yet finalized. It is also important to note that the official estimate released in August of year *t*+1 is sometimes revised as input data are updated by various USDA agencies.[4] However, these revisions do not follow a regular pattern and are therefore not included in this analysis. Therefore, the August estimates are treated as final estimates for the purposes of this study.

Methodology

Forecast errors are measured in this study in both unit and percentage terms. Unit errors are computed as the difference between the estimate and the current forecast: $e_{\tau-h,t}^{j} = f_{\tau,t}^{j} - f_{\tau-h,t}^{j}$, *h*

[3] Missing observations for *FRI* were imputed from an accounting equation where FRI = NCI + EXP – CR – LR – GP.

[4] This is especially true for cash receipts data which are based partially on NASS estimates which can be updated several times after their initial release and are not "final" until the NASS "final estimates" are released based on the most current Ag Census.

= {6, 9, 12, 18}. Within an income statement, unit errors from all categories add up to NCI errors following the same accounting equation (1). Percent errors are computed as percent difference between the estimate and the current forecast: $pe^{j}_{\tau-h,t} = \left(f^{j}_{\tau,t} - f^{j}_{\tau-h,t}\right) \Big/ f^{j}_{\tau,t}$, h = {6, 9, 12, 18}. These errors do not add up to NCI errors as they are expressed as a proportion of each component, but are informative as they express the size of error relative to the size of the total value of the forecast.

Following Kuethe, Hubbs, and Sanders (2018), unit errors and percent errors in NCI forecasts and their components are examined for bias using a test proposed by Holden and Peel (1990):

$$e^{j}_{\tau-h,t} = \alpha^{j}_{0,\tau-h} + u^{j}_{\tau-h,t}, \quad h = \{6, 9, 12, 18\}, t = 1986, \dots, 2017. \tag{2}$$

$$pe^{j}_{\tau-h,t} = \alpha^{j}_{0,\tau-h} + u^{j}_{\tau-h,t}, \quad h = \{6, 9, 12, 18\}, t = 1986, \dots, 2017. \tag{3}$$

The null hypothesis for a test of bias is H_0: $\alpha^{j}_{0,\tau-h} = 0$. A rejection of this null hypothesis indicates that the forecasts overestimate the final values if $\alpha^{j}_{0,\tau-h} < 0$, or underestimate the final values if $\alpha^{j}_{0,\tau-h} > 0$.

Since NCI forecasts are published as a system following an accounting equation (1), correlations between errors within the system are important (Isengildina Massa, Karali and Irwin, 2013). For example, Figure 3 shows how forecast errors in gross cash income and the negative value of cash expenses tend to offset each other sometimes to result in smaller NCI errors. Since EXP are subtracted from GCI to obtain NCI, positive correlation between GCI and EXP errors will result in smaller NCI errors, and vice versa. On the other hand, components within GCI are added together to result in GCI forecast, therefore a negative correlation between these components would result in smaller aggregate forecasts. Pearson correlation coefficients are calculated to examine correlations between errors of various components of the NCI forecasts. Correlations in percent errors are examined further using the following regression:

$$pe^{NCI}_{\tau-h,t} = \gamma_{0,\tau-h} + \gamma_{1,\tau-h} pe^{CR}_{\tau-h,t} + \gamma_{2,\tau-h} pe^{LR}_{\tau-h,t} + \gamma_{3,\tau-h} pe^{GP}_{\tau-h,t} + \gamma_{3,\tau-h} pe^{FRI}_{\tau-h,t} + \gamma_{4,\tau-h} pe^{EXP}_{\tau-h,t} + u^{NCI}_{\tau-h,t}, \quad h = \{6, 9, 12, 18\}, t = 1986, \dots, 2017. \tag{4}$$

This equation examines the correlations between percent errors in NCI and its components in order to identify sources of errors in the aggregate NCI forecasts. Because NCI is computed as the difference between gross cash income and cash expenses, the signs of the estimated coefficients should be positive for gross cash income components' forecast errors, and negative for the cash expenses forecast errors. The regression is estimated for each forecast horizon separately to evaluate if the source of errors changes across the forecasting horizon.

Further, forecast optimality implies that the forecast error should be a weakly increasing function of the forecast horizon (Patton and Timmermann, 2007). To test this property, we use two common measures of forecast accuracy: mean absolute error (MAE) and root mean squared error (RMSE):

$$(5)\quad MAE^{j}_{\tau-h} = \frac{1}{T}\sum_{t=1}^{T}\left|e^{j}_{\tau-h,t}\right|, \quad h = \{6, 9, 12, 18\}, t = 1986, \ldots, 2017,$$

$$(6)\quad RMSE^{j}_{\tau-h} = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(e^{j}_{\tau-h,t}\right)^{2}}, \quad h = \{6, 9, 12, 18\}, t = 1986, \ldots, 2017.$$

For optimal forecasts, we expect that both measures of forecast errors, MAE and RMSE, to decrease for a shorter forecast horizon.

Additionally, forecast improvement over time is examined using the following approach suggested by Bailey and Brorsen (1998) and Sanders and Manfredo (2003):

$$(7)\quad \left|pe^{j}_{\tau-h,t}\right| = \beta^{j}_{0,\tau-h} + \beta^{j}_{1,\tau-h}t + u^{j}_{\tau-h,t}, \quad h = \{6, 9, 12, 18\}, t = 1986, \ldots, 2017.$$

This equation measures whether the forecast error of a component increases over time. The null hypothesis is $\beta^{j}_{1,\tau-h} = 0$, which indicates that there is no systematic change in the size of the forecast error. If $\beta^{j}_{1,\tau-h} > 0$, the forecast becomes less accurate over time as evidenced by larger errors. If $\beta^{j}_{1,\tau-h} < 0$, the forecast improves over time as the errors are becoming smaller.

Results

Test of bias results for unit errors and percent errors are shown in panels A and B of Table 1, respectively. Our results are consistent with Kuethe, Hubbs, and Sanders' (2018) findings of underestimation in long horizon forecasts. For example, the 18-month ahead forecasts of NCI are on average $9.5 billion or 10.81% lower than the official estimate. This bias in NCI forecasts declines rapidly across the forecasting cycle, but is still significant in 12-month ahead forecasts for both unit and percent errors and in 9-month ahead forecasts for percent errors, with only 6-month ahead errors being not significantly different from zero using either measure.

Our findings for the components of the NCI forecasts indicate that crop and livestock receipts are the likely sources of this bias in forecasting errors. For example, the 18-month ahead forecasts of crop receipts are on average about $6.07 billion or 3.96% lower than the official estimate and the livestock receipt forecasts are $4.47 billion or 3.11% lower. [5] While this bias in livestock receipt forecasts is not observed beyond the 18-month horizon, underestimation in crop receipt forecasts persists throughout the forecasting cycle with positive errors in 6-month ahead forecasts averaging $1.63 billion or 0.97%. Other components of the NCI forecasts do not exhibit evidence of persistent bias with the only evidence of overestimation in 9-month ahead government payments forecasts and underestimation in 18-month ahead cash expenses forecasts.

[5] Note that 18-months ahead forecasts are partially based on expert price forecasts obtained prior to the start of the WASDE forecasting cycle.

Figure 3 shows that underestimation in 18-month ahead GCI and EXP forecasts frequently tend to offset each other to result in smaller NCI forecast error due to accounting equation (1). Only in 7 out of 32 years included in this study, errors in GCI and EXP were made in opposite directions thus combining into larger NCI errors. Table 2 shows Pearson correlation coefficients and demonstrates that positive correlation between GCI and EXP errors, that helps to reduce NCI errors, is present in both 18- and 12-months ahead forecasts, but not at shorter horizons. While GCI errors appear to drive NCI forecast errors at 18 months, both GCI and EXP errors are significantly correlated with NCI errors at other forecast horizons. On the other hand, since errors across GCI components are added up, a negative correlation between these errors would result in smaller GCI errors. Table 3 shows that the only evidence of large negative correlation across these components is detected between crop receipts and government payments at 18-months ahead horizon. Table 3 also demonstrates that livestock receipts is the largest contributor to GCI errors at 18-months horizon, but farm related income is most highly correlated component with GCI errors at other forecast horizons.

Table 4 demonstrates how percent errors in NCI are correlated with the percent errors in individual components. These results demonstrate that errors in all five components are contributing to errors in NCI, but with different magnitude. This analysis highlights that errors in expenses are a large contributor to NCI errors along with errors in livestock and crop receipts. Errors in government payments and farm related income also have a significant correlation with NCI errors, but of a much smaller magnitude.[6] For example, an increase in cash expense errors by 1% will decrease NCI errors by about 2.38 to 2.52 across the forecasting horizon percentage points. On the other hand, an increase in farm related income errors by 1% would increase NCI error by only 0.1 to 0.15 percentage points across the forecasting horizon. The magnitude of these coefficients does not change much across the forecasting cycle. These findings are consistent with our previous results for unit errors as they reflect the relative size of the components, where expenses are typically a larger category compared to crop or livestock receipts.

Figures 4 and 5 show changes in MAE and RMSE, respectively. Both measures suggest that forecast errors decline across the forecasting cycle with the largest decline taking place between 18- and 12-months ahead forecasts when MAE of NCI forecasts declines from about $11 billion to $6 billion. This decline in errors between 18- and 12-month ahead forecasts is also very pronounced for livestock and crop receipts while the decline in expenses and government payments errors is more gradual. Farm related income errors appear to be stable throughout the forecast horizon without much decline. On average, the magnitude of NCI and EXP errors appears the largest, followed by FRI, crop and livestock receipts. Errors in government payments tend to be the smallest relative to other categories.[7]

[6] This could be due to the size of government payment and farm related income categories, which is much smaller than the other NCI components.

[7] Note that due to source information, estimates for different components are finalized at different points in time. For example, much is still not known about the information required by ERS in its estimates for crops receipts when ERS official estimates are released in August of year t+1. For example, official estimates still rely on a forecast of the monthly marketing percentages for the current and previous years. In contrast, the official estimate for direct government payments released in August of year t+1 a completed estimate.

Table 5 shows changes in the size of percent errors in NCI and its components over time. This analysis shows whether a linear time trend fitted to the errors has a significant positive or negative slope. Significant negative coefficient indicates a reduction in errors over time. This is observed in 18- and 12-month ahead EXP forecasts where the errors declined by about 0.09 percentage points a year during 1986-2017. On the other hand, errors in 18-month ahead LR and 6-month ahead NCI forecasts increased over time. Figures 6 and 7 examine these patterns in more detail. Figure 6 shows that errors in livestock receipts forecasts have become larger since the early 2000s, suggesting a sudden shift in the size of errors rather than a gradual increase. These changes are likely associated with structural changes in the livestock industry associated with increased concentration and greater influence of international trade that made this category more difficult to forecast. Figure 7 suggests that an increasing trend in 6-month ahead NCI forecasts is driven by large errors in 2011, 2012, and 2015. In these years, errors in receipts and expenses were made in opposite directions and thus, tended to compound each other. Outside of these three years, the errors tended to remain in the normal range.

Summary and Conclusions

This study sought to examine the accuracy of the USDA's net cash income forecasts and its components over 1986-2017.[8] Our findings provide a number of important insights about these forecasts:

1. Consistent with the findings of Kuethe, Hubbs, and Sanders (2018), long term (18- and 12-month ahead) NCI forecasts underestimate the official estimate.
2. Crop receipts forecasts appear to be the main source of this bias as underestimation in crop receipts persists throughout the forecasting cycle.
3. Forecast errors in gross cash income and cash expenses are positively correlated at 18- and 12-month horizon and thus, tend to offset each other in calculating NCI.
4. The main contributors to NCI forecast errors are errors in expenses and in crop and livestock receipts.
5. Errors for all components except farm related income tend to decline over the forecasting cycle, especially between 18- and 12-month ahead forecasts.
6. There is not much evidence of forecast errors becoming larger or smaller over time except for 18-month ahead livestock receipts forecasts that became more volatile since 2000.

These findings reveal sources of errors in the NCI forecasts. Better forecasts of each component will help improve NCI forecasts, which, in turn, will enhance farm income forecasts. Farm income forecast accuracy is critical for agricultural policy design, implementation and analysis.

[8] Note that while McGath et al (2009) describes the basic models underlying these forecasts, several major changes to the forecasting and estimation procedures have been implemented in 2014.

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Table 1. Tests of Bias in Net Cash Income Forecasts and Its Components

	Initial h=18		August h=12		November h=9		February h=6	
Panel A: Unit Errors								
CR	6.07	***	2.69	***	2.21	***	1.63	***
LR	4.47	***	0.71		0.53		-0.03	
GP	1.11		-0.04		-0.72	**	-0.23	
FRI	1.27		-0.12		-0.07		0.61	
GCI	12.88	***	3.39	**	1.95		1.97	
EXP	3.70	*	0.99		-0.58		-0.13	
NCI	9.55	***	3.59	*	2.53		2.10	
Panel B: Percent Errors								
CR	3.96	***	1.91	***	1.40	***	0.97	**
LR	3.11	**	0.53		0.34		-0.03	
GP	6.66		-0.85		-4.57	**	-1.36	
FRI	9.28		1.14		-0.01		5.27	
EXP	1.74	**	0.59		-0.18		0.00	
NCI	10.81	***	4.27	**	2.57	*	2.26	

Note. CR=crop cash receipts; LR=livestock receipts; GP=government payments; FRI=farm related income; EXP=cash expenses; GCI=gross cash income; NCI=net cash income. Single, double and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level, respectively.

Table 2. Pearson Correlations among Errors in Gross Cash Income, Expenses and Net Cash Income

h=18

	GCI		*EXP*		*NCI*
GCI	1.00				
EXP	0.64	***	1.00		
NCI	-0.10		0.69	***	1.00

h=12

	GCI		*EXP*		*NCI*
GCI	1.00				
EXP	0.50	***	1.00		
NCI	0.61	***	-0.39	**	1.00

h=9

	GCI		*EXP*		*NCI*
GCI	1.00				
EXP	0.27		1.00		
NCI	0.75	***	-0.44	***	1.00

h=6

	GCI		*EXP*		*NCI*
GCI	1.00				
EXP	0.26		1.00		
NCI	0.72	***	-0.49	***	1.00

Note: GCI=gross cash income; EXP=cash expenses; NCI=net cash income. Single, double and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level, respectively.

Table 3. Pearson Correlations among Errors in Gross Cash Income and Its Components

h=18

	CR	*LR*	*GP*	*FRI*	*GCI*
CR	1.00				
LR	0.34 *	1.00			
GP	-0.54 ***	0.16	1.00		
FRI	-0.23	-0.11	-0.07	1.00	
GCI	0.55 ***	0.91 ***	0.09	0.09	1.00

h=12

	CR	*LR*	*GP*	*FRI*	*GCI*
CR	1.00				
LR	0.04	1.00			
GP	-0.26	0.30	1.00		
FRI	-0.04	-0.14	0.04	1.00	
GCI	0.45 ***	0.47 ***	0.38 **	0.60 ***	1.00

h=9

	CR	*LR*	*GP*	*FRI*	*GCI*
CR	1.00				
LR	0.09	1.00			
GP	0.09	0.21	1.00		
FRI	-0.03	-0.03	-0.08	1.00	
GCI	0.59 ***	0.39 **	0.29	0.67 ***	1.00

h=6

	CR	*LR*	*GP*	*FRI*	*GCI*
CR	1.00				
LR	0.03	1.00			
GP	-0.01	0.01	1.00		
FRI	0.02	0.13	0.06	1.00	
GCI	0.50 ***	0.40 **	0.19	0.81 ***	1.00

Note. CR=crop cash receipts; LR=livestock receipts; GP=government payments; FRI=farm related income; GCI=gross cash income. Single, double and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level, respectively.

Table 4. Correlations among Percent Errors in Net Cash Income and Its Components.

	Initial h=18		August h=12		November h=9		February h=6	
Intercept	2.61	***	0.54	*	0.20		0.19	
CR	1.36	***	1.42	***	1.62	***	1.71	***
LR	1.55	***	1.58	***	1.60	***	1.82	***
GP	0.16	***	0.21	***	0.19	***	0.15	***
FRI	0.10	***	0.14	***	0.15	***	0.13	***
EXP	-2.48	***	-2.38	***	-2.39	***	-2.52	***
R-squared	0.96		0.98		0.97		0.97	
Adjusted R-squared	0.96		0.97		0.96		0.97	

Note: CR=crop cash receipts; LR=livestock receipts; GP=government payments; FRI=farm related income; EXP=cash expenses. Single, double and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level, respectively.

Table 5. Changes in the Absolute Percent Errors Over Time (1986-2017).

	Initial h=18		August h=12		November h=9	February h=6	
CR	0.00		-0.05		-0.06	0.01	
LR	0.15	*	-0.05		-0.02	-0.01	
GP	-0.32		-0.07		0.12	-0.11	
FRI	0.37		0.30		0.43	0.63	
EXP	-0.09	*	-0.08	*	-0.04	0.03	
NCI	0.15		0.16		0.16	0.22	**

Note. CR=crop cash receipts; LR=livestock receipts; GP=government payments; FRI=farm related income; EXP=cash expenses; NCI=net cash income. Single, double and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level, respectively.

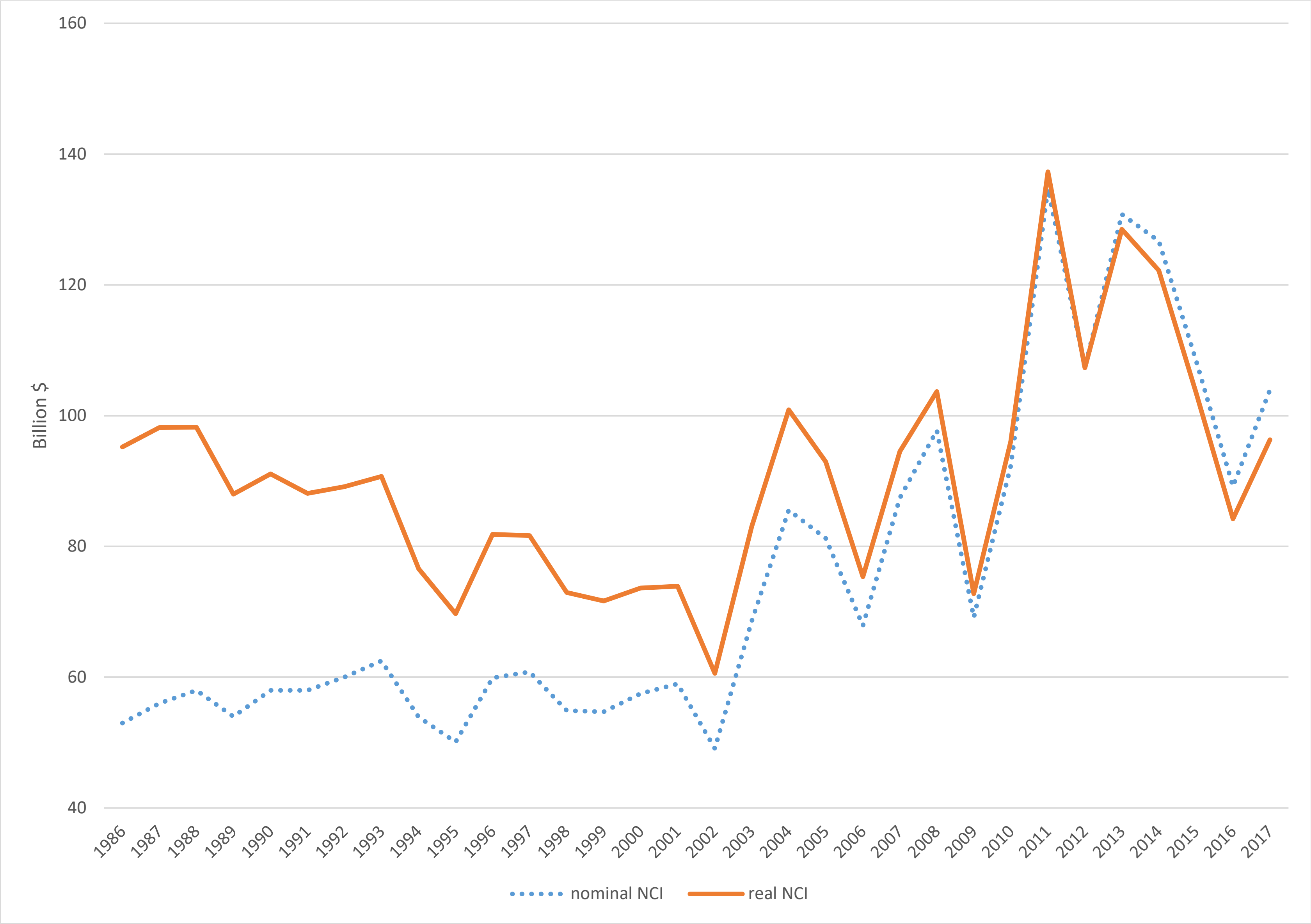

Figure 1. Nominal and Real Official Estimates of Net Cash Income, 1986-2017.

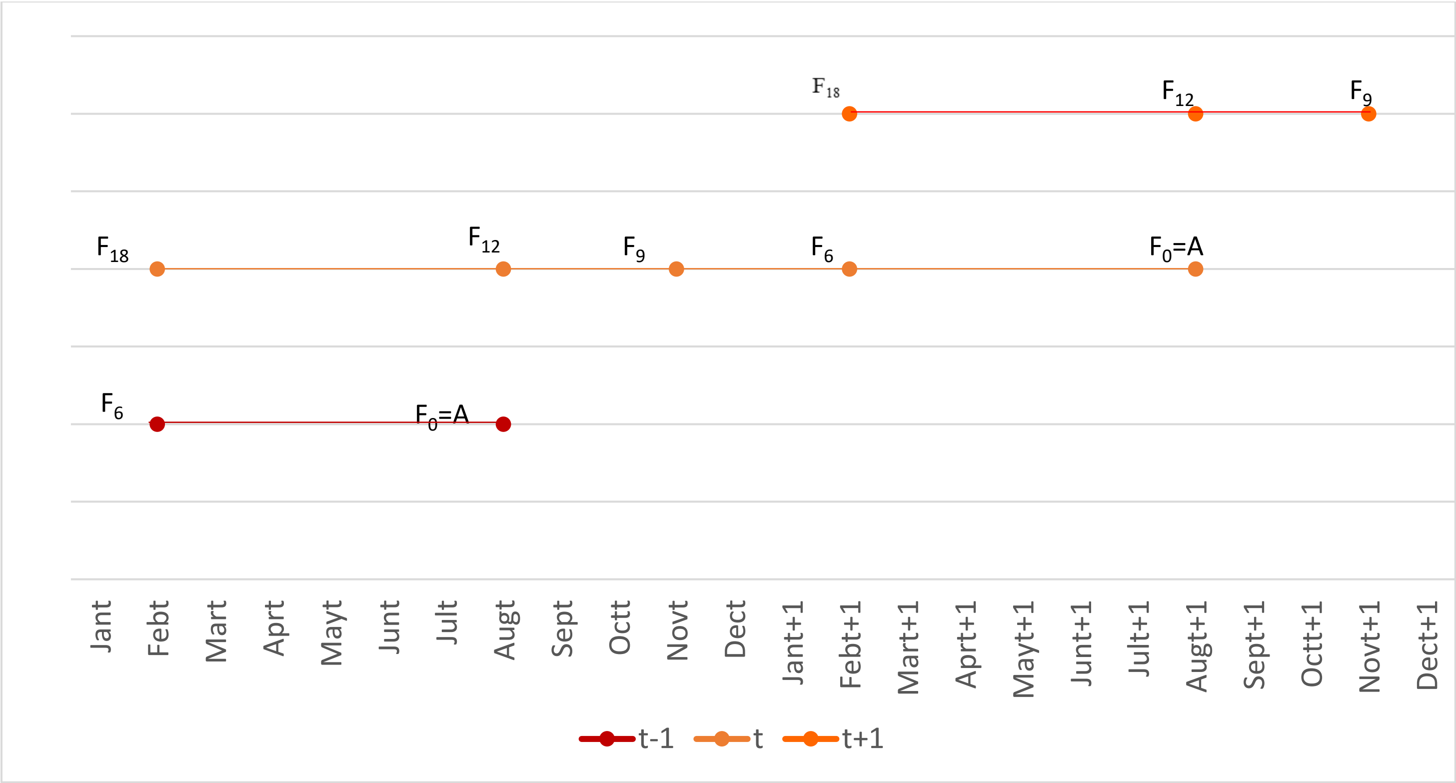

Figure 2. Forecasting Cycle for Net Cash Income Forecasts.

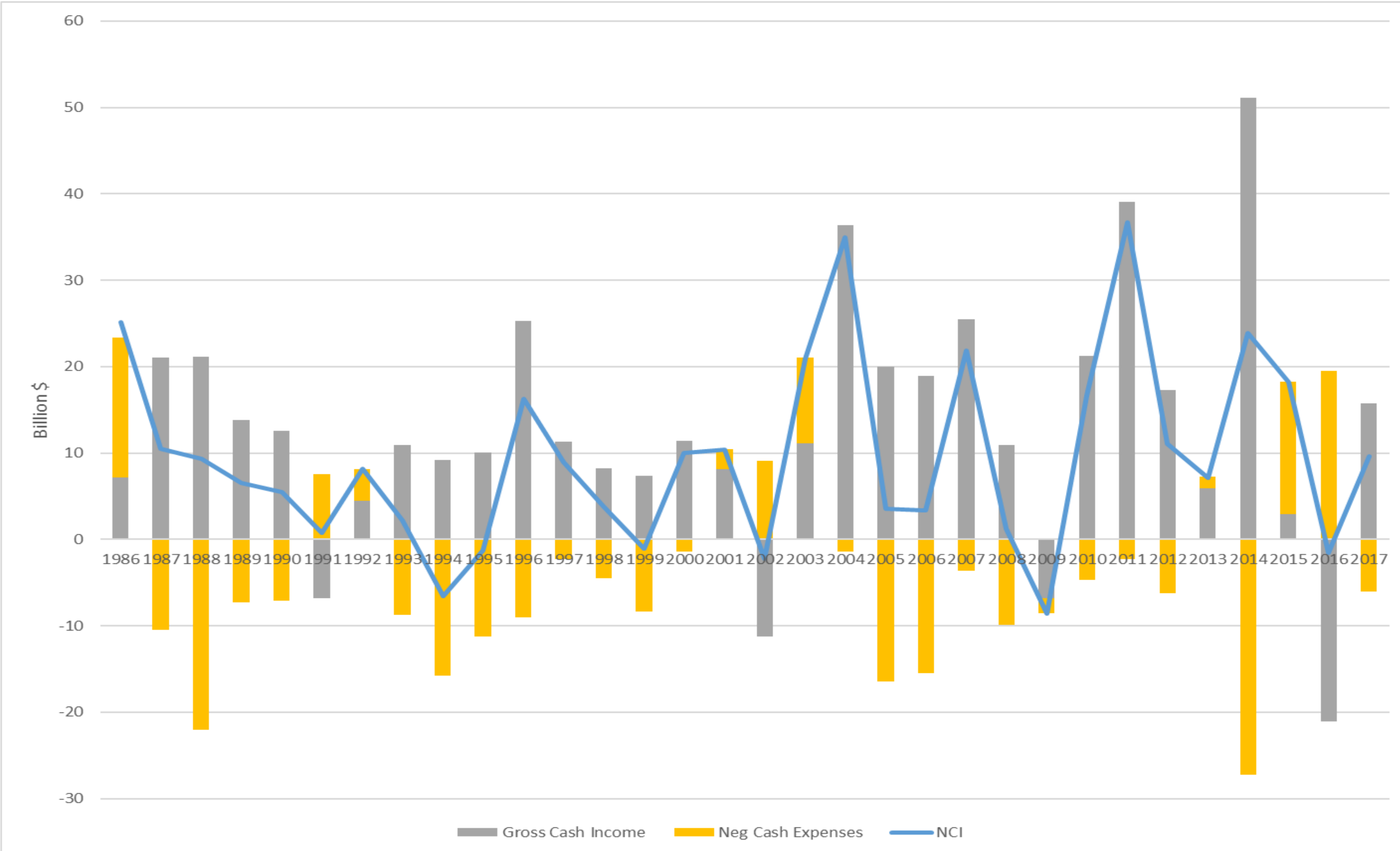

Figure 3. Additivity of Errors in 18-months ahead NCI Forecasts.

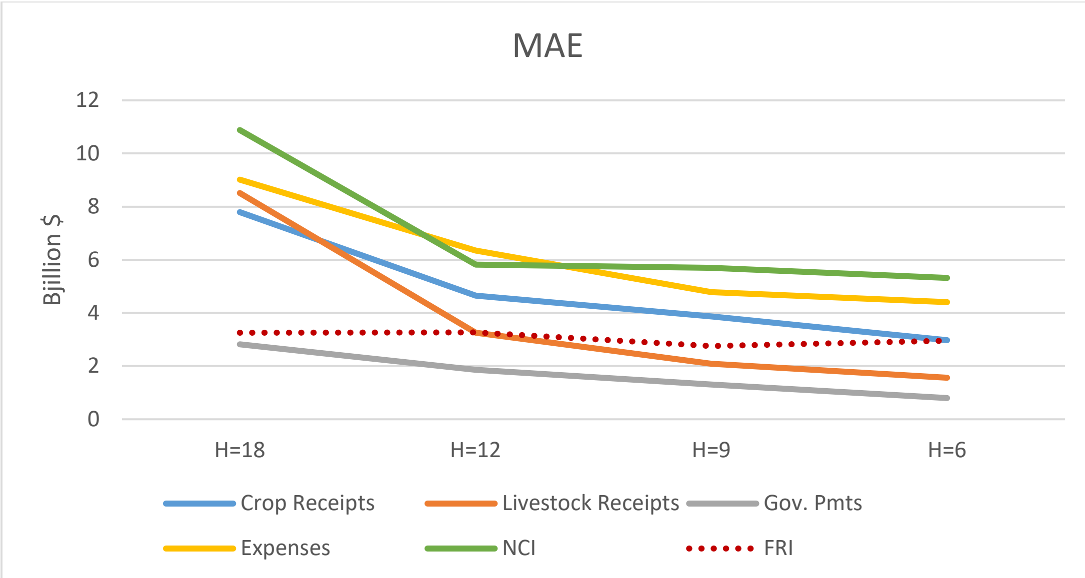

Figure 4. Changes in Mean Absolute Error across Forecasting Cycle.

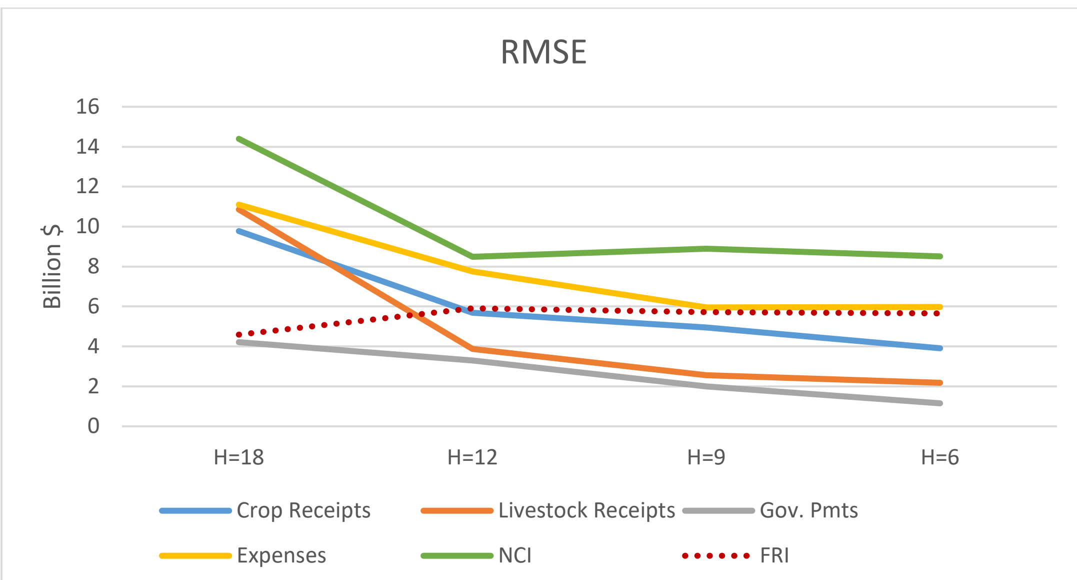

Figure 5. Changes in Root Mean Squared Error across Forecasting Cycle.

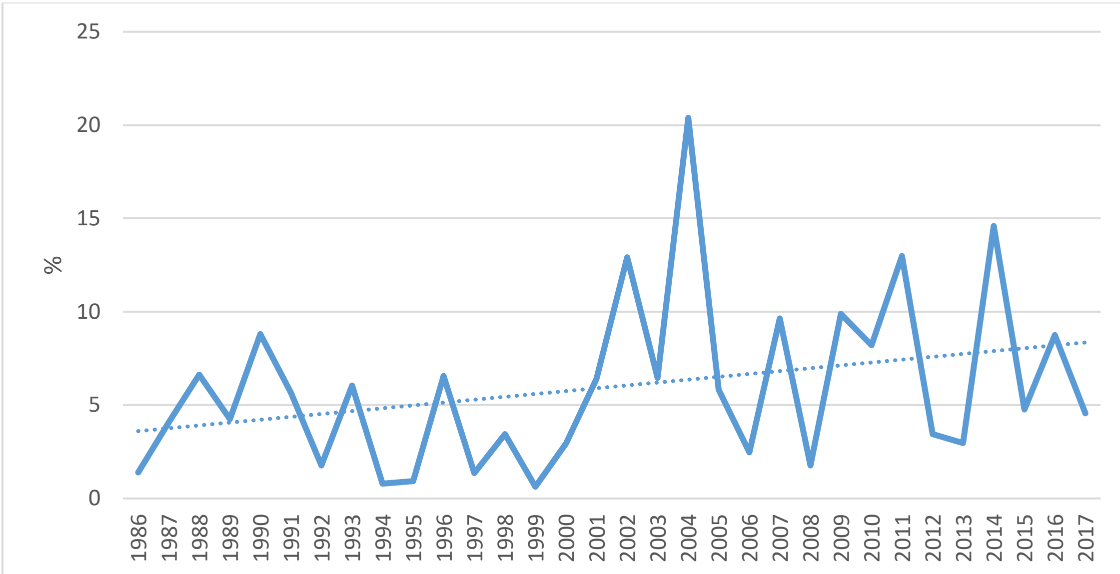

Figure 6. Changes in 18-month Ahead Livestock Receipts Absolute Percent Errors over Time.

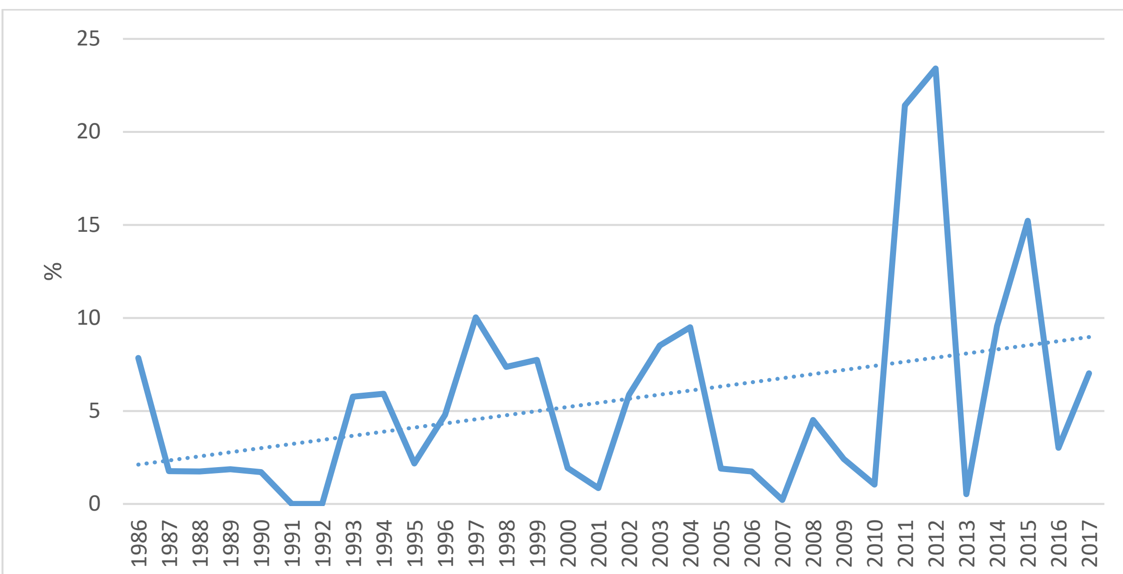

Figure 7. Changes in 6-month Ahead Net Cash Income Percent Errors over Time.