Historical performance of the Consensus Economic Forecasting Commission

A MEASUREMENT ERROR ANALYSIS OF THE CEFC FORECASTS & RELATED COMPONENTS

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Executive Summary

This report builds on previous analyses that focus on the historical performance of the Consensus Economic Forecasting Commission (CEFC). It includes an analysis of the accuracy of all variables forecast during the CEFC meetings. Additionally, it adds a new analysis of the historical performance of Moody's Analytics and IHS Markit[1] forecasts that are used during the CEFC forecasting process.

The CEFC forecast performs relatively well, though meets expected challenges during recessions and economic downturns. CEFC forecasts for some variables perform much better than others; for example, wage & salary employment, total personal income, wage & salary income and consumer price index (CPI-U) forecasts on average fall within 1.5 percentage points of actual values at all lead times, while others like corporate profits and nonfarm proprietors' income face average absolute deviations well over 4 percentage points. Additionally, the CEFC tends to underestimate growth rates, particularly for longer-run forecasts.

Moody's & IHS forecasts show overall similar results as the CEFC. When comparing these two proprietary models, neither largely outperforms the other in near-term forecasts, while IHS more often outperforms Moody's on medium- and long-run forecasts for some variables.

Detailed results from this analysis can be found in the following report.

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[1] Following a February 2022 merger, IHS Markit is now part of S&P Global.

Context

The Consensus Economic Forecasting Commission (CEFC) is responsible for providing economic forecasts to Maine's Governor, legislature, and Revenue Forecasting Committee. The accuracy of these forecasts is crucial, as it is used as a direct input in the state's revenue forecast and thus plays a critical role in Maine's budgetary process.

This report provides a follow-up to analyses conducted in 2009 and 2019. The most recent report in 2019 provided analysis on the accuracy of CEFC forecasts for Maine wage & salary employment, total personal income, wage & salary income, and the Consumer Price Index (CPI-U). In addition to providing an update to this analysis, this report also evaluates the accuracy of other key personal income components and before-tax corporate profits as well as the two proprietary forecast sources used by the CEFC: Moody's Analytics and IHS Markit (now S&P Global).

Data

Data for this analysis was collected from the CEFC forecast database created as part of the 2019 analysis. All CEFC forecasts and historical actuals that are newly available since the Spring 2019 report were added to the database. Data for Moody's and IHS forecast vintages were collected from historical data downloads that are kept in State Economist file archives. Details about the years of availability for CEFC, Moody's and IHS forecasts can be found in the Appendix.

Methodology:

I.   Error metrics and tests

This analysis relies on two primary error metrics: mean/median error and mean absolute error. Errors were calculated using the most recently available historical actuals. This analysis does not address revisions to historical actuals.

a. Mean Error (ME) is the average of the errors, or the average deviation between the forecast and the historical actual value. This metric is used to evaluate whether there is a tendency of the forecast to deviate negatively or positively; in other words, whether forecasts tend to over- or under-estimate growth. Mathematically, this metric is expressed as:

$$ME = \frac{1}{n}\sum F_t - Y_t$$

b. Mean Absolute Error (MAE) is the average of the absolute value of errors. This metric is used to evaluate the overall accuracy of the forecasts, as it demonstrates the average deviation from actual values. This metric ignores whether errors are positive or negative, and instead measures absolute deviation. Mathematically, MAE is expressed as:

$$MAE = \frac{\sum_i^n |F_t - Y_t|}{n} = \frac{\sum_i^n |e_i|}{n}$$

Where:

F = Forecast, and

Y = Observed actual

In this report, error is calculated as the difference between the forecast for variable v in a given year t over lead l. In other words, ME and MAE are calculated separately for each lead period; thus, we

evaluate how CEFC, Moody's and IHS forecast accuracy differs depending on how many years in the future it forecasts. To generate statistically valuable results and increase the observations used in analysis, lead periods are aggregated into three buckets: -1 to 0 years, 1-2 years, and 3-5 years out.

Other error metrics were considered but ultimately not used for this analysis in the interest of both statistical validity as well as interpretability.

Finally, evaluation of Moody's and IHS errors builds on ME and MAE by employing a sign test to compare performance based on absolute errors. These comparisons allow for exploration into whether one of the proprietary forecasts performs better than the other.

II.   Outliers

Outliers are determined using the Interquartile Range Rule. Using this rule, an observation[2] is determined to be an outlier if its error (forecast minus actual) is more than 1.5 times the interquartile range (IQR) lower than the 25th percentile or greater than the 75th percentile. For a summary of outliers for CEFC, Moody's and IHS observations, see the table below.

Analysis for all variables was completed twice: once for all observations and once excluding outliers.

Table 1. Summary of outliers

Error outliers	Interquartile Range	Lower threshold (percentage points)	Upper Threshold (percentage points)	Number of outliers	Percent Outliers
CEFC	2.1 percentage points	-4.55	3.85	227	13.3%
Moody's*	2.9 percentage points	-6.35	5.25	130	11.9%
IHS*	2.5 percentage points	-5.45	4.55	171	13.5%

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*The IQRs for Moody's and IHS are larger than for the CEFC. One reason for this may be due to the years available for analysis. The CEFC sample includes all forecasts starting in 1992, and errors were significantly smaller from 1992-2004. Conversely, Moody's and IHS forecast history only goes back to April 2009 and November 2004, respectively, when errors tended to be higher. Given the wider spread of errors for these two forecasts, fewer outliers are expected.

Notably, no outliers occurred for CEFC forecasts made between December 1992-April 2004.

Figure 1 details the percent of CEFC observations that are outliers by date of forecast. Orange bars indicate that the national economy was in recession at the time of forecast; 29.9% of forecasts made during recessions were outliers, compared to 12.0% during expansions. Overall, the period from November 2007-November 2008, at the start of the Great Recession, had the most outliers. Forecasts surrounding recession years tend to have higher errors.

Figure 1. percent of CEFC observations marked as outliers, by date of forecast

% of CEFC Observations marked as outlier, by date of forecast
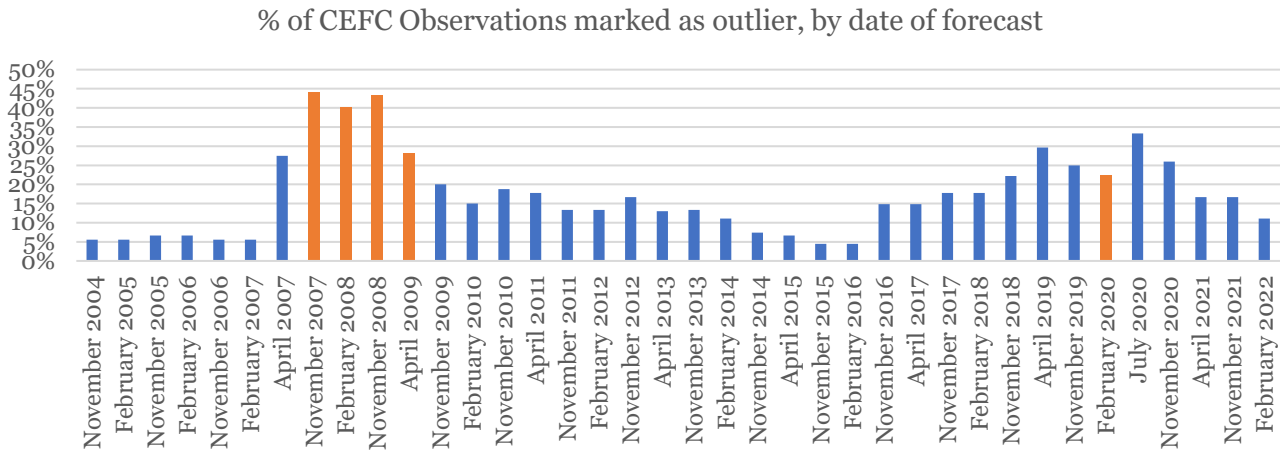
Figure 2 demonstrates that the CEFC's forecast accuracy, as described by the percent of observations marked as outliers, varies widely across the forecasted variables. For example, almost 60% of the observations for corporate profits have abnormally high levels of error, while 0% of CPI forecasts are outliers.

Figure 2. percent of CEFC observations marked as outliers, by variable forecasted

Percent of CEFC observations marked outlier, by variable
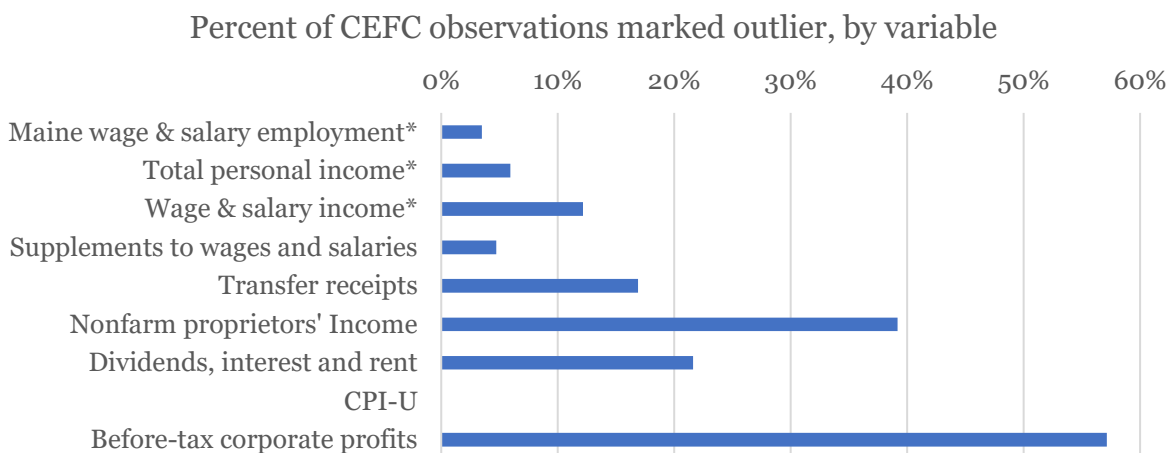
*available from 1992-2022; includes many more observations than other variables

Results:

    I.   **CEFC forecast accuracy**

Mean and Median Error (ME) Summary:

The CEFC tends to underestimate growth, particularly for long-term forecasts. Mean error is negative for every variable except for wages & salaries, transfer receipts, and corporate profits in the long run, and is negative for every variable in the long run when excluding outliers.

The sample with no outliers shows more underestimation than the full sample. This may be due to the qualities of outliers; since they tend to occur more often around recessions (when growth is lower than expected), the full sample is more heavily influenced by the overestimation of these outliers.

Table 2. Mean error summary by lead time

Mean Error (percentage points), by lead time	Pooled			No outliers		
	-1 to 0 years	1-2 years	3-5 years	-1 to 0 years	1-2 years	3-5 years
Wage & Salary Employment	0.1	(0.3)	(0.6)	0.1	(0.1)	(0.3)
Total personal income	0.2	0.2	(0.4)	0.1	0.0	(0.2)
Wages & Salaries	0.5	(0.2)	0.0	0.0	(0.4)	(0.7)
Supplements to Wages & Salaries	(0.0)	(0.8)	(0.7)	(0.2)	(0.7)	(0.3)
Transfer receipts	0.2	2.5	0.8	(0.4)	(0.3)	(0.4)
Nonfarm proprietors' income	(1.4)	(0.6)	(1.2)	(1.3)	(1.8)	(1.4)
Dividends, Interest and Rent	(0.3)	(1.3)	(1.4)	(0.2)	(0.6)	(1.1)
CPI-U	0.1	0.0	(0.1)	0.1	0.0	(0.1)
Before-tax corporate profits	(0.7)	0.8	5.1	(1.5)	(0.1)	(1.2)

*note: number of observations is significantly reduced for the sample without outliers for corporate profits and nonfarm proprietors' income, given high numbers of outliers for those variables.

Performing the same analysis using median instead of mean reduces the impact of extreme values. Results for median error show very similar patterns as above: that that CEFC tends to underestimate growth in longer-run forecasts. The CEFC also more consistently underestimates supplements to wages & salaries, transfer receipts, nonfarm proprietors' income, and before-tax corporate profits for all lead times but doesn't significantly overestimate growth for any variable.

Table 3. Median error summary by lead time

Median Error (percentage points), by lead time	Pooled			No outliers		
	-1 to 0 years	1-2 years	3-5 years	-1 to 0 years	1-2 years	3-5 years
Wage & Salary Employment	0.1	(0.2)	(0.5)	0.1	(0.2)	(0.5)
Total personal income	0.0	0.1	(0.1)	0.0	0.1	(0.1)
Wages & Salaries	0.1	(0.3)	(0.2)	(0.1)	(0.4)	(0.5)
Supplements to Wages & Salaries	(0.4)	(1.1)	(1.2)	(0.6)	(1.0)	(0.9)
Transfer receipts	(0.5)	0.3	(0.4)	(0.4)	0.2	(0.4)
Nonfarm proprietors' income	(2.3)	(2.2)	(2.2)	(2.1)	(2.2)	(2.2)
Dividends, Interest and Rent	0.1	(0.7)	(1.2)	0.1	(0.6)	(1.2)
CPI-U	0.0	(0.2)	(0.2)	0.0	(0.2)	(0.2)
Before-tax corporate profits	(2.1)	(5.0)	0.7	(1.6)	(0.1)	(1.8)

Excluding pandemic years

The COVID-19 Pandemic caused myriad unforeseen outcomes. The shortest recession on record also came with historically deep employment loss and extensive federal investment in COVID-19 aid that led to sharp growth in transfer receipts, among many other effects. Later on, external forces such as supply chain challenges, childcare shortages, and uncertainty about variants caused volatility to persist. That said, growth in the forecasted variables became much less easily predictable during the pandemic years, and the CEFC faced greater levels of uncertainty than ever before. The following table removes forecasted years 2020-2022 to evaluate errors preceding such uncertainty.

Removing pandemic years continues to show that the CEFC forecast consistently underestimates growth rates. However, unlike the full sample, all variables show underestimation in nearly all lead periods. There are no variables that are significantly overestimated. This result is even more pronounced when excluding outliers.

Table 4. Mean Error summary, excluding pandemic years

Mean Error (percentage points), by lead time (excluding pandemic years)	Pooled			No outliers		
	-1 to 0 years	1-2 years	3-5 years	-1 to 0 years	1-2 years	3-5 years
Wage & Salary Employment	0.1	(0.2)	(0.7)	0.1	(0.2)	(0.6)
Total personal income	(0.0)	(0.2)	(0.8)	(0.0)	(0.1)	(0.5)
Wages & Salaries	0.0	(0.9)	(0.7)	0.0	(0.4)	(0.7)
Supplements to Wages & Salaries	(0.4)	(1.1)	(1.2)	(0.4)	(1.0)	(0.8)
Transfer receipts	(0.2)	0.2	(1.2)	(0.2)	(0.5)	(0.8)
Nonfarm proprietors' income	(2.2)	(1.4)	(2.3)	(1.9)	(1.8)	(1.4)
Dividends, Interest and Rent	(0.2)	(1.1)	(1.1)	(0.0)	(0.2)	(0.7)
CPI-U	0.1	(0.1)	(0.2)	0.1	(0.1)	(0.2)
Before-tax corporate profits	(2.3)	(3.3)	0.2	(1.5)	(0.1)	(1.2)

*note: number of observations is significantly reduced for the sample without outliers for corporate profits and nonfarm proprietors' income, given high numbers of outliers for those variables.

Mean Absolute Error (MAE) Summary:

Overall, the CEFC's forecasts for CPI-U and wage & salary employment are the most accurate, while forecasts for nonfarm proprietors' income and before-tax corporate profits are the least accurate over the full sample. That said, before-tax corporate profits and nonfarm proprietors' income are also the most volatile, having among the largest standard deviations for historical actuals[3]. Forecasts for the CPI-U are within one percentage point of the actual, on average. Forecasts are typically more accurate in the short run and become less accurate with more years of lead time, with the major exception of nonfarm proprietors' income, which has lower mean absolute error with greater lead time.

Table 5. Mean Absolute Error summary

Mean Absolute Error (percentage points), by lead time	Pooled			No outliers		
	-1 to 0 years	1-2 years	3-5 years	-1 to 0 years	1-2 years	3-5 years
Wage & Salary Employment	0.5	1.1	1.4	0.4	0.9	1.1
Total personal income	1.1	1.4	1.5	1.1	1.1	1.1
Wages & Salaries	1.0	1.8	1.7	0.6	0.9	1.2
Supplements to Wages & Salaries	1.5	1.9	2.0	1.4	1.8	1.7
Transfer receipts	2.5	4.2	3.4	1.3	1.6	1.6
Nonfarm proprietors' income	6.3	5.9	4.4	2.3	2.3	2.0
Dividends, Interest and Rent	2.4	3.3	2.6	1.6	1.9	1.5
CPI-U	0.3	0.8	0.9	0.3	0.8	0.9
Before-tax corporate profits	5.8	9.4	8.6	2.1	1.2	2.3

*note: number of observations is significantly reduced for the sample without outliers for corporate profits and nonfarm proprietors' income, given high numbers of outliers for those variables.

Table 6. Mean absolute error summary, restricted to 2007-2022

Mean Absolute Error (percentage points), by lead time - 2007-2022	Pooled			No outliers		
	-1 to 0 years	1-2 years	3-5 years	-1 to 0 years	1-2 years	3-5 years
Wage & Salary Employment*	0.5	1.4	1.5	0.3	0.9	1.1
Total personal income*	1.0	1.9	1.7	1.0	1.3	1.2
Wages & Salaries	1.0	1.8	1.7	0.6	0.9	1.2
Supplements to Wages & Salaries	1.5	1.9	2.0	1.4	1.8	1.2
Transfer receipts	2.5	4.2	3.4	1.3	1.6	1.6
Nonfarm proprietors' income	6.3	5.9	4.4	2.3	2.3	2.0
Dividends, Interest and Rent	2.4	3.3	2.6	1.6	1.9	1.5
CPI-U*	0.2	1.0	1.0	0.2	1.0	1.0
Before-tax corporate profits^	5.8	9.4	8.6	2.1	1.2	2.3

*W&S employment, Total Personal Income, and CPI-U are the only variables that changed in this table.

^Before-tax corporate profits only available 2011-2021
note: number of observations is significantly reduced for the sample without outliers for corporate profits and nonfarm proprietors' income, given high numbers of outliers for those variables.

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[3] See Table 1 of appendix for more details

<u>Excluding pandemic years</u>

Excluding pandemic year forecasts, MAE tends to be less than when including all forecasts. Exceptions are DIR and nonfarm proprietors' income, which have slightly higher absolute errors when excluding pandemic years.

Table 7. Mean Absolute Error summary, excluding forecasts for pandemic years

| **Mean Absolute Error (percentage points), by lead time - excluding pandemic years (forecasted years through 2019)**	Pooled			No outliers		
	-1 to 0 years	1-2 years	3-5 years	-1 to 0 years	1-2 years	3-5 years
Wage & Salary Employment	0.4	0.8	1.1	0.4	0.8	1.0
Total personal income	1.0	1.1	1.3	1.0	1.0	1.0
Wages & Salaries	0.6	1.4	1.2	0.6	0.9	1.2
Supplements to Wages & Salaries	1.4	1.8	1.9	1.4	1.7	1.6
Transfer receipts	2.3	2.2	1.9	1.4	1.6	1.5
Nonfarm proprietors' income	6.9	5.9	4.1	2.4	2.3	2.0
Dividends, Interest and Rent	2.8	3.4	2.6	1.8	1.6	1.3
CPI-U	0.3	0.7	0.8	0.3	0.7	0.8
Before-tax corporate profits	4.7	6.2	3.2	2.2	1.2	2.3

note: number of observations is significantly reduced for the sample without outliers for corporate profits and nonfarm proprietors' income, given high numbers of outliers for those variables.

Figure 3. Mean Absolute Error, all years vs. excluding pandemic
Nonfarm proprietors' income and before-tax corporate profits excluded from figure for clarity
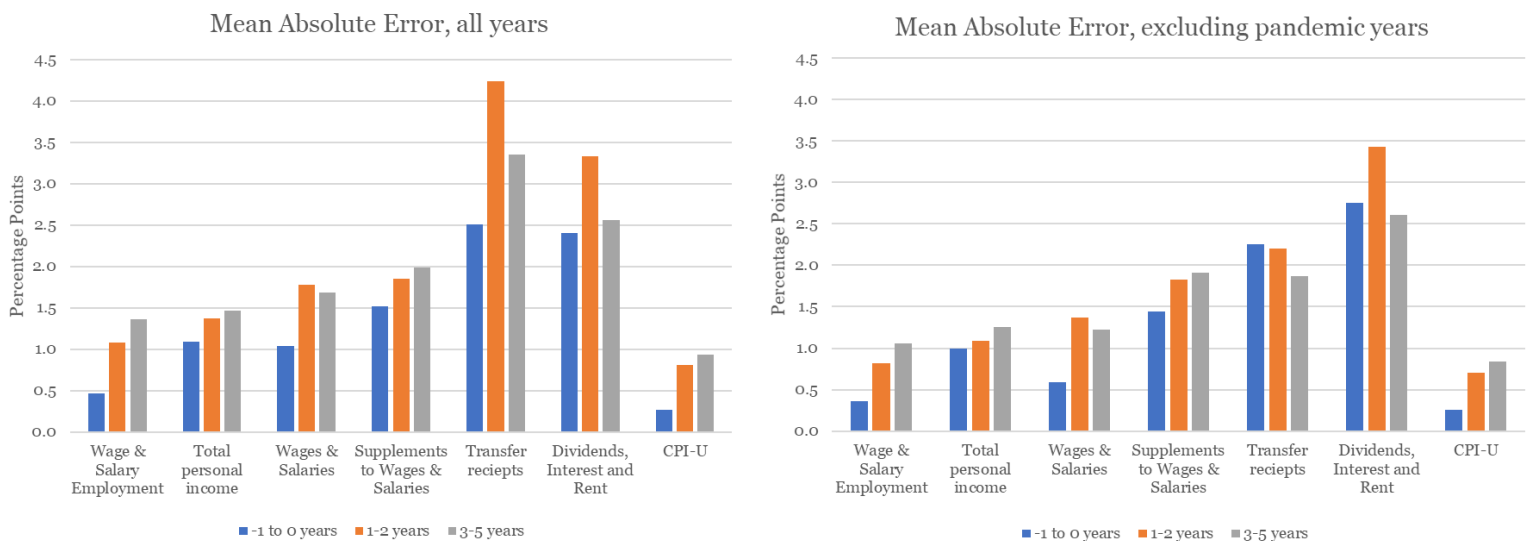
II.   Moody's and IHS forecast accuracy

Mean Error (ME) Summary

Like the CEFC forecast, Moody's and IHS forecasts tend to underestimate growth in the out-years while slightly overestimating growth in the short run.

Table 8. Mean Error (ME) Summary for Moody's & IHS forecasts, pooled

Mean Absolute Error (percentage points), pooled	Moody's			IHS		
	-1 to 0 years	1-2 years	3-5 years	-1 to 0 years	1-2 years	3-5 years
Wage & Salary Employment	0.1	(0.5)	(0.5)	0.1	(0.5)	(0.5)
Total personal income	0.3	0.3	0.2	0.1	0.4	(0.4)
Wages & Salaries	0.6	(0.2)	(0.2)	0.4	(0.5)	0.1
Supplements to Wages & Salaries	0.2	(0.3)	(0.3)	0.0	(0.9)	0.1
Transfer receipts	0.1	2.6	0.2	0.1	2.5	(0.7)
Nonfarm proprietors' income	0.1	(2.3)	(1.7)	(0.7)	0.3	(1.2)
Dividends, Interest and Rent	0.3	(0.8)	(1.8)	1.5	(1.7)	(2.8)
CPI-U	0.0	(0.3)	(0.6)	0.1	0.2	(0.2)
Before-tax corporate profits	(0.1)	(0.6)	1.2	(0.1)	2.4	6.6

Excluding outliers, underestimation is particularly common, likely because outliers tend to occur leading to recession years, which may contribute to overestimation in the full sample.

Table 9. Mean Error (ME) Summary for Moody's & IHS Forecasts, no outliers

Mean Error (percentage points), no outliers	Moody's			IHS		
	-1 to 0 years	1-2 years	3-5 years	-1 to 0 years	1-2 years	3-5 years
Wage & Salary Employment	0.2	0.1	0.0	0.2	(0.0)	0.1
Total personal income	0.3	(0.5)	0.3	(0.0)	(0.1)	(0.2)
Wages & Salaries	0.1	(1.1)	(1.2)	(0.0)	(0.6)	(0.6)
Supplements to Wages & Salaries	(0.0)	(0.3)	(0.3)	(0.1)	(0.9)	(0.3)
Transfer receipts	(0.0)	(0.2)	0.8	(0.6)	(0.5)	(0.8)
Nonfarm proprietors' income	(1.3)	(2.6)	(1.4)	(0.5)	(1.1)	(1.4)
Dividends, Interest and Rent	0.5	(1.2)	(1.0)	2.1	(1.0)	(0.2)
CPI-U	0.0	(0.3)	(0.6)	0.1	0.2	(0.2)
Before-tax corporate profits	(0.2)	(2.6)	(5.2)	(1.2)	0.9	0.4

*note: number of observations is significantly reduced for the sample without outliers for corporate profits and nonfarm proprietors' income, given high numbers of outliers for those variables.

Mean Absolute Error (MAE) Summary

As with the CEFC forecast, MAE was highest for before-tax corporate profits and nonfarm proprietors' income. MAE was lowest for wage & salary employment, CPI-U, and supplements to wages & salaries.

Table 10. Mean Absolute Error (MAE) Summary for Moody's & IHS Forecasts, pooled

Mean Absolute Error (percentage points)	Moody's			IHS		
	-1 to 0 years	1-2 years	3-5 years	-1 to 0 years	1-2 years	3-5 years
Wage & Salary Employment	0.6	1.3	1.7	0.6	1.2	1.6
Total personal income	1.2	2.4	1.9	1.2	1.7	1.7
Wages & Salaries	1.2	2.2	2.2	1.2	1.5	1.4
Supplements to Wages & Salaries	1.5	1.8	1.8	1.6	1.9	1.8
Transfer receipts	2.5	4.5	3.1	2.9	4.5	3.7
Nonfarm proprietors' income	5.3	5.3	4.2	6.2	5.8	4.4
Dividends, Interest and Rent	2.7	3.0	2.4	3.9	3.9	3.5
CPI-U	0.2	1.1	1.2	2.4	0.9	1.1
Before-tax corporate profits	4.7	8.7	9.6	5.6	9.8	8.5

Excluding outliers, before-tax corporate profits and nonfarm proprietors' income continues to show the highest MAE, while wage & salary employment and CPI-U have the lowest MAE.

Table 11. Mean Absolute Error (MAE) Summary for Moody's & IHS Forecasts, no outliers

Mean Absolute Error (percentage points), no outliers	Moody's			IHS		
	-1 to 0 years	1-2 years	3-5 years	-1 to 0 years	1-2 years	3-5 years
Wage & Salary Employment	0.4	1.1	1.4	0.5	0.8	1.2
Total personal income	1.2	1.9	1.8	1.1	1.4	1.7
Wages & Salaries	1.2	1.6	1.6	0.9	1.9	0.8
Supplements to Wages & Salaries	1.4	1.7	1.8	1.6	1.9	1.8
Transfer receipts	1.9	2.0	1.3	1.7	1.8	1.9
Nonfarm proprietors' income	2.3	2.4	2.2	2.0	1.9	2.2
Dividends, Interest and Rent	2.1	2.1	1.6	1.9	2.2	2.4
CPI-U	0.2	1.1	1.2	0.2	0.9	1.1
Before-tax corporate profits	2.1	3.2	3.1	2.6	2.5	2.6

*note: number of observations is significantly reduced for the sample without outliers for corporate profits and nonfarm proprietors' income, given high numbers of outliers for those variables.

Comparison of models

While the preceding sections demonstrate that ME and MAE differ slightly for each forecast model, we wish to evaluate whether these differences are statistically significant. Tests to compare means can be used to evaluate whether one model historically outperforms the other, and whether this may vary for different variables.

A t-test of means could be used to evaluate whether the MAE for Moody's and IHS is statistically significant, however this test relies on a normal distribution. MAE's measurement of *absolute* error means that it its distribution is heavily skewed right. For this reason, we rely on a non-parametric sign test. This can be used to test the hypothesis that the difference between two samples has zero median. In other words, we can test whether the difference between Moody's absolute error and IHS's absolute error is statistically different from zero, or whether one outperforms the other[4].

Neither model tends to outperform the other in the short run (-1 to 0 years out), except for before-tax corporate profits, which Moody's is better at. Otherwise, IHS outperforms Moody's on total personal income, wages and salaries, and CPI-U for 1–5-year lead times, while Moody's tends to do better at transfer receipts and dividends, interest and rent in the 3–5-year term.

Table 12. Results of sign test, Moody's vs. IHS forecasts

Better performer as determined by sign test	Better performer		
	-1 to 0 years	1-2 years	3-5 years
Wage & Salary Employment	--	--	--
Total personal income	--	IHS	IHS
Wages & Salaries	--	IHS	IHS
Supplements to Wages & Salaries	--	--	IHS
Transfer receipts	--	--	Moody's
Nonfarm proprietors' income	--	--	--
Dividends, Interest and Rent	--	--	Moody's
CPI-U	--	IHS	IHS
Before-tax corporate profits	Moody's	--	--

note: statistically significant at p<0.1

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[4] For example, the test may show that it is statistically probable that the difference between Moody's absolute error and IHS's absolute error is positive (Moody's – IHS>0), then IHS's model would be deemed a better performer, and vice versa.

When comparing the CEFC forecasts to proprietary models, the CEFC tends to outperform the proprietary models, particularly when comparing the CEFC forecast to Moody's. There are a few exceptions, for example, Wage & Salary Employment and Wages & Salaries tend to be better forecasted in the medium- to long-term by IHS, while long-term forecasts for Transfer Receipts tend to be better forecasted by Moody's.

The performance of the CEFC forecast in comparison to these proprietary models suggests that the current forecasting process in place provides added value compared to accepting the IHS or Moody's forecasts as given.

Table 13. Results of sign test, CEFC vs. Proprietary Forecasts

Sign test	CEFC vs. Moody's			CEFC vs. IHS		
	-1 to 0 years	1-2 years	3-5 years	-1 to 0 years	1-2 years	3-5 years
Wage & Salary Employment	CEFC	--	--	CEFC	IHS	IHS
Total personal income	--	CEFC	--	CEFC	--	--
Wages & Salaries	--	CEFC	CEFC	--	IHS	IHS
Supplements to Wages & Salaries	--	--	CEFC	--	--	--
Transfer receipts	CEFC	CEFC	Moody's	CEFC	--	--
Nonfarm proprietors' income	Moody's	--	--	--	--	--
Dividends, Interest and Rent	--	--	--	--	CEFC	CEFC
CPI-U	--	CEFC	CEFC	--	CEFC	--
Before-tax corporate profits	--	--	--	--	--	--

Conclusions

Overall, the CEFC's most accurate forecasts are for the consumer price index, wage & salary employment, and total personal income both for the full sample as well as when restricted to 2007-2022. The least accurate forecasts were for the most volatile variables, nonfarm proprietors' income and before-tax corporate profits. As found in the previous report, the CEFC's forecasts for recession years, when economic volatility is higher, tend to have generally high errors.

The CEFC tends to underestimate medium- to long-run growth, particularly when excluding outliers, though its short-run forecasts perform relatively well.

Results for Moody's and IHS forecasts are similar to those of the CEFC forecast; this makes sense, given that the CEFC forecast is based on these proprietary models. When compared to one another, IHS tends to outperform Moody's on total personal income, wages & salaries, supplements to wages & salaries, and the consumer price index for medium- to long-run forecasts. Meanwhile, Moody's is the more accurate forecast for transfer receipts and dividends, interest & rent in long-run forecasts and before-tax corporate profits in the short run

While this report expands the scope of previous analyses of CEFC forecast accuracy, it creates questions for further research. Future analyses should investigate how these forecast errors have impacted Maine's revenue forecasting and budgetary processes.

Appendix

Table 1. CEFC Data availability

Variable	Years in database (CEFC)	Included in 2019 analysis	Included in Current Analysis
Wage & Salary Employment	1992-2021	Yes	Yes
Total Personal Income	1992-2021	Yes	Yes
Wages & Salaries	2007-2021	Yes	Yes
Supplements to Wages & Salaries	2007-2021		Yes
Dividends, Interest and Rent	2007-2021		Yes
Nonfarm Proprietors' Income	2007-2021		Yes
Personal Current Transfer Receipts	2007-2021		Yes
Consumer Price Index	1992-2021	Yes	Yes
Before-Tax Corporate Profits	2011-2021		Yes

Table 2. Moody's & IHS Data availability

Variable	Moody's	IHS Markit
Wage & Salary Employment	2009-2022	2004-2022
Total Personal Income	2009-2022	2004-2022
Wages & Salaries	2009-2022	2007-2022
Supplements to Wages & Salaries	2009-2022	2007-2022
Dividends, Interest and Rent	2009-2022	2007-2022
Nonfarm Proprietors' Income	2009-2022	2007-2022
Personal Current Transfer Receipts	2009-2022	2007-2022
Consumer Price Index	2009-2022	2004-2022
Before-Tax Corporate Profits	2011-2022	2011-2022

Table 3. Summary of historical values by variable

Summary of historical actual values (percent growth rates)	Count	Mean	Standard Deviation	Minimum	Maximum
Wage & Salary Employment*	287	0.5	1.9	-6.1	3.7
Total personal income*	287	4.3	1.9	-0.1	7.9
Wages & Salaries	148	3.5	2.5	-3.0	9.4
Supplements to Wages & Salaries	148	3.0	2.0	-1.0	6.3
Transfer receipts	148	6.3	7.4	-0.5	29.3
Nonfarm proprietors' income	148	3.0	6.6	-10.9	17.5
Dividends, Interest and Rent	148	2.9	4.0	-7.3	10.3
CPI-U*	287	2.3	1.1	-0.4	4.7
Before-tax corporate profits^	105	5.5	13.0	-6.0	37.4

*W&S employment, Total Personal Income, and CPI-U have larger sample sizes as they are available from 1992-2021
^Before-tax corporate profits only available 2011-2021

Detailed MAE Results by Variable

Wage & Salary Employment					
Lead	Count	MAE	Standard Deviation	Minimum	Maximum
Pooled					
-1 to 0 years	82	0.5	0.8	0.0	6.6
1-2 years	111	1.1	1.3	0.0	6.5
3-5 years	94	1.4	1.4	0.1	6.1
Excluding outliers					
-1 to 0 years	81	0.4	0.4	0.0	1.9
1-2 years	107	0.9	0.8	0.0	4.2
3-5 years	89	1.1	1.0	0.1	4.2

Total Personal Income					
Lead	Count	MAE	Standard Deviation	Minimum	Maximum
Pooled					
-1 to 0 years	82	1.1	0.9	0.0	4.0
1-2 years	111	1.4	1.4	0.0	8.1
3-5 years	94	1.5	1.5	0.0	5.1
Excluding outliers					
-1 to 0 years	81	1.1	0.8	0.0	3.8
1-2 years	104	1.1	0.9	0.0	4.1
3-5 years	85	1.1	0.1	0.0	4.1

Wage & Salary Income					
Lead	Count	MAE	Standard Deviation	Minimum	Maximum
Pooled					
-1 to 0 years	46	1.0	1.5	0.0	7.9
1-2 years	55	1.8	2.2	0.0	7.4
3-5 years	47	1.7	1.7	0.2	5.9
Excluding outliers					
-1 to 0 years	42	0.6	0.6	0.0	2.0
1-2 years	46	0.9	0.7	0.0	3.5
3-5 years	42	1.1	0.9	0.2	3.9

Supplements to Wages & Salaries					
Lead	Count	MAE	Standard Deviation	Minimum	Maximum
Pooled					
-1 to 0 years	46	1.5	1.1	0.0	4.2
1-2 years	55	1.9	1.3	0.1	5.5
3-5 years	47	2.0	1.3	0.1	5.1
Excluding outliers					
-1 to 0 years	44	1.4	0.9	0.0	4.2
1-2 years	54	1.8	1.3	0.1	4.3
3-5 years	43	1.7	0.9	0.1	3.8

Nonfarm proprietors' income					
Lead	Count	MAE	Standard Deviation	Minimum	Maximum
Pooled					
-1 to 0 years	46	6.3	5.7	0.0	20.3
1-2 years	55	5.9	4.6	0.3	16.6
3-5 years	47	4.4	3.8	0.3	13.2
Excluding outliers					
-1 to 0 years	28	2.3	1.1	0.0	4.1
1-2 years	30	2.3	1.0	0.3	4.4
3-5 years	32	2.0	1.0	0.3	3.9

Dividends, Interest and Rent					
Lead	Count	MAE	Standard Deviation	Minimum	Maximum
Pooled					
-1 to 0 years	46	2.4	2.0	0.0	7.0
1-2 years	55	3.3	3.4	0.0	14.6
3-5 years	47	2.6	2.3	0.0	9.1
Excluding outliers					
-1 to 0 years	36	1.6	1.3	0.0	4.4
1-2 years	43	1.9	1.3	0.0	4.2
3-5 years	37	1.5	1.1	0.0	4.2

Personal Current Transfer Receipts					
Lead	Count	MAE	Standard Deviation	Minimum	Maximum
Pooled					
-1 to 0 years	46	2.5	4.0	0.0	23.8
1-2 years	55	4.2	6.5	0.0	24.2
3-5 years	47	3.4	5.7	0.0	24.7
Excluding outliers					
-1 to 0 years	39	1.3	1.2	0.0	4.5
1-2 years	44	1.6	1.2	0.0	4.2
3-5 years	40	1.6	1.1	0.0	3.7

Consumer Price Index					
Lead	Count	MAE	Standard Deviation	Minimum	Maximum
Pooled					
-1 to 0 years	82	0.3	0.4	0.0	2.8
1-2 years	111	0.8	0.7	0.0	3.2
3-5 years	94	0.9	0.7	0.0	3.2
Excluding outliers					
-1 to 0 years	--	--	--	--	--
1-2 years	--	--	--	--	--
3-5 years	--	--	--	--	--

Before-tax corporate profits					
Lead	Count	MAE	Standard Deviation	Minimum	Maximum
Pooled					
-1 to 0 years	36	5.8	5.8	0.0	26.9
1-2 years	39	9.4	9.8	0.1	33.9
3-5 years	30	8.6	11.7	0.1	33.9
Excluding outliers					
-1 to 0 years	18	2.1	1.4	0.0	4.2
1-2 years	11	1.2	1.1	0.1	3.1
3-5 years	16	2.3	1.4	0.1	4.4