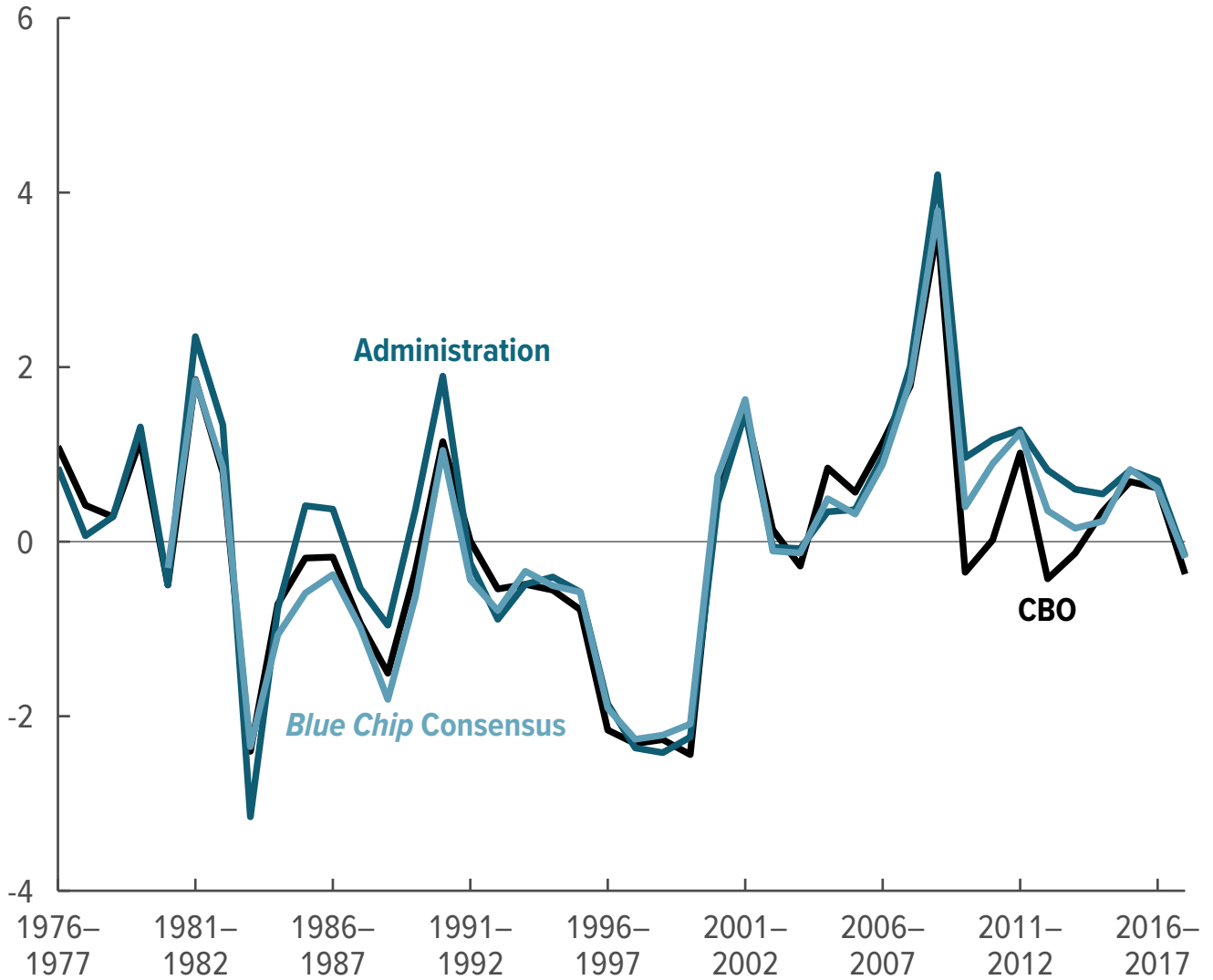


CBO

CBO's Economic Forecasting Record: 2019 Update

Percentage Points



Errors in Two-Year Forecasts of Real Output Growth

OCTOBER 2019

At a Glance

In this report, the Congressional Budget Office assesses its two-year and five-year economic forecasts and compares them with forecasts of the Administration and the *Blue Chip* consensus.

Measures of Quality. CBO focuses on three measures of forecast quality—mean error, root mean square error, and two-thirds spread of errors—that help the agency identify the centeredness (that is, the opposite of statistical bias), accuracy, and dispersion of its forecast errors.

The Quality of CBO’s Forecasts. CBO’s forecasts of most economic variables are, on average, too high by small amounts. As measured by the root mean square error, its two-year forecasts of most variables are not appreciably more accurate than its five-year forecasts. CBO is least accurate in forecasting growth of wages and salaries.

Comparison With Other Forecasts. For the most part, CBO’s and the Administration’s forecasts exhibit similar degrees of centeredness, but CBO’s forecasts are slightly more accurate and have smaller two-thirds spreads. For all three quality measures, CBO’s forecasts are roughly comparable to the *Blue Chip* consensus forecasts.

Sources of Forecast Errors. All forecasters failed to anticipate certain key economic developments, resulting in significant forecast errors. The main sources of those errors are turning points in the business cycle, changes in labor productivity trends and crude oil prices, the persistent decline in interest rates, the decline in labor income as a share of gross domestic product, and data revisions.

Forecast Uncertainty. CBO uses its past forecast errors to gauge the uncertainty of its current forecasts. For example, using the root mean square error, CBO estimated in August 2019 that there is approximately a two-thirds chance that economic growth will average between 0.7 percent and 3.3 percent over the next five years. Its central estimate is 2.0 percent.



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CBO's Economic Forecasting Record: 2019 Update

Summary

Each year, the Congressional Budget Office prepares economic forecasts that underlie its projections of the federal budget. CBO forecasts hundreds of economic variables, but some—including output growth, the unemployment rate, inflation, interest rates, and wages and salaries—play a particularly significant role in the agency's budget projections. To evaluate the quality of its economic projections, estimate uncertainty ranges, and isolate the effect of economic errors on budgetary projections, CBO regularly analyzes its historical forecast errors. That analysis serves as a tool for assessing the usefulness of the agency's projections.

In this report, CBO evaluates its two-year and five-year economic forecasts from as early as 1976 and compares them with analogous forecasts from the Administration and the *Blue Chip* consensus—an average of about 50 private-sector forecasts published in *Blue Chip Economic Indicators*. External comparisons help identify areas in which the agency has tended to make larger errors than other analysts. They also indicate the extent to which imperfect information may have caused all forecasters to miss patterns or turning points in the economy.

How CBO Measures Forecast Quality

CBO's analysis focuses on three metrics of forecast quality—mean error, root mean square error, and two-thirds spread of errors:

- The mean error is CBO's primary measure of centeredness, which indicates how close the average forecast value is to the average actual value over time. Centeredness is the opposite of statistical bias, which quantifies the degree to which a forecaster's projections are too high or too low over a period of time.
- The root mean square error is CBO's primary measure of accuracy, or the degree to which forecast values are dispersed around actual outcomes.

- The two-thirds spread, computed as the range between the minimum and maximum errors after removing the one-sixth largest errors and the one-sixth smallest errors, illustrates a forecaster's typical range of errors and provides information about the extent of the dispersion of those errors.

The Quality of CBO's Forecasts

When a mean error is used to assess the quality of a forecast, the standard for comparison is a mean error of zero. A forecast that has a mean error of zero is, on average, neither too high nor too low. CBO's forecasts of most economic variables tend to exhibit small positive mean errors—that is, on average, they are too high by small amounts.¹ CBO's forecasts of interest rates and growth in wages and salaries exhibit larger mean errors than its forecasts of other economic indicators.

When a root mean square error and spread are used to assess the quality of a forecast, there is no absolute standard for comparison. Moreover, it is difficult to compare quality measures across variables because magnitudes of variables can differ substantially, and some variables are relatively easy to forecast but others are relatively hard. It is possible, however, to compare those measures across forecast horizons for a given variable. For example, as measured by the root mean square error, CBO's two-year forecasts of most variables are not appreciably more accurate than its five-year forecasts. For most variables, the agency's two- and five-year forecasts exhibit a similar two-thirds spread of errors.

Comparing CBO's Forecasts With the Administration's Forecasts and the *Blue Chip* Consensus Forecasts

In general, forecasts produced by CBO, the Administration, and the *Blue Chip* consensus display similar error patterns over time. Because all forecasters faced the same challenges, periods in which CBO made

1. Forecast errors throughout this report were calculated as projected values minus actual values; thus, a positive error is an overestimate.

Table 1.

Summary Measures for Two-Year and Five-Year Forecasts, by Sample Years

Percentage Points

	Two-Year Forecasts			Five-Year Forecasts		
	CBO	Administration	<i>Blue Chip</i> Consensus	CBO	Administration	<i>Blue Chip</i> Consensus
Output						
Growth of real output ^a		1980–2017^b			1979–2014	
Mean error	-0.1	0.2	0	0.2	0.5	0.1
Root mean square error	1.3	1.4	1.3	1.2	1.3	1.1
Two-thirds spread	1.9	2.2	2.0	2.0	2.4	1.9
Growth of nominal output		1980–2017			1982–2014	
Mean error	0.2	0.5	0.4	0.6	0.8	0.7
Root mean square error	1.5	1.6	1.5	1.2	1.4	1.2
Two-thirds spread	2.4	3.0	2.4	2.0	2.2	1.6
Unemployment						
Unemployment rate		1982–2017			1982–2014	
Mean error	0.2	0.1	0.1	0	-0.1	0
Root mean square error	0.8	0.8	0.8	1.1	1.2	1.1
Two-thirds spread	1.3	1.1	1.4	1.7	2.0	1.7
Inflation						
Inflation in the consumer price index		1981–2017			1983–2014	
Mean error	0.2	0.2	0.3	0.2	0.1	0.4
Root mean square error	0.9	0.9	0.9	0.6	0.6	0.8
Two-thirds spread	1.5	1.7	1.6	0.9	1.2	1.1
Inflation differential ^c		1981–2017			1983–2014	
Mean error	-0.1	-0.2	-0.1	-0.1	-0.2	-0.2
Root mean square error	0.4	0.5	0.4	0.4	0.5	0.4
Two-thirds spread	0.7	0.9	0.7	0.8	1.0	0.8
Interest Rates						
Interest rate on 3-month Treasury bills		1981–2017			1983–2014	
Mean error	0.5	0.2	0.5	1.2	0.8	1.3
Root mean square error	1.2	1.3	1.2	1.7	1.6	1.7
Two-thirds spread	2.3	2.1	1.9	2.5	3.2	2.5
Real interest rate on 3-month Treasury bills ^d		1981–2017			1983–2014	
Mean error	0.3	0.1	0.2	0.9	0.7	0.9
Root mean square error	1.2	1.4	1.3	1.6	1.6	1.5
Two-thirds spread	2.2	2.2	2.1	2.7	3.2	2.7
Interest rate on 10-year Treasury notes		1984–2017			1984–2014	
Mean error	0.4	0.2	0.5	0.8	0.4	1.0
Root mean square error	0.8	0.9	0.8	1.1	1.3	1.2
Two-thirds spread	1.1	1.9	1.2	1.0	2.4	1.2

Continued

Table 1.

Continued

Summary Measures for Two-Year and Five-Year Forecasts, by Sample Years

Percentage Points

	Two-Year Forecasts			Five-Year Forecasts		
	CBO	Administration	<i>Blue Chip</i> Consensus	CBO	Administration	<i>Blue Chip</i> Consensus
Wages and Salaries						
Growth of wages and salaries						
		1980–2017		1980–2014		
Mean error	0.4	0.7	n.a.	1.0	1.1	n.a.
Root mean square error	1.8	2.0	n.a.	1.8	1.9	n.a.
Two-thirds spread	2.9	2.9	n.a.	2.1	2.7	n.a.
Change in wages and salaries as a share of output						
		1980–2017		1980–2014		
Mean error	0.1	0.1	n.a.	0.1	0.1	n.a.
Root mean square error	0.4	0.5	n.a.	0.3	0.3	n.a.
Two-thirds spread	0.8	0.9	n.a.	0.6	0.6	n.a.

Sources: Congressional Budget Office; Office of Management and Budget; Wolters Kluwer, *Blue Chip Economic Indicators*; Bureau of Economic Analysis; Bureau of Labor Statistics; Federal Reserve.

Forecast errors are calculated by subtracting the average actual value from the average projected value over the two- and five-year time horizon.

For details on the data underlying the summary measures presented here, see the appendix.

CPI = consumer price index; n.a. = not available.

- a. The measure of output is gross national product in years before 1992 and gross domestic product in 1992 and following years.
- b. The quality comparisons for each variable shown use the sample of data that is common to all three forecasters. Because forecasts by the Administration and the *Blue Chip* consensus are not available for the full period of CBO's forecasts, the samples generally are shorter than CBO's full sample dating back to 1976.
- c. The inflation differential is the difference between growth in the CPI and growth in the output price index.
- d. The real interest rate is the nominal interest rate deflated by projected growth in CPI inflation.

large overestimates typically coincide with periods in which other forecasters made similarly large overestimates. Over time, however, even small differences in the magnitude of errors can result in appreciable differences in measures of forecast quality.

CBO and the *Blue Chip* consensus tend to produce less-biased forecasts of output growth but more-biased forecasts of interest rates than the Administration (see Table 1 on page 2). As measured by the root mean square error, CBO's forecasts tend to be slightly more accurate, on net, than the Administration's forecasts and roughly comparable to the *Blue Chip* consensus forecasts. Finally, CBO's forecasts tend to exhibit smaller two-thirds spreads than the Administration's forecasts do; the agency's forecasts tend to have two-thirds spreads that are similar to those of the *Blue Chip* consensus forecasts.

Sources of Forecast Errors

Forecasters made large errors in their economic forecasts as a result of several economic developments:

- Turning points in the business cycle;
- Changes in labor productivity trends;
- Changes in crude oil prices;
- The persistent decline in interest rates;
- The decline in the labor share—that is, labor income as a share of gross domestic product (GDP); and
- Data revisions.

Some of those developments resulted in errors in forecasting specific variables. Changes in crude oil prices, for example, resulted in misestimates of inflation in the consumer price index (CPI). Other developments, such as turning points in the business cycle, affect the entirety of an economic forecast, and their effects are observable in the error patterns of several variables.

How CBO Uses Its Forecast Errors to Estimate Uncertainty

CBO most frequently uses the root mean square error of its historical forecasts to quantify the uncertainty of its current economic projections. For example, CBO's baseline forecast for real (inflation-adjusted) GDP growth over the next five years is 2.0 percent. Using its historical root mean square error for that variable (1.3 percentage points), CBO then estimates that there is approximately a two-thirds chance that the rate of real GDP growth over the next five years will be between 0.7 percent and 3.3 percent. Although the agency typically uses the historical root mean square error to estimate uncertainty, it uses the two-thirds spread of errors in instances where the statistical bias of its historical forecasts is high.

CBO's Methods for Evaluating Forecasts

To evaluate the quality of its forecasts, CBO examines its historical forecast errors and compares them with errors made by the Administration and the *Blue Chip* consensus. Comparison with the *Blue Chip* consensus is particularly useful because it incorporates a wide variety of viewpoints and methods, and some research has suggested that composite forecasts often provide better estimates than projections made by a single forecaster.²

2. See Allan Timmermann, "Forecast Combinations," in Graham Elliott, Clive W. J. Granger, and Allan Timmermann, eds., *Handbook of Economic Forecasting*, vol. 1 (North Holland, 2006), pp. 135–196, [https://doi.org/10.1016/S1574-0706\(05\)01004-9](https://doi.org/10.1016/S1574-0706(05)01004-9); Andy Bauer and others, "Forecast Evaluation With Cross-Sectional Data: The Blue Chip Surveys," *Economic Review*, vol. 88, no. 2 (Federal Reserve Bank of Atlanta, 2003), pp. 17–31, <https://tinyurl.com/y3qmyjzg> (PDF, 219 KB); Henry Townsend, "A Comparison of Several Consensus Forecasts," *Business Economics*, vol. 31, no. 1 (January 1996), pp. 53–55, www.jstor.org/stable/23487509; and Robert T. Clemen, "Combining Forecasts: A Review and Annotated Bibliography," *International Journal of Forecasting*, vol. 5, no. 4 (1989), pp. 559–583, [https://doi.org/10.1016/0169-2070\(89\)90012-5](https://doi.org/10.1016/0169-2070(89)90012-5).

For this analysis, CBO reviewed the economic projections that it published each winter, usually in January, beginning in 1976, as the basis for its baseline budget projections. Each of those economic projections spans the current year (that is, the calendar year already under way) and either 5 or 10 subsequent years. This report evaluates CBO's economic forecasts over the first two years and first five years of its baseline projection period. CBO evaluates forecasts over the two-year time horizon because that interval is most relevant when the agency is preparing its baseline budget projections for the upcoming fiscal year. (That second year is often called the budget year.) CBO evaluates forecasts over the five-year time horizon to better understand the quality of its longer-term projections.³ The agency calculates errors by subtracting the average actual value from the average projected value.

The span of years evaluated for this analysis varies by economic indicator and depends on two factors: the availability of historical forecast data and the availability of actual economic data. To ensure that differences in the availability of forecast data do not affect the comparisons of forecast errors, those comparisons begin in the earliest year for which forecast data were available for all three sets of forecasts. So although CBO has two-year real output growth forecasts dating back to 1976, its forecast errors for comparison purposes are computed starting in 1980—the first year the *Blue Chip* consensus data were available.⁴ Likewise, the final year of forecast analysis depends on the availability of actual economic data. This report incorporates data through the end of 2018, which allows CBO to analyze two-year forecasts that were made through the beginning of 2017 and five-year forecasts that were made through the beginning of 2014. (See the appendix for details.)

3. CBO cannot compare forecasts over longer time horizons because some data are not available. Although the agency has produced 11-year economic forecasts since 1992, it produced only 6-year economic forecasts before then. In addition, the *Blue Chip* consensus currently produces long-run economic forecasts spanning just 7 years.
4. The time periods used in the comparison of forecast quality vary on the basis of the availability of comparable data. Table 1 shows the sample periods used for each comparison.

Selecting Forecast Variables

CBO examines 10 forecast variables on the basis of their relative importance in the economic outlook and their relevance to projections of revenues, outlays, and deficits. Those variables include measures of output growth, the unemployment rate, inflation, interest rates, and wages and salaries.

Projections of real and nominal output growth are fundamental to CBO's budget projections. Faster output growth is typically accompanied by faster growth in real income and hence faster growth of revenues from individual income taxes. Similarly, periods of faster output growth are typically associated with smaller transfer payments and smaller expenditures on unemployment insurance, resulting in lower outlays.

New to this analysis is an examination of CBO's errors in forecasting the unemployment rate, a key component of the agency's economic forecast. CBO's forecast of the unemployment rate affects its projections of inflation, interest rates, and other labor market variables and also informs the agency's projections of certain outlays, including unemployment insurance outlays.

CBO's evaluation of inflation forecasts focuses on two measures: the percentage change in the CPI and the inflation differential, which is computed as the difference between growth in the CPI and growth in the output price index.⁵ All else being equal, higher CPI inflation implies faster growth in federal outlays (because the index is used to adjust payments to Social Security beneficiaries as well as payments made for some other programs) and slower growth in federal revenues (because elements of the individual income tax,

including the tax brackets, are indexed to the CPI).⁶ Growth in the output price index is closely linked to growth in nominal income subject to federal taxes, which implies faster growth in revenues. Consequently, if CPI inflation grew more quickly than anticipated and the output price index grew more slowly than anticipated, the projected deficit would generally be larger than expected.

The interest rates on 3-month Treasury bills and 10-year Treasury notes summarize CBO's projections of short- and long-term interest rates, respectively. Interest rates primarily affect the budget through their effect on net interest outlays—the difference between income earned on interest-bearing assets and the cost of servicing the debt. As a result, overestimates of interest rates result in overestimates of debt and deficits. This report also analyzes the real 3-month Treasury bill rate, which is computed by removing the effects of CPI inflation from forecasts of the nominal 3-month Treasury bill rate. Considering errors in projecting the real 3-month Treasury bill rate isolates interest rate errors from errors in inflation projections.

Finally, CBO examines growth in wage and salary disbursements and the change in those disbursements as a share of output. Wages and salaries are the largest component of national income, and their growth informs CBO's revenue projections and its analysis of the distribution of income. Analyzing wages and salaries as a share of output offers an approximation of forecasters' views about the labor share of national income and helps isolate errors in projecting wages and salaries from errors in projecting nominal output.

Calculating Forecast Errors

CBO computes each forecast error as the difference between the average forecast value and the average actual value. (See Box 1 for an example of how CBO calculates its forecast errors.) The actual values are reported as calendar year averages and are based on the latest available data from various agencies. A positive error indicates that the forecast value exceeded the actual value, whereas a

5. For most years examined here, the inflation forecasts were for the CPI-U, which measures inflation in the prices of goods and services consumed by all urban consumers. Some forecasts, however, were for the CPI-W, which measures inflation in the prices of goods and services consumed by urban wage earners and clerical workers. CBO forecast the CPI-W from 1976 to 1978 and again from 1986 to 1989; the Administration forecast the CPI-W through 1991. For the purpose of this evaluation, the distinction between the two measures was most consequential in 1984, when inflation in the CPI-U and CPI-W diverged by 0.9 percentage points.

6. In future analyses, tax brackets will be indexed to the chained CPI as a result of policy changes in the Tax Cuts and Jobs Act of 2017.

Box 1.

How CBO Calculates Economic Forecast Errors

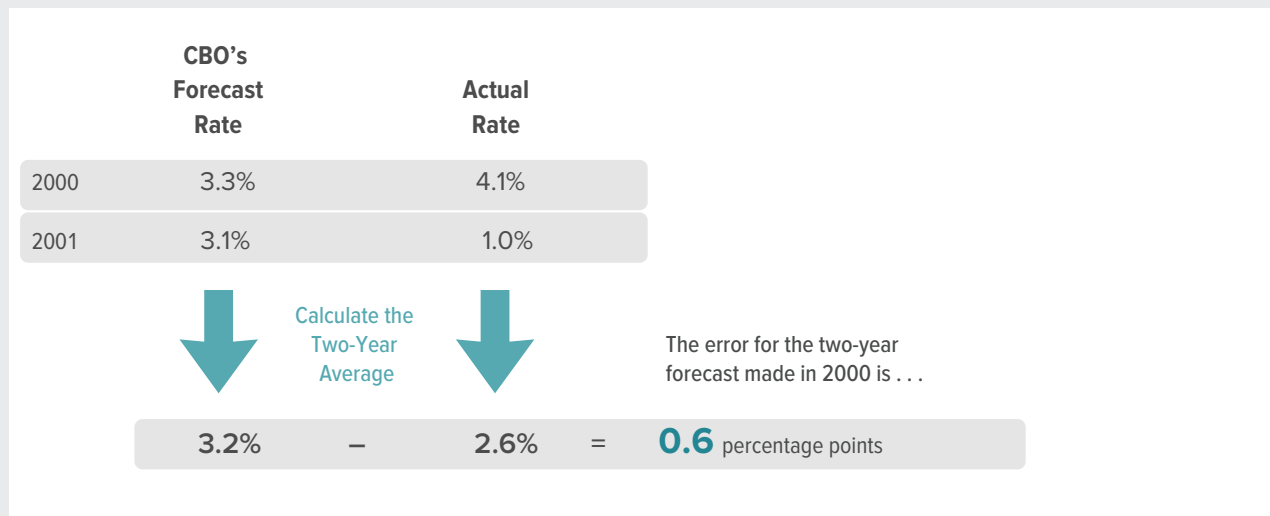
The Congressional Budget Office calculates forecast errors by subtracting the average actual value of an economic indicator over a two-year (or five-year) period from the average projected value of that indicator over the same period. For example, to calculate the error for the two-year forecast of the growth of real (inflation-adjusted) gross domestic product (GDP) that was published in the January 2000 *Budget and Economic Outlook*, CBO first calculated the geometric average of the projected growth rates of real GDP for calendar years 2000 and 2001, which was 3.2 percent.¹ The agency then calculated

the average actual growth rate of real GDP for those two years, which was 2.6 percent. Finally, it subtracted the average actual rate of 2.6 percent from the average projected rate of 3.2 percent, resulting in an error of 0.6 percentage points. To determine the error for the five-year forecast made that same year, CBO took the averages of projected and actual output growth rates for calendar years 2000 through 2004.

1. The geometric average is the appropriate measure for averaging growth rates. It is used to calculate the average for all indicators except the change in wages and salaries as a percentage of output. Because that

indicator is a ratio rather than a growth rate, the appropriate measure for averaging is the arithmetic average.

Example: Calculating the Error in the Two-Year Forecast of the Growth of Real GDP That CBO Published in January 2000



Sources: Congressional Budget Office; Bureau of Economic Analysis.
GDP = gross domestic product.

negative error indicates that the forecast value was below the actual value.

The method used to calculate forecast errors for this report differs from the method used in CBO's revenue and outlay forecast evaluations.⁷ In those reports, errors were

calculated for a single fiscal year. For example, the error in CBO's two-year revenue projection for 2007 is the percentage difference between the actual amount of revenues received in fiscal year 2007 and the revenues projected

7. See Congressional Budget Office, *An Evaluation of CBO's Past Deficit and Debt Projections* (September 2019), www.cbo.gov/publication/55234, *An Evaluation of CBO's Past Outlay Projections*

(November 2017), www.cbo.gov/publication/53328, and *CBO's Revenue Forecasting Record* (November 2015), www.cbo.gov/publication/50831.

for that year in January 2006.⁸ In this report, errors are calculated over a span of either two or five calendar years.

Measuring Forecast Quality

This evaluation focuses on three metrics of forecast quality: mean error, root mean square error, and two-thirds spread of errors. Together, those measures help CBO identify the statistical bias, accuracy, and dispersion of its forecast errors. Other measures of forecast quality, such as whether forecasters optimally incorporate all relevant information when making their projections, are harder to assess.⁹

Mean Error. CBO primarily uses the mean error—the arithmetic average of forecast errors—to measure the statistical bias of each variable. The agency uses the statistical bias to determine whether its forecasts are systematically too high or too low relative to actual economic outcomes. CBO's goal is to provide forecasts of economic indicators that lie in the middle of the distribution of possible outcomes.

The mean error does not, however, provide a complete characterization of the quality of a forecast. Because positive and negative errors are added together to calculate the average, forecast underestimates and overestimates offset one another. A small mean error might indicate that all forecasts had small errors, but a small mean error can also result from large overestimates and large underestimates that mostly offset one another. CBO uses the mean error as its primary measure of statistical bias because it is widely used and easily interpretable.¹⁰

Root Mean Square Error. CBO's primary measure of forecast accuracy, the root mean square error, is calculated by squaring the forecast errors, averaging those squares, and taking the square root of that average.¹¹

8. In evaluating its revenue projections, CBO calculated errors as the percentage difference (rather than the simple difference used in this report) between the projected and actual values because revenues are expressed as dollar amounts. If the errors in revenue projections were measured as simple differences in dollar amounts, they would be difficult to compare over time. (A \$5 billion error in 1992, for example, would be significantly larger than a \$5 billion error in 2014.) The simple difference is more appropriate here because this report evaluates errors in forecasts of economic indicators that are expressed as rates or percentages—growth rates, interest rates, and changes in wages and salaries as a percentage of output. Forecast errors in this report are thus percentage-point differences between forecast and actual values.
9. Several studies that examined how well CBO's economic forecasts incorporate relevant information—a characteristic referred to as forecast efficiency—found that the agency's forecasts are relatively efficient. See, for example, Robert Krol, "Forecast Bias of Government Agencies," *Cato Journal*, vol. 34, no. 1 (Winter 2014), pp. 99–112, <https://tinyurl.com/y7cmapw3> (PDF, 88 KB); Stephen M. Miller, "Forecasting Federal Budget Deficits: How Reliable Are US Congressional Budget Office Projections?" *Applied Economics*, vol. 23, no. 12 (December 1991), pp. 1789–1799, <http://doi.org/10.1080/00036849100000168>; and Michael T. Belongia, "Are Economic Forecasts by Government Agencies Biased? Accurate?" *Review*, vol. 70, no. 6 (Federal Reserve Bank of St. Louis, November/December 1988), pp. 15–23, <http://tinyurl.com/y7chze7ah>. Although statistical tests can identify sources of inefficiency in a forecast after the fact, they generally do not indicate how such information could be used to improve forecasts when they are being made.

10. Several analysts outside of CBO have used more elaborate techniques to test for bias in the agency's forecasts. One such alternative approach to testing a forecast for bias is based on linear regression analysis of actual values compared with forecast values. For details of that method, see Jacob A. Mincer and Victor Zarnowitz, "The Evaluation of Economic Forecasts," in Jacob A. Mincer, ed., *Economic Forecasts and Expectations: Analysis of Forecasting Behavior and Performance* (National Bureau of Economic Research, 1969), pp. 3–46, www.nber.org/chapters/c1214. Studies that have used that method to evaluate CBO's and the Administration's short-term forecasts have not found statistically significant evidence of bias over short forecast horizons. See, for example, Robert Krol, "Forecast Bias of Government Agencies," *Cato Journal*, vol. 34, no. 1 (Winter 2014), pp. 99–112, <https://tinyurl.com/y7cmapw3> (PDF, 88 KB); Graham Elliott and Allan Timmermann, "Economic Forecasting," *Journal of Economic Literature*, vol. 46, no. 1 (March 2008), pp. 3–56, <https://doi.org/10.1257/jel.46.1.3>; George A. Krause and James W. Douglas, "Institutional Design Versus Reputational Effects on Bureaucratic Performance: Evidence from U.S. Government Macroeconomic and Fiscal Projections," *Journal of Public Administration Research and Theory*, vol. 15, no. 2 (April 2005), pp. 281–306, <https://doi.org/10.1093/jopart/mui038>; and Michael T. Belongia, "Are Economic Forecasts by Government Agencies Biased? Accurate?" *Review*, vol. 70, no. 6 (Federal Reserve Bank of St. Louis, November/December 1988), pp. 15–23, <http://tinyurl.com/y7chze7ah>. For more elaborate studies of bias that included CBO's forecasts among a sizable sample, see J. Kevin Corder, "Managing Uncertainty: The Bias and Efficiency of Federal Macroeconomic Forecasts," *Journal of Public Administration Research and Theory*, vol. 15, no. 1 (January 2005), pp. 55–70, <https://doi.org/10.1093/jopart/mui003>; and David Laster, Paul Bennett, and In Sun Geoum, "Rational Bias in Macroeconomic Forecasts," *Quarterly Journal of Economics*, vol. 114, no. 1 (February 1999), pp. 293–318, <https://doi.org/10.1162/003355399555918>.

11. The mean square forecast error is equal to the square of the bias in the errors plus the variance of the errors. The variance measures the average squared difference between the errors and the mean error.

That calculation places greater weight on instances in which the forecast values deviate significantly from actual values. Unlike the computation of mean error, forecast underestimates and overestimates do not offset one another when computing the root mean square error.

CBO also uses the root mean square error of its historical forecasts to quantify the uncertainty of its current economic projections. When CBO's historical forecasts display low statistical bias and have an approximately normal distribution of errors, about two-thirds of actual values will be within a range of plus or minus one root mean square error of the forecasted values. Since 2017, CBO has used that method to quantify the uncertainty of its projections of real GDP.

Two-Thirds Spread. CBO uses the two-thirds spread of errors—defined as the difference between the minimum and maximum error after removing the one-sixth largest and one-sixth smallest errors—to measure the dispersion of its forecast errors. Larger two-thirds spreads imply greater variability in forecast errors, whereas smaller two-thirds spreads imply a narrower range of forecast misestimates.

In certain cases, CBO uses the two-thirds spread instead of the root mean square error to quantify the uncertainty of its current economic projections. The agency relies on the two-thirds spread when the ratio of the mean error to the root mean square error is greater than or equal to 0.3. Above that threshold, the root mean square error reflects a substantial amount of bias in the estimates in addition to their variance. When that criterion is met, CBO estimates that about two-thirds of actual values will be within a range of plus or minus one-half of the two-thirds spread of the forecasted values.

Limitations of the Forecast Evaluations

CBO's interpretation of forecast errors is somewhat limited for two reasons. First, forecast methodology continues to evolve. Over time, CBO and other forecasters have adjusted the procedures they use to develop economic forecasts in response to changes in the economy and advances in forecasting methods. Even when such adjustments improve the quality of forecasts, they make it difficult to draw inferences about the size and direction of future errors.

The second challenge is understanding the effects of different assumptions about future fiscal policy. CBO

is required by statute to assume that future fiscal policy will generally reflect the provisions in current law, an approach that derives from the agency's responsibility to provide a benchmark for lawmakers as they consider proposed legislative changes.¹² When the Administration prepares its forecasts, however, it assumes that the fiscal policy in the President's proposed budget will be adopted. The private forecasters included in the *Blue Chip* survey all make their own assumptions about fiscal policy, but the survey does not report them.

Forecast errors may be affected by those different fiscal policy assumptions, especially when forecasts are made while policymakers are considering major legislative changes. In early 2009, for example, contributors to the *Blue Chip* consensus reported that they expected additional fiscal stimulus, which implied stronger output growth than would be expected under current law. By contrast, CBO's growth projections were tempered by the requirement that its forecasts reflect current law. In February 2009, shortly after CBO's forecast was published, lawmakers enacted the American Recovery and Reinvestment Act (Public Law 111-5). Similarly, in early 2017, the *Blue Chip* consensus forecast for 2017 and 2018 probably incorporated some anticipation of a tax cut, as well as other changes in fiscal policy that would boost output in those years. Those anticipated changes probably led the *Blue Chip* consensus economic forecast to be stronger than CBO's in early 2017.¹³ Major tax legislation was enacted in December 2017.

Differences From CBO's 2017 Report

In addition to updating the forecasts and historical data cited in the 2017 edition of *CBO's Economic Forecasting Record*, this report compares errors in forecasts of a new variable—the unemployment rate.¹⁴ To illustrate the connection between CBO's forecast errors and its current economic projections, the report also discusses how CBO quantifies the uncertainty in its economic

12. There are some exceptions to that rule. For details, see Congressional Budget Office, *What Is a Current-Law Economic Baseline?* (June 2005), www.cbo.gov/publication/16558.

13. Different assumptions about monetary policy can also make it difficult to compare CBO's forecasts with other forecasts. CBO's forecasts incorporate the assumption that monetary policy will reflect the economic conditions that the agency expects to prevail under the fiscal policy specified in current law.

14. See Congressional Budget Office, *CBO's Economic Forecasting Record: 2017 Update* (October 2017), www.cbo.gov/publication/53090.

projections. Supplementing that discussion, this report adds a new measure of forecast quality—the two-thirds spread of errors—that serves as a secondary measure of forecast uncertainty.

The Quality of CBO's Forecasts

Although CBO's forecasts of most economic variables exhibit small positive mean errors, there are notable differences between variables. In particular, CBO's forecasts of interest rates and growth in wages and salaries exhibit larger mean errors than its forecasts of other economic indicators. That pattern is observable over both the two- and five-year time horizons.

Similarly, as measured by the root mean square error, CBO's two-year forecasts of most variables are not appreciably more accurate than its five-year forecasts, because anticipating short-term fluctuations is often more difficult than identifying long-term trends. For example, the agency's two-year forecasts of inflation as measured by the CPI are less accurate than its five-year forecasts of that variable. That pattern does not hold for all variables, however. For example, CBO's two-year forecasts of interest rates (for both the 3-month Treasury bill and the 10-year Treasury note) are more accurate than its five-year forecasts of that variable. For both time horizons, however, CBO is least accurate when forecasting growth in wages and salaries.

CBO's forecasts also exhibit similar two-thirds spreads for most variables across the two- and five-year forecast horizons. But there are exceptions. For example, CBO's five-year forecasts of the unemployment rate and the interest rate on 3-month Treasury bills have larger error spreads than its comparable two-year forecasts. Conversely, the agency's forecasts of CPI inflation, growth of nominal output, and the growth in wages and salaries have smaller two-thirds spreads over the five-year horizon than over the two-year horizon.

A Comparison of Forecast Quality

CBO compares its economic forecasts with analogous forecasts produced by the Administration and the *Blue Chip* consensus. (For a comparison of CBO's two-year forecasts with forecasts made by the Federal Reserve, see Box 2.) The agency examines projections of output growth, the unemployment rate, inflation, interest rates, and growth in wages and salaries. Each set of forecasts displays similar error patterns over time, but small

differences in the magnitude of those errors lead to some appreciable differences in measures of forecast quality.

In terms of mean errors, CBO's two- and five-year economic forecasts are broadly similar to forecasts produced by the Administration and the *Blue Chip* consensus. However, CBO and the *Blue Chip* consensus have smaller mean errors when forecasting output growth, whereas the Administration produces the least upwardly biased forecasts of interest rates. In terms of root mean square errors, CBO's forecasts are similar to the *Blue Chip* consensus forecasts and slightly more accurate than the Administration's forecasts. Finally, CBO's forecasts tend to display two-thirds spreads that are smaller than those of the Administration's forecasts and similar to those of the *Blue Chip* consensus forecasts.¹⁵ There are exceptions, however, for some variables and forecast horizons (see Table 1 on page 2).

Real and Nominal Output Growth

Over both the two- and five-year horizons, CBO's forecasts of real and nominal output growth display less bias, greater accuracy, and smaller two-thirds spreads than the Administration's forecasts.

Compared with the *Blue Chip* consensus forecasts, CBO's forecasts are roughly comparable for the various quality measures. Although CBO's nominal output forecasts display slightly less statistical bias than the *Blue Chip* consensus forecasts, its real output forecasts display slightly more bias. The *Blue Chip* consensus produces five-year forecasts of real output growth that have smaller two-thirds spreads than the corresponding CBO forecasts.

15. This description of relative forecast quality is strictly qualitative. CBO also conducted a series of statistical tests to assess the differences in root mean square errors among forecasters. Compared with the Administration's forecasts, CBO's forecasts had root mean square errors for 5 of 20 variables examined in this report that were smaller by statistically significant amounts. The Administration's forecasts were never more accurate than CBO's forecasts by amounts that were statistically significant. Compared with the *Blue Chip* consensus forecasts, CBO's forecasts had root mean square errors for 2 of 20 variables examined in this report that were smaller by statistically significant amounts. The *Blue Chip* consensus forecasts were more accurate than CBO's forecasts for 1 of those variables by an amount that was statistically significant.

Box 2.

Comparing CBO's and the Federal Reserve's Two-Year Forecasts

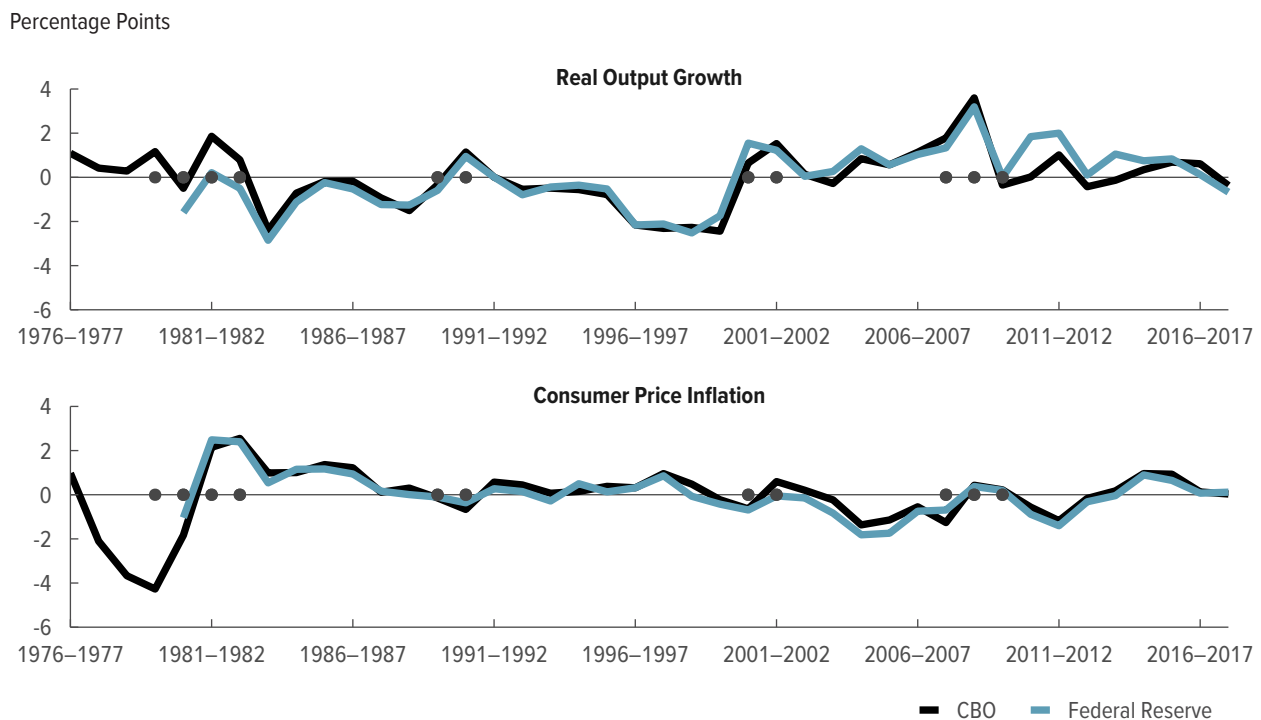
Like the Administration and the *Blue Chip* consensus, the Federal Reserve regularly produces economic forecasts that serve as a useful comparison when evaluating the quality of forecasts by the Congressional Budget Office. The scope of the Federal Reserve's forecasts is limited: It does not publish forecasts of interest rates or growth in wages and salaries, nor does it publish any five-year forecasts. As a result, CBO did not include the Federal Reserve's forecasts in the principal analysis for this report. However, the Federal Reserve does publish comparable forecasts of real output growth and consumer price inflation for a two-year time horizon.

CBO's forecasts of real output growth are generally similar to the Federal Reserve's forecasts (see the figure). For all measures of forecast quality, both CBO and the Federal Reserve produce forecasts of real output growth that are relatively unbiased and that display a similar degree of accuracy. CBO's forecasts, however, have a smaller two-thirds spread of errors.

CBO's and the Federal Reserve's forecasts of consumer price inflation are also quite similar. Each set of forecasts has a similar degree of accuracy and comparable two-thirds spreads. However, CBO tends to produce forecasts of consumer price inflation that contain an upward bias, whereas the Federal Reserve tends to produce unbiased forecasts.

The Federal Reserve's forecasts differ from CBO's forecasts in two ways. First, the Federal Reserve's forecasts include the effects of anticipated changes in fiscal policy, whereas CBO's forecasts reflect the assumption that current laws governing fiscal policy will remain generally unchanged. Second, the Federal Reserve's recent forecasts are modal—that is, they represent the single most likely outcome for the economy. By contrast, CBO's forecasts represent the middle of the range of possible outcomes. In periods when the range of possible outcomes is highly skewed, the Federal Reserve's forecasts will differ from CBO's.

Comparison of Two-Year Forecasts by CBO and the Federal Reserve



Sources: Congressional Budget Office; Federal Reserve; Bureau of Economic Analysis.

The measure of real output is gross national product in years before 1992 and gross domestic product in 1992 and later years. Positive errors represent overestimates. The dots shown on the horizontal axis indicate that the forecast period overlapped a recession by six months or more. The years indicate the time span covered by each of the forecast errors shown in the figure.

Most inflation errors are errors in forecasting the consumer price index for all urban consumers, but some are errors in forecasting the consumer price index for urban wage earners and clerical workers, and some are errors in forecasting personal consumption expenditures. For details on the underlying data, see the appendix.

Unemployment Rate

CBO, the Administration, and the *Blue Chip* consensus tend to produce similar forecasts of the unemployment rate, which results in similar measures of forecast quality. Over both the two- and five-year time horizons, all three sets of forecasts show little variation in their mean errors, root mean square errors, and two-thirds spreads. Although the three forecasters have slightly overestimated the unemployment rate over the two-year time horizon, they have produced unbiased or slightly downward biased estimates over the five-year time horizon.

Inflation

CBO's forecasts of CPI inflation are similar to those of the Administration and the *Blue Chip* consensus over the two-year time horizon. At the five-year time horizon, CBO's inflation forecasts are less biased and more accurate than forecasts from the *Blue Chip* consensus. Likewise, CBO's five-year inflation forecasts display a smaller two-thirds spread than the forecasts of both the Administration and the *Blue Chip* consensus.

Compared with the Administration, CBO produces forecasts of the inflation differential that display less bias, greater accuracy, and smaller two-thirds spreads. CBO's forecasts are comparable to the *Blue Chip* consensus forecasts. Over both time horizons, each set of forecasts has underestimated the inflation differential—the only variable in this analysis with a uniform and persistent downward bias.

Interest Rates

All forecasters have struggled to produce high-quality forecasts of real and nominal interest rates.

At the two-year horizon, CBO and the *Blue Chip* consensus produce interest rate forecasts that have a positive statistical bias. The Administration's interest rate forecasts display less bias but also less accuracy than the other forecasters because its forecasts tend to include large and partially offsetting overpredictions and underpredictions. Two-thirds-spread measures do not follow a clear pattern; CBO has a noticeably larger two-thirds spread in its forecast of the nominal interest rate on 3-month Treasury bills, but the Administration has the largest two-thirds spread in its forecast of the interest rate on 10-year Treasury notes.

Over the five-year time horizon, a similar pattern holds. CBO produces interest rate forecasts that are

considerably more biased than, but roughly as accurate as, the Administration's forecasts. CBO's forecasts are comparable to the *Blue Chip* consensus forecasts. The five-year horizon differs from the two-year horizon in one respect: The Administration produces forecasts with a much larger two-thirds spread than the forecasts of both CBO and the *Blue Chip* consensus.

Wages and Salaries

Over the two-year horizon, CBO's forecasts of the growth in wages and salaries are less biased and more accurate than the Administration's forecasts. (The *Blue Chip* consensus does not provide forecasts of the growth in wages and salaries.) Over the five-year time horizon, CBO's forecasts are similar in bias and accuracy but have a considerably smaller two-thirds spread than the Administration's forecasts. Over both time horizons, CBO's and the Administration's forecasts exhibit significant upward bias.¹⁶ Forecasts of wages and salaries as a share of output are nearly indistinguishable from one another.

Some Sources of Forecast Errors

Forecast errors often occur in response to difficulties in anticipating significant economic developments. Such developments include turning points in the business cycle, changes in labor productivity trends, changes in crude oil prices, the persistent decline in interest rates, the declining labor share, and data revisions. Some of those developments are closely tied to errors in forecasting specific variables—for example, the changes in crude oil prices that resulted in misestimates of CPI inflation. Other developments, such as turning points in the business cycle, have wide-ranging effects on economic forecasts and affect the projections of many variables.

Turning Points in the Business Cycle

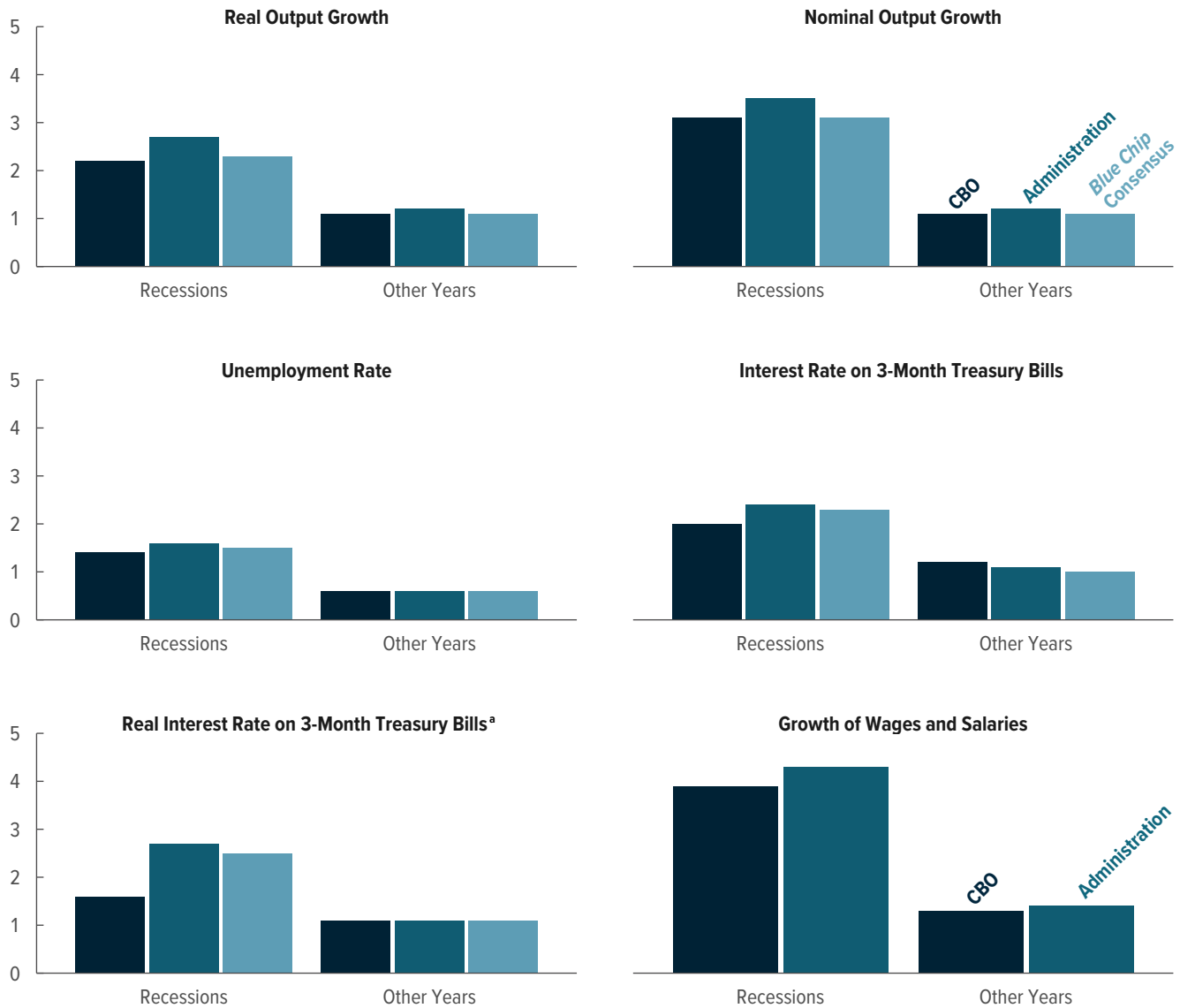
Business cycle peaks and troughs mark the beginning and end of recessions—periods of significant economic contraction. Five recessions occurred in the years covered by this analysis: those in 1980, 1981 to 1982, 1990 to

16. CBO also examined its forecasts of real growth in wages and salaries, which inform its analysis of the distribution of taxable income. Examining errors in real wage and salary growth helps isolate errors in forecasting nominal wage and salary growth from errors in forecasting growth in consumer price inflation. Although those forecasts exhibited slightly less statistical bias than their nominal counterparts, the accuracy of the forecasts was similar. For that reason, CBO elected not to include those results in its primary summary tables.

Figure 1.

Root Mean Square Errors of Two-Year Forecasts Made Near Business Cycle Peaks

Percentage Points



Sources: Congressional Budget Office; Office of Management and Budget; Wolters Kluwer, *Blue Chip Economic Indicators*; Bureau of Economic Analysis; Bureau of Labor Statistics; Federal Reserve.

The root mean square errors for recessions are based on forecasts made near business cycle peaks—those published in 1981, 1990, 2001, and 2008. The root mean square errors for other years are based on all two-year forecasts made through 2017, except for the four made near business cycle peaks.

The measure of output is gross national product in years before 1992 and gross domestic product in 1992 and later years. Real output is nominal output adjusted to remove the effects of inflation.

a. The real interest rate is the nominal interest rate deflated by the projected rate of growth in the consumer price index.

1991, 2001, and 2007 to 2009. Although the depth and duration of each recession differed, all contributed to forecast misestimates that were substantially larger than those made in nonrecession years (see Figure 1).

Forecasters struggle to produce accurate forecasts around business cycle downturns for three main reasons. Because business cycle downturns are hard to predict, the first challenge is anticipating when one will occur. During periods of growth, it is often difficult to identify which economic imbalances will ultimately result in a recession. Moreover, it is often difficult to know whether the economy is in a recession until well after it has begun. Thus, forecasts made just before a recession tend to be overly optimistic about economic outcomes.

The second challenge is identifying the length and severity of a recession. Recessions often coincide with periods of great uncertainty, both in economic outcomes and in fiscal and monetary policy. Under those conditions, a wide range of outcomes can appear equally probable, making it difficult to produce a forecast that is in the middle of the distribution of possible outcomes.

The final challenge is predicting the speed with which the economy will recover from a recession.¹⁷ Until the early 1990s, the U.S. economy typically grew rapidly for several quarters after a recession ended. Since then, however, recoveries have been much slower.¹⁸ Failing to predict slower economic recoveries has caused forecasters to overestimate economic growth in the aftermath of business cycle downturns.

Changes in Labor Productivity Trends

Growth of labor productivity in the nonfarm business sector—the ratio of real output to labor hours worked—is a key input into CBO's forecast of real output growth. Although growth in labor productivity fluctuates widely from quarter to quarter, its average growth rate tends

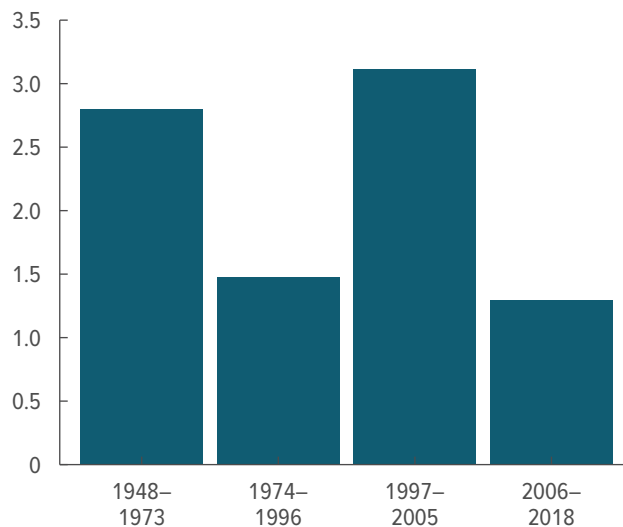
17. For more information about what caused recent recoveries to be slow, see Congressional Budget Office, *The Slow Recovery of the Labor Market* (February 2014), www.cbo.gov/publication/45011.

18. Another change that caught most forecasters by surprise was the reduction in the volatility of GDP growth beginning in the mid-1980s. In particular, from the mid-1980s until the 2007–2009 recession, quarterly movements in real GDP growth were more muted compared with previous decades. See, for example, Jordi Galí and Luca Gambetti, “On the Sources of the Great Moderation,” *American Economic Journal: Macroeconomics*, vol. 1, no. 1 (January 2009), pp. 26–57, <https://tinyurl.com/y65mv7fj>.

Figure 2.

Trends in Labor Productivity

Average Annual Percentage Change



Source: Congressional Budget Office, using data from the Bureau of Labor Statistics.

Data show the average annual growth of labor productivity in the nonfarm business sector. Labor productivity equals real (inflation-adjusted) output divided by the total number of hours worked.

to remain stable over long periods of time. The stability of that average typically helps forecasters estimate real output growth over longer time horizons. However, three shifts in labor productivity trends have contributed to errors in projecting real output growth (see Figure 2).

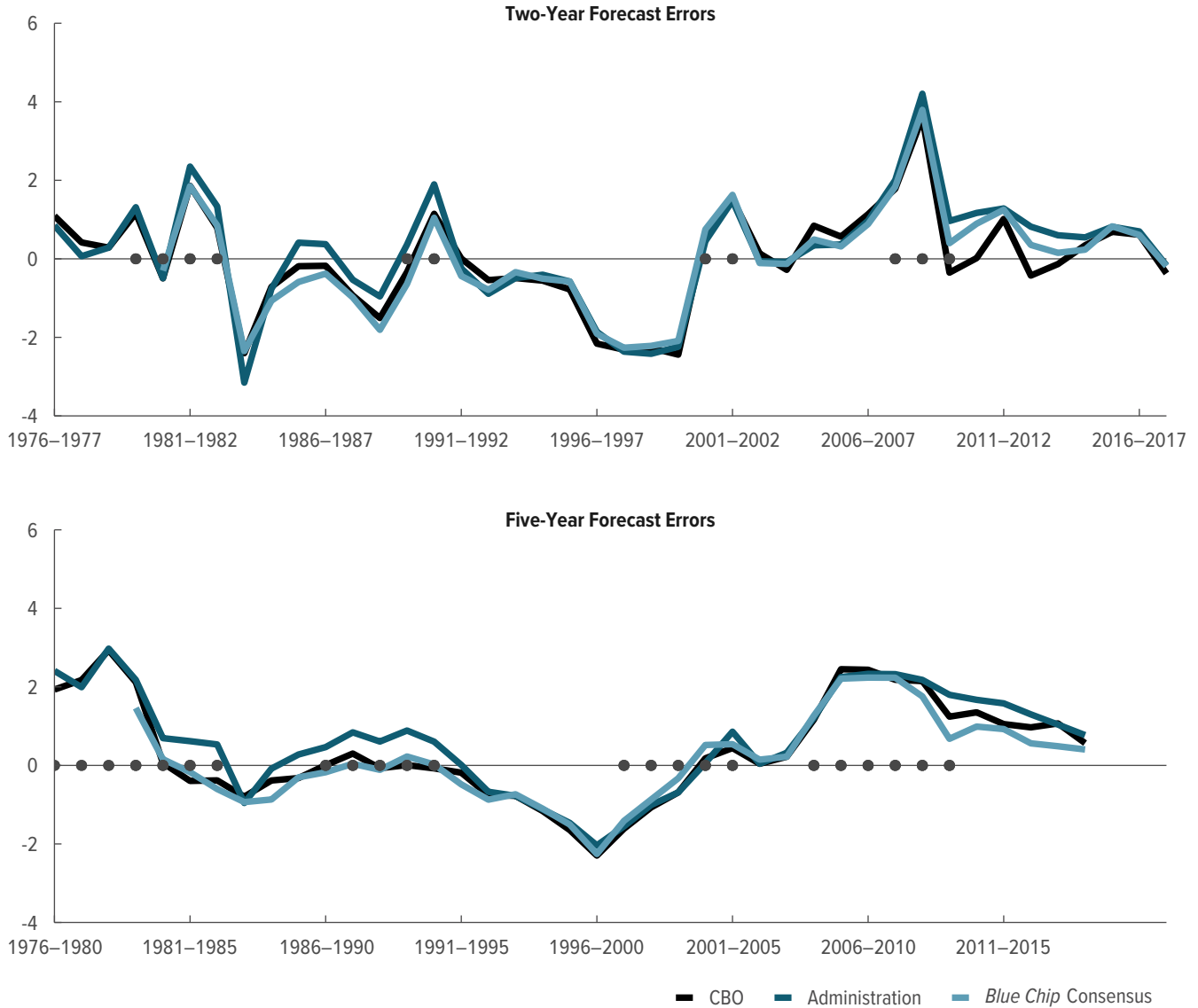
The first shift occurred in 1974, stemming in part from the 1973 recession. Whereas productivity had grown at an average rate of 2.8 percent per year over the previous 25 years, it grew by an average of only about 1.5 percent per year through the mid-1990s. Partly because most forecasters in the 1970s expected that the productivity trend of the previous decades would prevail, their forecasts of real output growth in the latter half of the 1970s turned out to be too optimistic (see Figure 3).

The second shift occurred in 1997, when growth in labor productivity in the nonfarm business sector accelerated, averaging more than 3 percent per year for nearly a decade. For the first several years of that period, forecasters underestimated the trend of productivity growth, which partly explains why their projections of the economy's growth rate were too low and their projections

Figure 3.

Errors in Forecasts of Real Output Growth

Percentage Points



Sources: Congressional Budget Office; Office of Management and Budget; Wolters Kluwer, *Blue Chip Economic Indicators*; Bureau of Economic Analysis.

The measure of real output is gross national product in years before 1992 and gross domestic product in 1992 and later years. Positive errors represent overestimates. The dots shown on the horizontal axis indicate that the forecast period overlapped a recession by six months or more. The years indicate the time span covered by each of the forecast errors shown in the figure.

of inflation in the output price index were too high.¹⁹

The acceleration in labor productivity stemmed from a pickup in technological progress (especially in

19. See Spencer Krane, “An Evaluation of Real GDP Forecasts: 1996–2001,” *Economic Perspectives*, vol. 27, no. 1 (Federal Reserve Bank of Chicago, January 2003), pp. 2–21, <http://tinyurl.com/y8wadllm>; and Scott Schuh, “An Evaluation

of Recent Macroeconomic Forecast Errors,” *New England Economic Review* (Federal Reserve Bank of Boston, January/February 2001), pp. 35–56, <http://tinyurl.com/y7zk8d>.

information technology) and an increase in the amount of capital per worker as firms invested heavily in new technology.

The third shift occurred in 2006, when the average growth of labor productivity slowed to 1.3 percent per year through 2018, for reasons that are not fully understood. The slowdown partly reflects cyclical factors related to the severe recession that occurred from 2007 to 2009 and the ensuing weak recovery. In addition, the growth of the labor force decelerated, which in turn slowed the growth of investment and of capital services. That slowdown in investment may have also reduced the rate at which businesses could introduce new technologies into the production process. Some research suggests that other long-term structural problems might be impeding the rate at which new technologies diffuse through industries.²⁰

In general, shifts in labor productivity are difficult to forecast. Such shifts are typically the result of changes in capital accumulation, changes in educational attainment, and technological innovation—factors that are difficult to forecast and that are only easily identified several years after the fact. Consequently, if CBO and other forecasters make incorrect inferences about the percentage of the labor force receiving higher education degrees, for example, that error affects their projections of productivity growth and, by extension, real output growth.

Changes in Crude Oil Prices

Crude oil is an important energy source in the United States, with petroleum accounting for more than one-third of total energy consumption.²¹ As a result, crude oil prices are a major component of consumer price inflation. Relative to overall prices, crude oil prices are volatile, and they fluctuate widely in response to economic and geopolitical developments in oil-producing

countries (see Figure 4). Some of the largest errors in forecasting CPI inflation can be attributed to forecasters' inability to predict major changes in crude oil prices. For example, the rise in the price of oil in the late 1970s and early 1980s probably contributed to the sizable underprediction of inflation by CBO, the Administration, and the *Blue Chip* consensus; all three forecasters underpredicted the rise in inflation over that time period when they completed their forecasts at the end of the 1970s (see Figure 5).

Large changes in crude oil prices reflect producers' and consumers' limited capacity to quickly adjust supply and demand in response to changing market conditions.²² Fluctuations in oil prices are often difficult to forecast because markets for petroleum products can be sensitive to developments that forecasters cannot reasonably be expected to predict. For example, during the 1973–1981 period, oil prices spiked in response to the oil embargo imposed by the Organization of Arab Petroleum Exporting Countries (1973 to 1974), the Iranian Revolution (1979), and the start of the Iran–Iraq War (1980). Those developments affected forecasters' ability to correctly forecast CPI inflation.

Political factors remain a source of uncertainty, but they appear to have become less important in explaining volatility. Recently, oil prices rose steeply in the lead-up to the 2007–2009 recession and fell sharply in 2014 and 2015 because of shifts in global supply and demand as well as technological changes, such as horizontal drilling and hydraulic fracturing.

The Persistent Decline in Interest Rates

Interest rates have trended downward since the early 1980s (see Figure 6 on page 18). Although that decline is partly attributable to a lower average rate of inflation over the past two decades, the effect persists even after taking into account the change in prices. Recent research has identified several factors that may have contributed to the decline in real interest rates: the aging of the population, increased income inequality, a trend toward

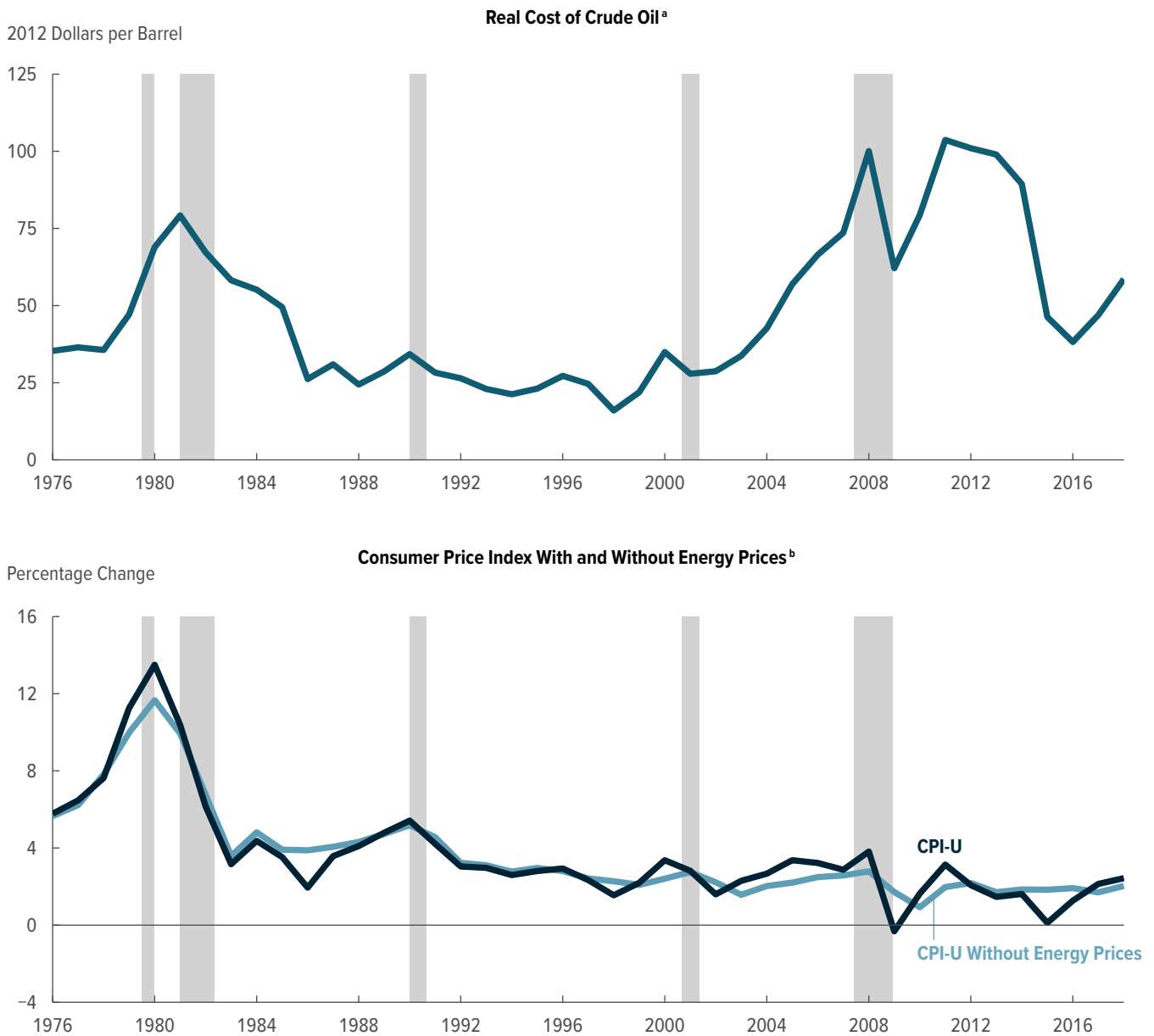
20. See Ryan A. Decker and others, *Declining Business Dynamism: Implications for Productivity?* Hutchins Center Working Paper 23 (Brookings Institution, September 2016), <http://tinyurl.com/lv9cs9h>; and Dan Andrews, Chiara Criscuolo, and Peter N. Gal, *The Global Productivity Slowdown, Technology Divergence, and Public Policy: A Firm Level Perspective*, Hutchins Center Working Paper 24 (Brookings Institution, September 2016), <http://tinyurl.com/km6942w>.

21. See Energy Information Administration, *Monthly Energy Review* (June 2019), Table 1.3, <https://go.usa.gov/xyVJg> (PDF, 2.48 MB).

22. In the near term, consumers are constrained by the existing energy efficiency of their homes, places of work, and modes of transportation; producers are constrained by their equipment, technology, and the availability and accessibility of natural resources. For further discussion, see Congressional Budget Office, *Energy Security in the United States* (May 2012), www.cbo.gov/publication/43012.

Figure 4.

The Effect of Oil Prices on Consumer Price Inflation



Sources: Congressional Budget Office; Bureau of Labor Statistics; Bureau of Economic Analysis.

Vertical bars indicate the duration of recessions. A recession extends from the peak of a business cycle to its trough.

CPI-U = consumer price index for all urban consumers.

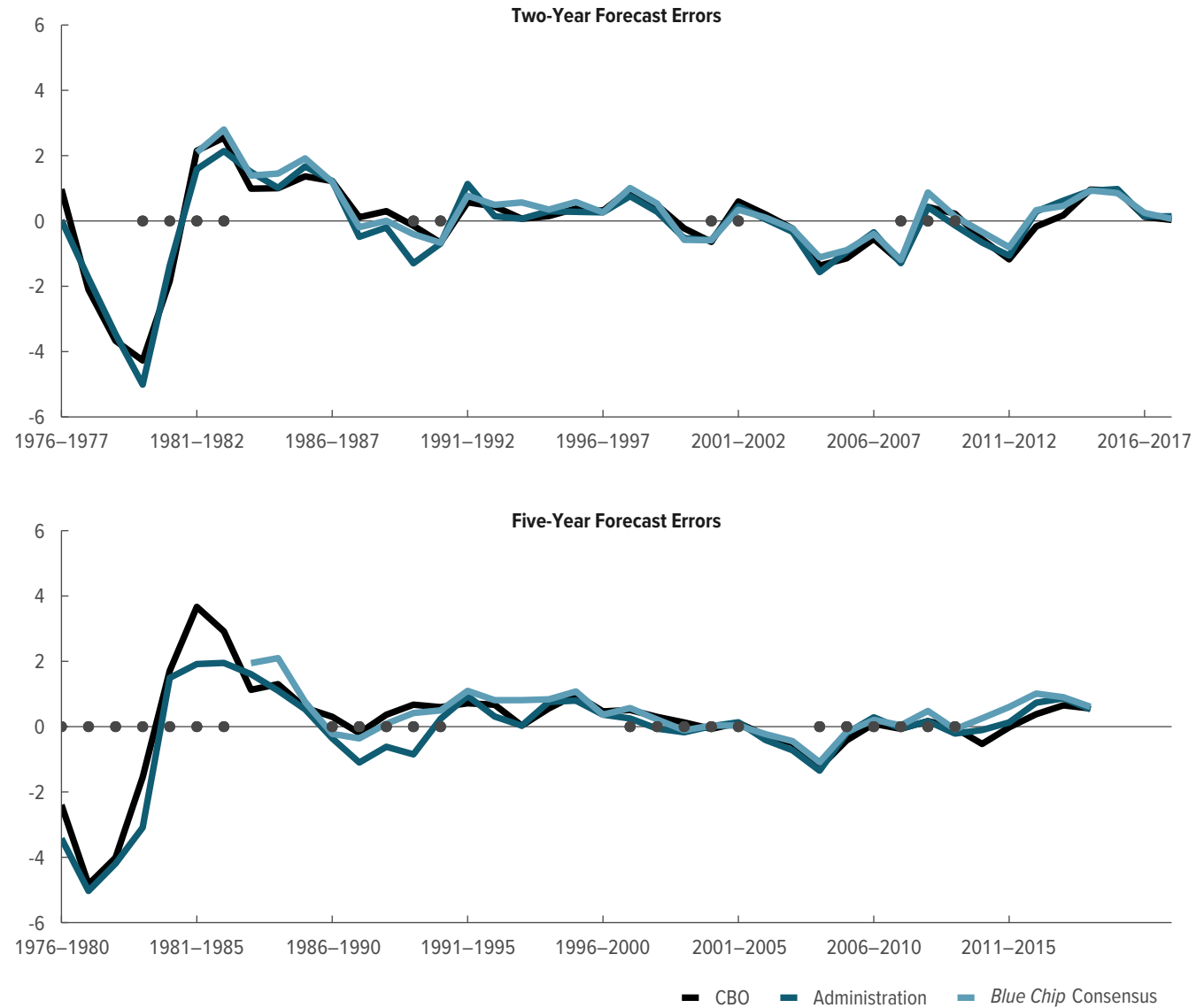
a. The real cost of crude oil is the refiners' cost of acquiring crude oil divided by the price index for personal consumption expenditures, excluding prices for food and energy.

b. The major components of energy prices in the CPI-U are motor fuel (which is primarily composed of petroleum products), electricity, and natural gas purchased from utilities.

Figure 5.

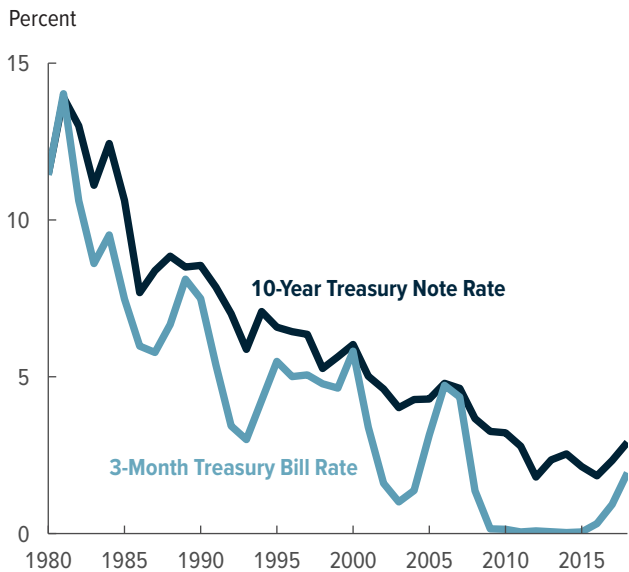
Errors in Forecasts of Consumer Price Inflation

Percentage Points



Sources: Congressional Budget Office; Office of Management and Budget; Wolters Kluwer, *Blue Chip Economic Indicators*; Bureau of Labor Statistics. Most forecast errors are errors in forecasting the consumer price index for all urban consumers, but some are errors in forecasting the consumer price index for urban wage earners and clerical workers. For details on the underlying data, see the appendix. Positive errors represent overestimates. The dots shown on the horizontal axis indicate that the forecast period overlapped a recession by six months or more. The years indicate the time span covered by each of the forecast errors shown in the figure.

Figure 6.

The Persistent Decline in Interest Rates

Source: Congressional Budget Office, using data from the Federal Reserve.

slower output growth, and increased saving among emerging market economies.²³

Over the past two decades, forecasters have underestimated the effect of those factors on interest rates, and they did not anticipate the extent or persistence of the eventual decline. Thus, all forecasters have tended to make sizable overpredictions of both short- and long-term interest rates since the early 2000s (see Figure 7).

The Decline in the Labor Share

Labor share refers to the total compensation paid to labor as a percentage of GDP. The labor share is composed of several components, the largest of which is total wages and salaries paid to employees, which accounts for about 80 percent of all labor income. Therefore, misestimates of the labor share typically result in misestimates of wages and salaries.

23. See Lukasz Rachel and Thomas D. Smith, “Are Low Real Interest Rates Here to Stay?” *International Journal of Central Banking* (September 2017), pp. 1–42, www.ijcb.org/journal/ijcb17q3a1.htm; and Council of Economic Advisers, *Long-Term Interest Rates: A Survey* (July 2015), <https://go.usa.gov/xyVS3>.

Since 2000, the labor share has experienced a structural decline for reasons that are only partially understood (see Figure 8). One theory is that globalization may have increased incentives for businesses to move their production of labor-intensive goods abroad.²⁴ Another is that technological innovation may have increased the returns to capital more than it has increased the returns to labor. Either way, forecasters at the start of the millennium projected the labor share to stabilize or return to its historical average. That expectation resulted in upwardly biased projections of wage and salary growth (see Figure 9 on page 21).

Transient factors can also cause movements in the labor share and lead to forecast misestimates. One such factor is the downward shift in the number of employees enrolling in employment-based health insurance plans that occurred in the late 1980s and early 1990s.²⁵ The decline in enrollment was largely the result of rising employee premiums and stagnant employer contributions, which reflected the rising cost of medical care during that time period. Employees who declined employment-based health insurance implicitly reduced their total compensation, because employers’ payments toward health insurance premiums are counted in total employee compensation. That development led forecasters to overestimate labor’s share of income and contributed to overestimates of the growth in wages and salaries between 1989 and 1994.

Data Revisions

Many of the data series analyzed in this report are periodically revised in response to new data, methods, and definitions. For example, the Bureau of Economic Analysis (BEA) periodically issues comprehensive revisions of its national income and product accounts, which contain historical data on real output growth and growth of wages and salaries. Those data revisions affect

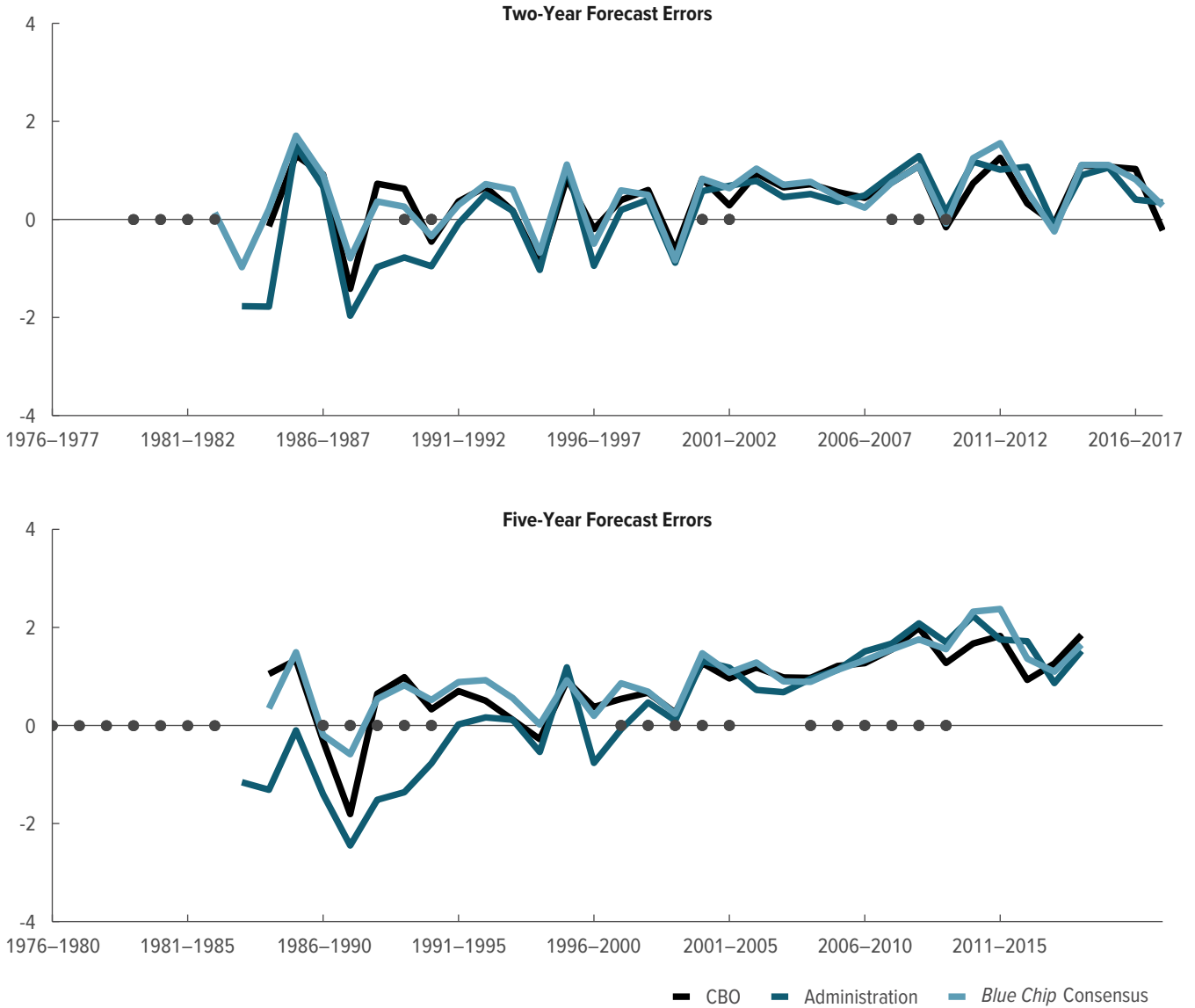
24. See, for example, Michael W. L. Elsby, Bart Hobijn, and Aysegul Sahin, “The Decline of the U.S. Labor Share,” *Brookings Papers on Economic Activity*, vol. 44, no. 2 (Fall 2013), pp. 1–63, <https://brook.gs/2VCVbyx>.

25. For information about changes in employers’ contributions to health insurance during the late 1990s, see David M. Cutler, *Employee Costs and the Decline in Health Insurance Coverage*, Working Paper 9036 (National Bureau of Economic Research, July 2002), www.nber.org/papers/w9036.

Figure 7.

Errors in Forecasts of the 10-Year Treasury Note Rate

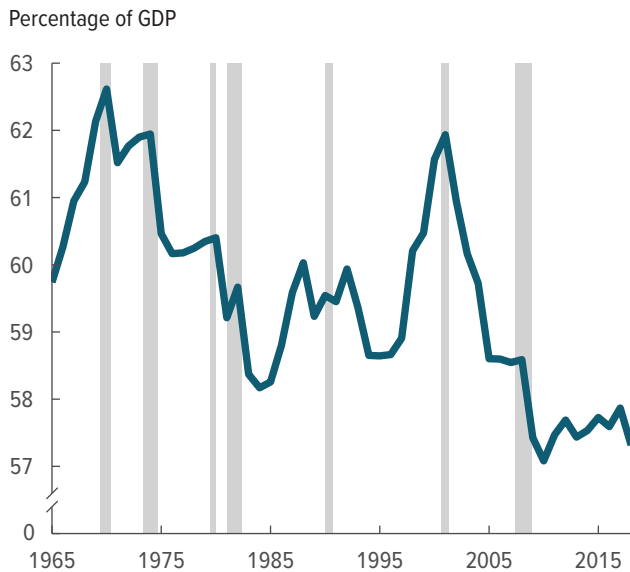
Percentage Points



Sources: Congressional Budget Office; Office of Management and Budget; Wolters Kluwer, *Blue Chip Economic Indicators*; Federal Reserve.

Positive errors represent overestimates. The dots shown on the horizontal axis indicate that the forecast period overlapped a recession by six months or more. The years indicate the time span covered by each of the forecast errors shown in the figure.

Figure 8.

Labor's Share of GDP

Source: Congressional Budget Office; Bureau of Economic Analysis.

Labor income is the sum of employees' compensation and CBO's estimate of proprietors' income that is attributable to labor.

Vertical bars indicate the duration of recessions. A recession extends from the peak of a business cycle to its trough.

GDP = gross domestic product.

the computation of forecast errors and, by extension, measures of forecast quality.

One way that data revisions affect the computation of forecast errors is by creating a wedge between the currently available data and the data that were available when the forecast was completed. For example, the root mean square error of CBO's two-year forecasts of real output growth is 1.3 percentage points if calculated from the most recently available data (as shown in Table 1 on page 2)—but is 1.2 percentage points if calculated from the real-time data available immediately after the conclusion of the two-year horizon. Although some recent literature suggests that real-time data may be more appropriate for that kind of analysis, CBO uses the most recently available data.²⁶ That decision simplifies the

26. See, for example, Tom Stark and Dean Croushore, "Forecasting With a Real-Time Data Set for Macroeconomists," *Journal of Macroeconomics*, vol. 24, no. 4 (December 2002), pp. 507–531, [https://doi.org/10.1016/S0164-0704\(02\)00062-9](https://doi.org/10.1016/S0164-0704(02)00062-9).

analysis and helps account for definitional changes that affect the interpretation of certain data series over time.²⁷

In addition to affecting the analysis of forecast errors after the fact, data revisions can affect a forecaster's projections in real time. For example, BEA made several downward revisions to estimates of real GDP growth during the 2007–2009 recession (see Figure 10). When CBO prepared its baseline forecast in January 2009, real GDP had reportedly fallen by an annualized rate of 0.5 percent during the third quarter of 2008; however, revised data now show a 2.1 percent drop during that quarter. Similarly, the latest revisions show that the average annual growth of real GDP was nearly one-quarter of a percentage point lower during the recession than BEA initially reported in January 2010. Had CBO and other forecasters known the true state of the economy at the time of their forecast, their projections probably would have been different.

Quantifying the Uncertainty of CBO's Economic Forecasts

To quantify the uncertainty of its economic projections, CBO most frequently relies on the root mean square error of its historical forecasts. For each variable, CBO computes root mean square errors at the one-, three-, and four-year time horizons, in addition to the two- and five-year time horizons presented in this report.²⁸ Those root mean square errors are applied symmetrically to the agency's baseline projections to produce the range of the middle two-thirds of outcomes.

Such analysis has informed the uncertainty ranges surrounding CBO's projections of real GDP in recent

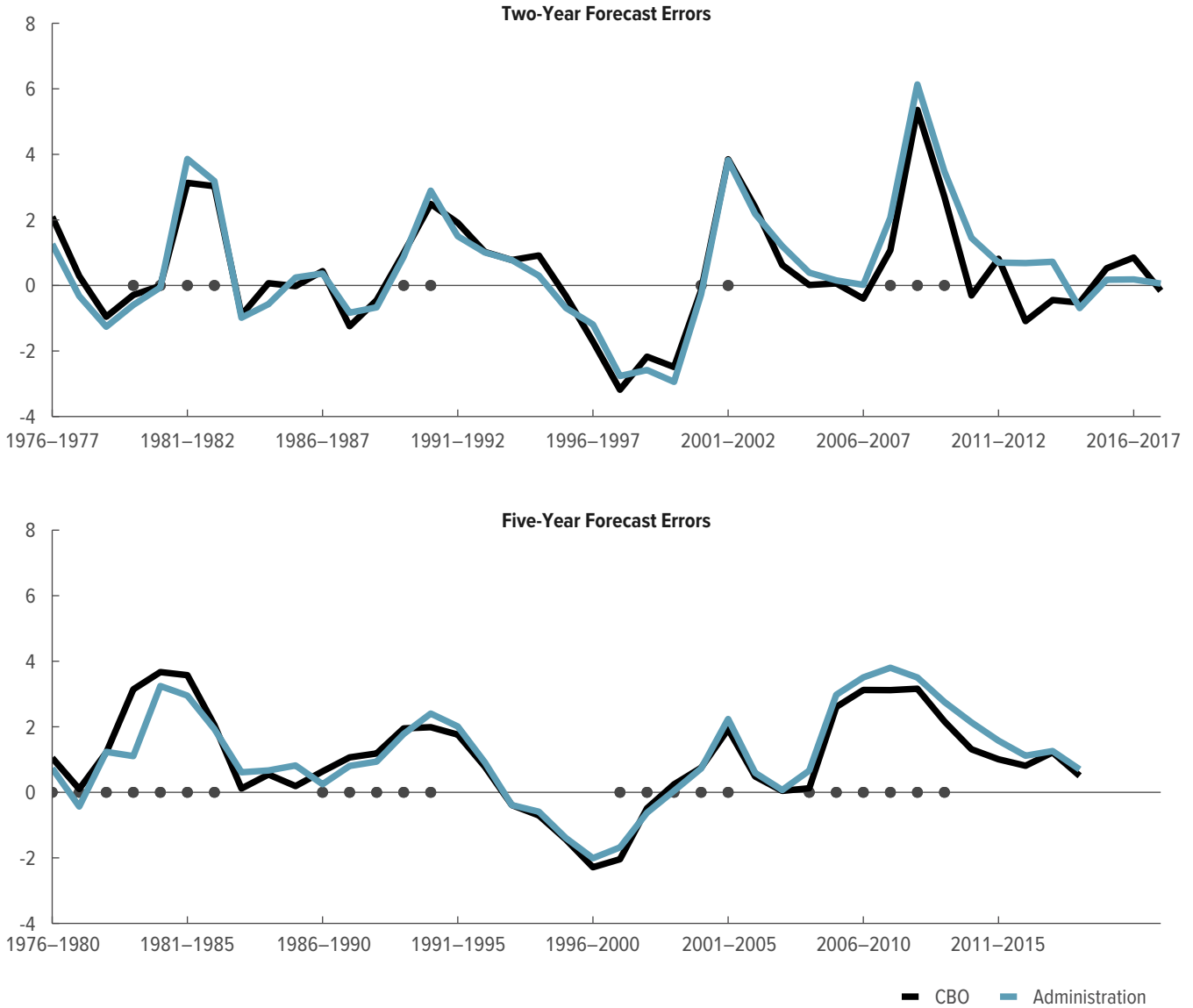
27. For example, business and government spending on computer software was once treated as spending for an intermediate good—that is, an input into the production process—and thus did not count as a component of GDP, which measures only final spending. But in 1999, BEA reclassified such spending as investment, which is a category of final spending. That same year, BEA adopted new methods for calculating the price indexes for various categories of consumption. Largely as a result of those changes, BEA increased its estimates of growth in real GDP for the 1980s and 1990s. In particular, BEA's estimates of average annual growth in real GDP from 1992 to 1998 rose by 0.4 percentage points, and inflation in the GDP price index for those years was revised downward by 0.1 percentage point per year.

28. CBO's root mean square errors for forecasts of real output growth at the one-, three-, and four-year horizons are 1.1, 1.2, and 1.3 percentage points, respectively.

Figure 9.

Errors in Forecasts of the Growth in Wages and Salaries

Percentage Points



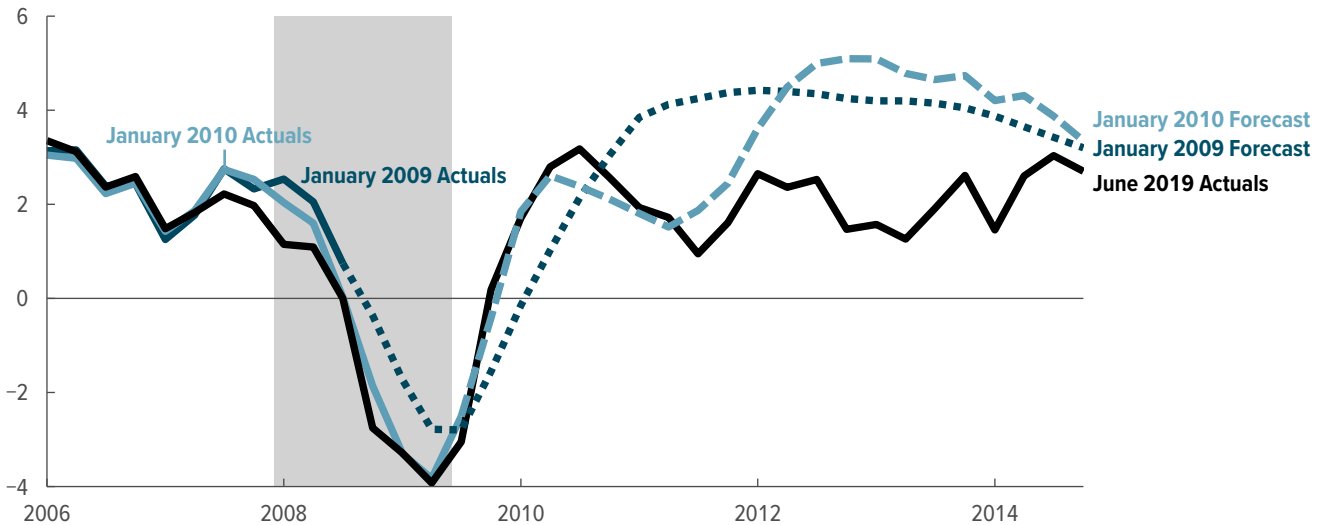
Sources: Congressional Budget Office; Office of Management and Budget; Bureau of Economic Analysis.

Positive errors represent overestimates. The dots shown on the horizontal axis indicate that the forecast period overlapped a recession by six months or more. The years indicate the time span covered by each of the forecast errors shown in the figure.

Figure 10.

The Effect of Data Revisions on Real Growth of Gross Domestic Product

Percentage Change From Previous Year



Sources: Congressional Budget Office; Bureau of Economic Analysis.

editions of *The Budget and Economic Outlook*. Publishing those ranges helps illustrate the breadth of possible outcomes and the degree of certainty underlying CBO's economic forecasts. For example, CBO estimated in August 2019 that there is approximately a two-thirds chance that the average annual growth rate of real GDP will be between 0.7 percent and 3.3 percent over the next five years (see Figure 11). Its central estimate is 2.0 percent.

Sometimes CBO uses the two-thirds spread instead of the root mean square error to quantify the uncertainty of its current economic projections. When the ratio of the mean error to the root mean square error is greater than or equal to 0.3, CBO estimates that about two-thirds of actual values will fall within a range of plus or minus one-half of the two-thirds spread of forecasted values. For example, CBO's two-year forecasts of 10-year Treasury notes have a mean error of 0.4 percentage points and a root mean square error of 0.8 percentage points (see Table 1 on page 2). Because the ratio

of those numbers is greater than 0.3, CBO uses the two-thirds spread to estimate that there is a two-thirds chance that the average interest rate on 10-year Treasury notes will fall within a range of roughly 0.6 percentage points above or below the agency's central estimate of 2.2 percent.

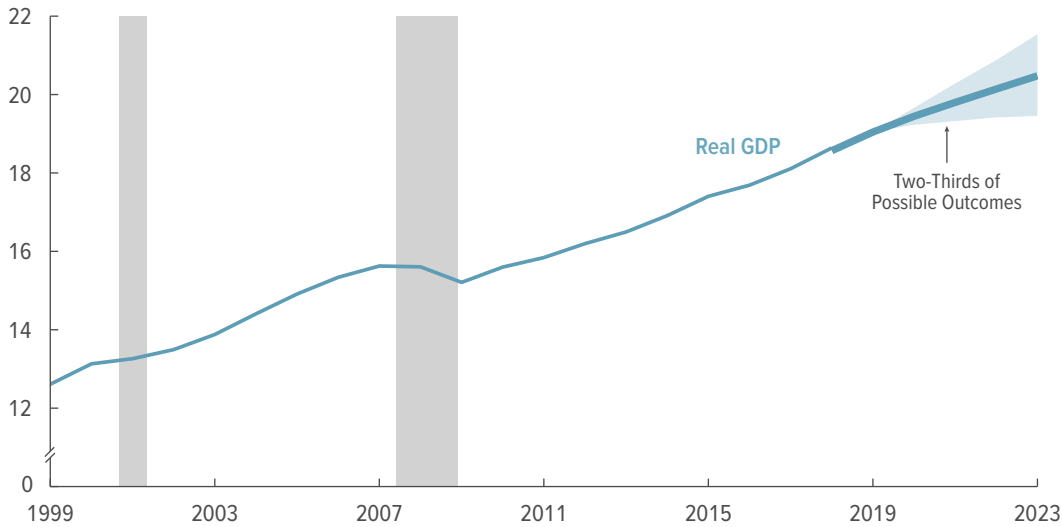
Forecast errors for economic variables have implications for the budget. For example, according to CBO's rules of thumb, if interest rates were 0.1 percentage point higher than projected for five consecutive years (and all else remained constant), the budget deficit over that period would be an estimated \$46 billion higher relative to the baseline budget projection. Similarly, if inflation was 0.1 percentage point higher than projected for five consecutive years (and all else remained constant), the budget deficit would be an estimated \$27 billion higher relative to the baseline budget projection.²⁹

29. See Congressional Budget Office, *How Changes in Economic Conditions Might Affect the Federal Budget* (June 2018), www.cbo.gov/publication/54052.

Figure 11.

The Uncertainty of CBO's Projections of Real GDP

Trillions of 2012 Dollars



CBO estimates that—if the errors in the agency's current economic forecast are similar to those in its previous forecasts—there is approximately a two-thirds chance that the average annual rate of real GDP growth will be between 0.7 percent and 3.3 percent over the next five years.

Sources: Congressional Budget Office; Bureau of Economic Analysis.

Real values are nominal values that have been adjusted to remove the effects of changes in prices. The shaded area around CBO's baseline projection of real GDP illustrates the uncertainty of that projection. The area is based on the errors in CBO's one-, two-, three-, four-, and five-year projections of the average annual growth rate of real GDP for calendar years 1976 through 2018.

Values for real GDP from 1999 to 2018 (the thin line) reflect revisions to the national income and product accounts that the Bureau of Economic Analysis released on July 26, 2019. Values from 2018 to 2029 (the thick line) reflect the data available when the projections were made earlier in July.

GDP = gross domestic product.



Appendix: The Data CBO Uses to Evaluate Its Economic Forecasting Record

This appendix provides an overview of the forecast and historical data the Congressional Budget Office uses to evaluate its forecasting record. In the report, CBO analyzes its errors in forecasting output growth, the unemployment rate, inflation, interest rates, and changes in wages and salaries. Forecast values are primarily compiled from CBO's annual *Budget and Economic Outlook*, the Administration's annual budget documents, and *Blue Chip Economic Indicators* reports from the first quarter of each calendar year. Actual values for each variable are based on the latest available data from various agencies, including the Bureau of Economic Analysis (BEA) and the Bureau of Labor Statistics (BLS).

Forecasts Included in This Evaluation

This report evaluates forecasts published between 1976—the first year CBO made economic projections—and 2017. The agency's forecasts are typically published in the first quarter of each calendar year. From 1976 to 1984, however, those reports did not regularly include CBO's forecasts of wages and salaries, so this analysis incorporates some unpublished forecasts of those amounts.

For comparison, this report also evaluates the Administration's forecasts made between 1976 and 2017, all but two of which were taken from the Office of Management and Budget's annual budget documents. In Presidential transition years, forecasts are taken from the budget documents of incoming Presidential administrations, with two exceptions: First, the Reagan Administration's 1981 economic projections were based on revisions of the Carter Administration's final budget and were released separately. Second, the Clinton Administration chose not to make its own economic projections before releasing its 1993 budget, adopting instead CBO's economic projections as the basis of its budget. As a result, errors in the 1993 forecast are the same for both forecasters.

The *Blue Chip Economic Indicators* was published beginning in 1976, but because of data constraints this report only analyzes *Blue Chip* forecasts dating back to 1979. Although the *Blue Chip* consensus is published monthly, only the March and October forecasts extend beyond two years. As a result, this analysis uses the January publication to obtain two-year forecasts of each economic variable and the March publication to obtain five-year forecasts. One exception is the five-year forecasts published in 1980, which were released in May. Because the *Blue Chip* consensus forecasts are only available starting in 1979, comparisons of forecast quality shown in Table 1 on page 2 do not include CBO's forecasts produced from 1976 through 1978.

The Federal Reserve's forecasts are taken from two sources. The first is the Federal Reserve's Greenbook, a publication prepared by the staff of its Board of Governors. The Greenbook contains two-year projections for a wide range of economic variables, but it is not released to the public until several years after the forecast is made. As a result, this analysis only incorporates Greenbook forecasts from 1979 to 2013. The second source is the economic projections prepared by individual members of the Federal Reserve's Federal Open Market Committee (FOMC). The ranges and central tendencies of those forecasts encompass a smaller set of variables, but they have been published regularly since 2007. This analysis uses the midpoint of the central tendency of the FOMC forecasts in 2014 and 2015 and the median of the FOMC forecasts in 2016 and 2017. All of the Federal Reserve forecasts used in this analysis were issued in January or February of the initial forecast year or in December of the preceding year.

Output Growth

Growth of real (inflation-adjusted) and nominal output is computed from calendar year averages of the most recently available quarterly data published by BEA. To calculate the average annual growth rate over two- and

five-year time horizons, CBO computes the geometric average of each series over the relevant sample period.¹ One major methodological shift occurred in 1991, when BEA changed its featured measure of output from gross national product (GNP) to gross domestic product (GDP). In response, most economic forecasters switched to forecasting GDP starting in 1992. As a result, for this analysis CBO computes forecast errors for GNP growth before 1992 and forecast errors for GDP growth between 1992 and 2017.

Unemployment Rate

The unemployment rate is computed from calendar year averages of monthly data published by BLS. To calculate the average unemployment rate over two- and five-year time horizons, CBO computes the arithmetic mean of the annual unemployment rate series over the relevant sample period. A major methodological shift occurred in 1994, when BLS updated and modernized its Current Population Survey, which is used to measure the unemployment rate. Because the methodology was changed in February of that year, some forecasters included projections of unemployment on the new basis as well as the old basis. For this report, CBO computes forecast errors relative to the old basis for forecasts between 1976 and 1994 and relative to the new basis for forecasts made from 1995 to 2017.

Inflation

CBO computes inflation in the consumer price index (CPI) from calendar year averages of monthly data published by BLS. To calculate the average annual growth rate over two- and five-year time horizons, CBO computes the geometric average of each series over the relevant sample period. In January 1978, BLS began publishing the CPI-U (the price index for all urban consumers) in addition to the CPI-W (the price index for urban wage earners and clerical workers). Although annual fluctuations in the two price indexes are typically very similar, they occasionally diverge. To account for those divergences, this report compares CPI-U forecasts with CPI-U actuals and CPI-W forecasts with CPI-W actuals.

The introduction of the CPI-U also resulted in different approaches to forecasting consumer price inflation. The Administration published forecasts of the CPI-W from 1976 to 1991 because that measure was used to index most of the federal government's spending for entitlement programs, but it switched to forecasting the CPI-U starting in 1992. By contrast, CBO based all but four of its inflation forecasts after 1978 on the CPI-U. The exceptions are CBO's forecasts from 1986 to 1989, which were based on the CPI-W. The *Blue Chip* consensus and the Federal Reserve have always forecasted the CPI-U.

In this report, CBO also analyzes errors in the inflation differential—the difference between CPI inflation and inflation in the output price index. To compute growth in the output price index, CBO uses calendar year averages of the most recently available quarterly data published by BEA. Similar to its computations of real output growth, the agency's computations of the inflation differential use the GNP price index for forecasts made before 1992 and the GDP price index for forecasts made between 1992 and 2017. CBO subtracts growth in the output price index from growth in CPI inflation to compute the inflation differential.

Interest Rates

CBO computes the interest rate on 3-month Treasury bills from calendar year averages of monthly data published by the Federal Reserve. To calculate the average interest rate over two- and five-year time horizons, CBO computes the geometric mean of the annual interest rate series over the relevant sample period. The agency's analysis of the interest rate on 3-month Treasury bills focuses on two main measures: the new-issue rate and the secondary-market rate.

The new-issue rate reflects the interest that would be earned by an investor who purchased a bill at auction and held it to maturity. The secondary-market rate corresponds to the price of 3-month bills traded outside of Treasury auctions. Such transactions occur continually in markets that have many more traders than there are bidders in Treasury auctions. The difference between the calendar year averages of the two series is small, which makes them easily comparable across time horizons.

The Administration published forecasts of the new-issue rate until 2001, when it switched to forecasting the secondary-market rate. Unlike the Administration,

1. A geometric average is calculated by first multiplying the growth rates for each year and then taking the n th root of that product. The geometric average is the appropriate measure for averaging growth rates.

CBO has always forecasted the secondary-market rate. The *Blue Chip* consensus, by contrast, has alternated between the two rates and, in 1981, even projected a third—the six-month commercial paper rate. The *Blue Chip* consensus forecast the new-issue rate from 1982 to 1985, the secondary-market rate from 1986 to 1991, and the new-issue rate again from 1992 to 1997. Since March 1997, the *Blue Chip* consensus has forecast the secondary-market rate.

As part of this analysis, CBO also computes errors in forecasting the real interest rate on 3-month Treasury bills. To do that, the agency deflates each forecaster's annualized projections of nominal interest rates by that forecaster's annualized projections of CPI inflation. Although the forecasters used different measures of inflation and short-term interest rates, the resulting real interest rate forecasts are comparable across time horizons.

CBO's analysis of long-term interest rates focuses on two measures: the 10-year Treasury note rate, published by the Federal Reserve, and Moody's Aaa corporate bond rate. For each series, CBO uses calendar year averages of the latest available monthly data. To calculate the average interest rate over two- and five-year time horizons, CBO computes the geometric average of the annual interest rate series over the relevant sample period.

Both the 10-year Treasury note and the Aaa corporate bond are widely considered low-risk financial securities. Although the return on 10-year Treasury notes is guaranteed by the federal government, the return on Aaa corporate bonds depends on the solvency of the corporations deemed most likely to pay back their financial obligations. Because investors perceive the government to be slightly more creditworthy than the safest corporations, the 10-year Treasury note rate is consistently slightly

lower than the Aaa corporate bond rate. Annual fluctuations in the two series are highly correlated, however, making them roughly comparable across time horizons.

CBO projected the Aaa corporate bond rate in 1984 and 1985 but since then has projected the 10-year Treasury note rate. The Administration has always published forecasts of the 10-year Treasury note rate. The *Blue Chip* consensus forecast the Aaa corporate bond rate until 1996, when it switched to the 10-year Treasury note rate. Because of data constraints, it is not possible to compare forecasts made before 1984.

Wages and Salaries

The growth of wages and salaries is computed from calendar year averages of the most recently available quarterly data published by BEA. To calculate the average annual growth rate over two- and five-year time horizons, CBO computes the geometric average of each series over the relevant sample period. Because the *Blue Chip Economic Indicators* report does not publish a consensus forecast of the growth in wages and salaries, it is omitted from the forecast analysis of that variable.

In this report, CBO also analyzes errors in projections of wages and salaries as a share of output. For the wages and salaries component, the agency uses calendar year averages of the most recently available quarterly data published by BEA. For the output component, the agency uses nominal GNP for forecasts made between 1976 and 1991 and nominal GDP for forecasts made between 1992 and 2017. The agency then divides the amount of wages and salaries by the amount of nominal output to compute wages and salaries as a share of output. CBO uses the arithmetic average to compute the average share of wages and salaries over two- and five-year time horizons.



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About This Document

The Congressional Budget Office regularly evaluates the accuracy of its economic forecasts by comparing them with the economy's actual performance and with others' forecasts. Such evaluations help guide CBO's efforts to improve the quality of its forecasts and, as background information, are also intended to assist Members of Congress in using the agency's estimates. In keeping with CBO's mandate to provide objective, impartial analysis, the report makes no recommendations.

Edward Gamber and Adam Staveski (formerly of CBO) prepared the report with guidance from Robert Arnold, John Kitchen, and Jeffrey Werling. Kim Kowalewski (formerly of CBO) and John McClelland provided helpful comments, as did Tara Sinclair of George Washington University. (The assistance of an external reviewer implies no responsibility for the final product, which rests solely with CBO.) Erin Deal and Sarah Robinson fact-checked the report.

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CBO continually seeks feedback to make its work as useful as possible. Please send any comments to communications@cbo.gov.

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