CBO's Revenue Forecasting Record

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Summary

To prepare the baseline budget projections on which much of its analysis is based, the Congressional Budget Office must regularly produce revenue forecasts. As a part of that process, the agency assesses the accuracy of its past projections and continually refines its methods for projecting revenues to attempt to make them more accurate. This report examines the accuracy of CBO's revenue projections since 1982, the earliest year for which the information necessary to assess the forecasts is available. On average, the agency's projections have been a bit too high—more so for projections spanning six years than for those spanning two—owing mostly to the difficulty of predicting when economic downturns will occur. The overall accuracy of CBO's revenue projections has been similar to that of the projections of other government agencies.

How Accurate Have CBO's Two-Year Revenue Projections Been?

On average, CBO has overestimated total revenues by 1.1 percent in its two-year projections—those that provide estimates of revenues for the fiscal year following the year in which they are released. A misestimate of that size in its January 2015 baseline projection, for example, would amount to $37 billion out of the roughly $3.5 trillion in total revenues that CBO projected for fiscal year 2016.[1] Overestimates

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1. See Congressional Budget Office, *The Budget and Economic Outlook: 2015 to 2025* (January 2015), www.cbo.gov/publication/49892.

Notes: Unless otherwise indicated, all years referred to are federal fiscal years, which run from October 1 to September 30 and are designated by the calendar year in which they end.

Numbers in the text and tables may not add up to totals because of rounding.

Some figures have vertical bars that indicate the duration of recessions. (A recession extends from the peak of a business cycle to its trough.)The historical data on revenues and gross domestic product used in this report are based on information available as of January 2015. Incorporating more recent data into this analysis would have only a very minor effect on the results.

Supplemental data for this analysis are posted along with this report on CBO's website (www.cbo.gov/publication/50831).

and underestimates offset one another in the mean error measure, so that average overestimate of 1.1 percent over the past three decades includes projections for years in the latest recession for which CBO overestimated revenues by as much as 25 percent and projections for the late 1990s and the mid-2000s for which CBO underestimated revenues by nearly 10 percent (see Figure 1). The calculation of those errors—and of all such measures cited in this report—includes an adjustment to remove the estimated effects of legislation enacted after the projections were produced. That adjustment is necessary because the baseline projections incorporate the assumption that current laws governing taxes will generally not be modified by future legislation.

In addition to the mean error, CBO employs two other commonly used measures to evaluate the accuracy of revenue projections: the root mean square error (RMSE) and the mean absolute error. Unlike the mean error, the mean absolute error is the average of the errors without regard to direction (the negative signs are removed from underestimates before averaging), so errors in different directions do not offset one another. The RMSE, the calculation of which involves squaring the errors (thus removing the negative signs), also measures the size of errors without regard to direction, but by squaring the errors, it places a greater weight on larger deviations. The mean absolute error is an easier measure to understand, but the RMSE may be a more useful measure of forecast errors for revenue projections because larger forecast errors may have a disproportionately greater cost for policymaking than smaller ones.

For CBO's two-year revenue projections made since 1982, the mean absolute error is 5.2 percent, and the RMSE is 7.4 percent (see Table 1). A mean absolute error of that magnitude would correspond to an error of about $180 billion in the revenue estimate for 2016 that CBO released in its January 2015 baseline projections. Because a disproportionate share of the misestimates occurred in projections made in years immediately preceding recessions, both the RMSE and the mean absolute error are roughly one-third smaller when the four two-year projections (out of the 32 included in this analysis) that were produced at or near peaks in the business cycle are excluded.

The RMSE provides a useful guide for assessing the distribution of CBO's past two-year projection errors. If the errors of a given set of forecasts are normally distributed around a mean error of zero—that is, if the misestimates are roughly symmetrically distributed around zero and there are more relatively small errors than large ones—about two-thirds of the forecasts will have misestimates within a range of plus or minus one RMSE.[2] CBO's two-year projections have had a small mean error, and they have misestimated revenues by small amounts more often than they have misestimated by large amounts. Thus, about two-thirds of those projections could be expected to have misestimated revenues by 7.4 percent (the RMSE of CBO's two-year projections) or less

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2. More precisely, if the errors were normally distributed around a mean of zero, 68 percent of them would have an absolute value equal to or less than one RMSE.

in either direction; indeed, three-quarters of the misestimates fell into that range. Because the sample size of historical forecasts is relatively small, however, it is not possible to know the true distribution of the forecast errors.

By CBO's calculation, the Administration's forecast errors for revenues have been very similar to CBO's. In its two-year forecasts over the same period (adjusted to exclude the effects of its proposed policy changes), the Administration also overestimated revenues, on average—by 1.7 percent, a little more than CBO's average overestimate of 1.1 percent; the RMSE of its forecasts is 7.8 percent, very close to CBO's RMSE of 7.4 percent. Likewise, the accuracy of revenue projections by state governments has also been very similar to CBO's for comparable sources of revenues.

How Accurate Have CBO's Six-Year Revenue Projections Been?

The projection errors have tended to be larger for longer horizons than shorter ones. CBO's six-year revenue projections—those that estimate revenues for the fifth fiscal year after the year in which they are released—have, on average, overestimated revenues by 5.3 percent. The mean absolute error of those projections is 10.4 percent, and the RMSE is 12.1 percent. A mean absolute error of that magnitude would correspond to an error of about $420 billion in the revenue estimate for 2020 that CBO released in its January 2015 baseline projections. The preponderance of overestimates over that longer horizon results in part from the fact that many of the six-year periods encompassed a recession that reduced economic activity and tax revenues below projected amounts.

The RMSE is not as helpful for analyzing the distribution of the errors for CBO's six-year projections as it is for the two-year projection errors because the six-year projections have a larger mean error than the two-year projections and have resulted in about as many relatively large errors as small ones. The mean absolute error and the RMSE show some signs of stabilizing at the six-year horizon, measuring not much higher than those calculated for the five-year horizon. However, the general accuracy of CBO's forecasts extending beyond six years may not become clearer until well into the future, when enough such forecasts have been produced to allow for a comprehensive assessment.[3]

CBO's six-year forecasts of revenues as a share of gross domestic product (GDP) have an RMSE of 1.1 percentage points and a mean absolute error of 0.9 percentage points. In CBO's January 2015 baseline projections, revenues for 2020, the sixth year of the projection, total 18.0 percent of GDP. On the basis of the mean absolute error of

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3. Before 1996, CBO's baseline typically covered six years: the year in progress at the time of the projections and the subsequent five years. In 1996, CBO adopted its current practice of releasing projections that cover the current year and the next 10 years. The agency first published supplemental projections covering that longer period in 1992, but those projections did not include information about the source of changes from the previous projections; the effects of recently enacted legislation for the extended period were not published until 1996. The limited data for those extended projections do not allow for a general assessment of forecast quality.

past forecasts, revenues for that year might be expected to be as low as 17.1 percent of GDP or as high as 18.9 percent if there are no changes to current law. (The actual error for that particular projection might still fall outside that range.)

How Efficiently Has CBO Incorporated New Information?

CBO has tended to revise consecutive revenue forecasts in the same direction, suggesting that the agency does not efficiently incorporate new information into its forecasts. That tendency was less pronounced in the past 15 years than it was in the previous period, although the limited number of forecasts that can be assessed makes it difficult to conclude that CBO has improved its use of new information. That tendency, furthermore, has varied significantly over the entire history of CBO's forecasts, and CBO's forecast accuracy would not have been systematically improved had the agency incorporated into its forecasts what was known at the time about that tendency; such modifications would have over adjusted the forecasts in many cases.

What Factors Have Contributed to Forecast Errors in CBO's Revenue Projections?

All revenue forecast errors can be attributed either to errors in projections of GDP or to errors in projections of revenues raised as a percentage of GDP. The largest forecast errors are associated with revenue projections produced for years during which recessions occurred and GDP ended up being significantly lower than expected. Those substantial revenue shortfalls have also stemmed from other factors, including unexpected declines relative to GDP in certain types of income—most notably wages and salaries, corporate profits, and capital gains realizations—and declines in the share of overall income earned by the highest-earning taxpayers, which push down the effective tax rate (that is, total taxes as a percentage of total income). To a lesser extent, those same factors and others, working in both directions, have contributed to forecast errors in years without recessions.

At the two-year horizon, the RMSE for revenues as a percentage of GDP has been a little over twice as large as the RMSE for GDP. By the six-year horizon, the RMSE of each of those two measures is very similar. The projection errors for GDP have tended to be larger for longer forecast horizons, increasing steadily with each additional year of the horizon through the six-year horizon, whereas forecast errors for revenues as a percentage of GDP have tended to be larger for each year added to the horizon through the first four years but then to decline slightly at the five- and six-year horizons. It is unclear whether those patterns would continue in projections extending beyond six years.

Errors in revenue forecasts can also be broken down by source of revenues, and the projection errors for each of those specific sources vary widely. Of the seven categories of revenue sources, the forecasts of corporate income taxes exhibited the largest errors (measured as percentages of the actual revenues from the specific source), and those of payroll taxes, the smallest. Although the misestimates for projections of individual

income taxes fall in the middle of the range of errors for the source categories, the projections of such taxes, which were the largest source of federal revenues each year over the historical period, have contributed the most to CBO's forecast errors for total revenues, followed by those of corporate income taxes (the third largest revenue source) and payroll taxes (the second largest). The Administration's forecasts for those revenue sources have had errors similar to those in CBO's forecasts, as have states' projections for individual income taxes and corporate income taxes, the main comparable sources of states' revenues.

CBO's Methods for Projecting Revenues

CBO's methods for projecting revenues reflect the key assumption that underlies the baseline projections—namely, that current laws governing taxes will generally remain unchanged. Therefore, the methods involve more than simply using the past relationship between receipts and macroeconomic measures like GDP as a guide because that relationship has been significantly altered over time by changes to provisions of tax law.

Instead, CBO projects revenues largely by identifying the macroeconomic variables in its economic forecasts that constitute the bases on which the various federal taxes are imposed and applying to those bases the appropriate effective tax rates—which are often much different than the statutory tax rates set by law. CBO therefore models each major revenue source separately and projects total revenues by summing up the projections of the separate sources. The macroeconomic measures used to project revenues include wages and salaries and certain business income, all of which influence both individual income taxes and payroll taxes; asset prices, which affect the income tax base (through capital gains realizations and distributions from tax-deferred retirement accounts) as well as the base for estate and gift taxes; and corporate profits, the key determinant of corporate income taxes. The effective tax rates are modeled in different ways, including using a microsimulation approach that projects individual income and payroll taxes on the basis of data for individual tax-filing units as well as a model that projects corporate income taxes on the basis of more aggregate measures.

When projecting revenues, CBO also assesses how tax collections from recent months deviated from the amounts that were estimated for the course of the full year by its various models. That assessment includes determining whether the factors that may explain such deviations, which typically are not known until more detailed information becomes available in the future, are temporary or are likely to persist.

As detailed data about tax collections become available, CBO modifies its forecasting models and methods appropriately. Over the three decades covered in this report, CBO made numerous adjustments to its methods to reflect developments revealed by the data. For example, more than a decade ago, CBO incorporated into its income and payroll tax projections the expectation that earnings of higher-income

taxpayers would grow more quickly than those of other taxpayers, continuing a trend that has been evident since the late 1970s. More recently, CBO modified its projection methods when it found that past deviations in collections from individual income taxes that were not caused by inaccuracies in the economic forecast tended to be temporary rather than permanent.[4] That conclusion appears to be broadly consistent with this report's finding that errors in projections of revenues as a percentage of GDP tend to flatten and then decline somewhat for progressively longer forecasting horizons through the six-year horizon.

CBO's Method for Assessing Forecast Accuracy

Both CBO and the Administration have published a number of forecasts over the years that, with the adjustments described below, can be analyzed for accuracy and compared with one another. The quality of those forecasts can be measured in various ways, but in this assessment, CBO focuses primarily on two characteristics: statistical bias (how consistently high or low errors are) and accuracy (how large errors are in either direction). Although assessing past forecasts is an important part of the forecasting process, a number of factors limit the extent to which such assessments can improve the accuracy of future projections.

Sources of Data

This evaluation uses single-year estimates from the revenue projections that CBO has released near the beginning of each calendar year, typically in January or February, since 1982. Each of those projections covered the fiscal year in progress and at least the subsequent five years. For example, in February 2013, CBO released projections of revenues for fiscal year 2013 (the one-year projection), fiscal year 2014 (the two-year projection), and for each of the next nine years (see Figure 2). The Treasury Department reports the actual amounts of revenues for the fiscal year (subject to later revisions, which are typically small) each October, shortly after the fiscal year ends.

Although CBO has made economic and budget projections since shortly after it began operating in 1975, the projections produced before 1982 are not comparable with later forecasts because detailed data on the effects of subsequently enacted legislation are not available; those early forecasts are therefore excluded from this analysis. The remaining sample of forecast inaccuracies is relatively small by large-scale statistical standards: 33 one-year forecasts (that is, forecasts for the current year), 32 two-year forecasts, 31 three-year forecasts, and so forth, meaning there are 28 six-year forecasts.

This analysis compares CBO's projections with those released by the Administration since 1982, typically in February, when it submits the budget to the Congress. Each of

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4. See Congressional Budget Office, *Improving CBO's Methodology for Projecting Individual Income Tax Revenues* (February 2011), www.cbo.gov/publication/22007.

CBO's baseline projections is by design a neutral benchmark against which proposed policy changes can be measured; the agency's projections are therefore based on the assumption that laws generally remain the same. In contrast, the official budget projections prepared by the Administration include the estimated effects on revenues of its proposed policies that had not been enacted at the time the projections were made. To make those projections comparable with CBO's revenue projections for the same period, CBO removed the effects of the proposed policies from the Administration's revenue projections by subtracting the Administration's estimates of the effects of those proposed policies, which are published separately.[5]

Actual revenues are, however, affected by legislation that was enacted after the projections were made. To remove the effects of such legislation from its measure of forecast errors (the difference between projected and actual revenues), CBO adjusted the projections to incorporate the effect of the subsequently enacted legislation on revenues before comparing them to actual revenues. The Administration does not generally publish estimates of the revenue effects of legislation that is enacted after it releases its projections, so CBO used the Congressional estimates of the revenue effects—generally the estimates prepared by the staff of the Joint Committee on Taxation near the time of the legislation's enactment—to adjust the Administration's projections as well as its own.[6] The adjustment for subsequent legislation is imperfect because the estimates of the effects of that legislation are themselves imperfect.

To calculate forecast errors, actual revenues were subtracted from those adjusted revenue projections, and the difference was divided by actual revenues. Thus, the forecast errors are expressed as percentages of actual revenues, with positive values representing overestimates and negative values underestimates. CBO's assessment of

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5. The Administration's economic projections include the effects of the proposals, but the Administration does not include changes in revenues that would result from those economic effects in its separate revenue projections for the proposals. Therefore, the Administration's revenue projections with the effects of proposed policies removed may include some economic feedback from the policy proposals and thus are not completely comparable with CBO's baseline projections.

    In the past, the Administration published its own revenue projections without the effects of its proposed policies as its "current services baseline"; more recently, it has published those projections as the "Balanced Budget and Emergency Deficit Control Act baseline." CBO used those estimates directly, but for some details, it used information provided separately by the Administration at the time that the budget was released.

6. The Administration includes a historical assessment of its projections of overall budget deficits and surpluses in its annual budget, but it does not separately assess the projections of revenues and outlays. The budget does, however, contain a separate assessment of the Administration's two-year revenue projection for the most recently completed year, including an estimate of the effects of subsequently enacted legislation. CBO's estimates of the Administration's forecast errors (adjusted for the effects of subsequently enacted legislation) for those two-year projections were very similar to what the Administration reported. Therefore, for consistency, in this report CBO used its own estimates of the Administration's forecast errors for all time periods. The ideal assessment of the Administration's forecast accuracy would use its estimates of the effects of subsequently enacted legislation, which could result in findings that differ from CBO's.

its January 2009 projection offers an example: That month, the agency released baseline projections for 2009 through 2019, estimating that revenues would total $2,533 billion in fiscal year 2010 (see Table 2). To assess the accuracy of that two-year projection, CBO adjusted it to incorporate the effects of legislation enacted between January 2009 and the end of fiscal year 2010. That legislation reduced revenues in 2010 by an estimated $219 billion, most of which was attributable to the enactment of the American Recovery and Reinvestment Act of 2009. Adjusting the January 2009 projection to incorporate the effects of subsequent laws yields an adjusted projection totaling $2,315 billion. The actual revenues in 2010—$2,163 billion—were then subtracted from that adjusted amount, indicating an overestimate of $152 billion, or 7.0 percent of the actual amount (see Figure 3).

Both CBO's and the Administration's revenue projections include details on the different sources of federal revenues: individual income taxes, payroll taxes, corporate income taxes, excise taxes, customs duties, estate and gift taxes, and miscellaneous receipts, which include remittances from the Federal Reserve System, fees, and fines. In addition to an evaluation of the projections of total revenues, this analysis includes a separate evaluation for the specific projections of each source of federal revenues.

Measuring the Quality of Forecasts

This evaluation focuses on two aspects of the quality of CBO's forecasts: statistical bias and accuracy. To a lesser extent, it also assesses how efficiently CBO incorporates new information into its forecasts.

Statistical Bias. The statistical bias of a forecast is its tendency to err in a particular direction. CBO's intent is to provide a revenue baseline that is free of such statistical bias—that is, one that is equally likely to be higher than actual revenues as it is to be lower. To measure statistical bias, CBO uses the mean error—the arithmetic average of the forecast errors—which is the simplest and most widely used measure of forecast bias. However, because the negative values of underestimates offset the positive values of overestimates when calculating the mean error, the measure provides an imperfect view of the accuracy of a forecast. For example, a number of forecasts with small misestimates in both directions that largely offset one another would produce a small mean error. But so, too, would relatively large overestimates and underestimates, as long as they were approximately the same magnitude and counterbalanced one another.

Accuracy. The accuracy of a forecast can be measured by the degree to which a set of forecast values differs from the actual outcomes. Such accuracy is determined by two properties of a set of forecast values: bias (also known as centeredness), discussed above, and variance (also known as spread), the dispersion of the differences between the forecast values and the actual values around the average of those differences. Estimates that have less bias and less variance are more accurate.

In this evaluation, CBO used two standard measures of accuracy: the mean absolute error and the root mean square error. The mean absolute error is the average of the errors without regard to direction, so errors in different directions do not offset one another. The RMSE also measures the size of errors without regard to direction, but by squaring the errors, it places a greater weight on larger deviations.[7] By design, it combines estimates of bias and variance into a single measure.

Although the mean absolute error is conceptually an easier measure to understand, the RMSE may be a better measure of forecast errors for revenue projections because larger forecast errors may have a disproportionately greater cost than smaller ones by, for example, leading policymakers to make adjustments to tax or spending policies that later turn out to be unwarranted. Thus, this report focuses more on the RMSE than on the mean absolute error. Other summary measures of accuracy might also be constructed to identify and emphasize those patterns of forecast errors that most negatively affect policymaking.

Efficient Use of New Information. Another way to assess a forecasting record is to evaluate how forecasts made in one year compare with those made in subsequent years. If revisions to a given forecast in one direction tend to be followed by revisions in the same direction in the subsequent forecasts, then the forecaster may not be incorporating all available information that could reduce forecast errors.

Limitations of Forecast Evaluations

Despite the importance of evaluating those three characteristics of forecasts, the extent to which conclusions drawn from this assessment can help improve CBO's revenue projections is limited for several reasons: Projection methods have changed, estimates of the effects of legislation are imperfect, and only a small number of forecasts are available to examine.

CBO has significantly changed its methods of projecting revenues over the years. The agency has attempted to improve its projections by incorporating new information, and the characteristics of the resulting projection errors may well have changed as it has done so. As a result, it is difficult to learn from past forecast errors precisely how to prevent forecast errors in the future.

In addition, it is not possible to separately analyze the quality of baseline revenue projections and the quality of the estimates that CBO later incorporates to account for the effects of legislation enacted after the forecast was produced. Because the estimates of subsequently enacted legislation are themselves imperfect, the calculated

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7. The root mean square error is calculated by squaring the forecast errors, averaging those squares, and taking the square root of that average. Because the forecast errors in this case are measured as a percentage of the actual amount, the RMSE measurement reported in this assessment is often referred to as the root mean square percentage error. Likewise, the mean absolute error reported in this assessment is often referred to as the mean absolute percentage error.

forecast errors are also imperfect; that is, what may appear to be misestimates in the baseline projections may in reality be misestimates of the effects of legislation, and vice versa. Those estimates of legislative effects exhibit error in part because they use only information available at the time of enactment and thus do not incorporate information that is available later, such as that from tax returns or the actual data on GDP or other macroeconomic indicators. Furthermore, even when all such information is on hand, analysts cannot calculate all of the actual effects on revenues of past legislative changes with certainty.

The conclusions that can be drawn from this forecast evaluation are also limited by the fact that the number of forecasts available is relatively small for the purpose of statistical analysis. Thirty or so years of forecasts is a small sample size given the variability of economic performance and the many different factors in the economy that interact with one another to determine the amount of revenues collected.

Assessment of the Forecasts

CBO's projections for shorter time periods have tended to be more accurate than those for periods extending further into the future, through the six-year horizon—the longest projection period considered in this discussion. The same is true for the Administration's revenue projections. In addition, CBO has been slow to incorporate new information into its revenue projections, resulting in revisions to estimates in one direction in a forecast tending to be followed by revisions in the same direction in the subsequent forecast.

Two-Year Forecasts

CBO's two-year forecasts of total revenues cover the upcoming fiscal year—the year for which policymakers are typically considering appropriation bills and in which proposed changes to tax policy and mandatory spending would often first take effect. On average, CBO's two-year revenue projections were overestimated—that is, actual revenues fell short of the projected amounts—by 1.1 percent between 1983 and 2014; an error of that magnitude would correspond to $37 billion out of the roughly $3.5 trillion in total revenues that CBO projected for 2016 (the two-year forecast) in its January 2015 baseline projections.[8] As with all measures cited, that mean error percentage is adjusted to exclude the effects of legislation enacted after the forecast was produced because the baseline is created under the assumption that no future legislation affecting revenues will be enacted.[9]

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8.   See Congressional Budget Office, *The Budget and Economic Outlook: 2015 to 2025* (January 2015), www.cbo.gov/publication/49892.

9.   Without excluding those effects of legislation, CBO's average overestimate at the two-year horizon would have been about three times as large, indicating that policymakers have cut taxes more than they have raised them over the past 30 years or so (sometimes by extending previous cuts that were scheduled to expire).

That relatively small average error of 1.1 percent does not capture the substantial amount of offsetting that occurs between the overestimates and underestimates. Only 6 of the 32 two-year forecasts—4 overestimates and 2 underestimates—had errors of 1.1 percent or less (with the sign of the error disregarded). Overall, exactly half of the forecasts were overestimated and half were underestimated, but the overestimates, most notably for years that ended up being marked by recession, tended to be larger. The forecast error of the revenue projection for 2009, which was released in January 2008, just about the time the recession hit, is the largest for all of the two-year forecasts, at 24.9 percent. Indeed, if that one forecast is excluded from the analysis, the average error at the two-year horizon is an overestimate of 0.3 percent rather than 1.1 percent.

The RMSE of CBO's two-year forecasts is 7.4 percent, and the mean absolute error is 5.2 percent, both much larger than the mean error of 1.1 percent, which for such a limited number of forecasts suggests the lack of statistical bias. Such a result is consistent with the past findings of several researchers who have studied CBO's revenue forecasts.[10] Testing for statistical bias is not straightforward for multistep forecasts such as these, in which the overlap of time periods in consecutive forecasts causes errors to be related over time. In this case, the fact that both the RMSE and mean absolute error are significantly larger than the mean error indicates a significant degree of offsetting from overestimates and underestimates, making it more likely that a small average error in one direction is simply the result of random chance. One implication is that the addition of more forecasts in a future analysis could well eliminate the mean error or even swing it in the opposite direction.

In addition to exhibiting little or no statistical bias, CBO's two-year forecasts have tended to misestimate revenues by relatively small amounts more often than by larger amounts. Together, those characteristics imply that the RMSE would provide a useful guide for assessing the distribution of forecast errors. In fact, three-quarters of the two-year forecasts—24 of the 32—had errors between -7.4 percent and 7.4 percent, an interval spanning plus or minus one RMSE. That fraction is not far from the approximately two-thirds of errors that would fall within that range if the errors were normally distributed around zero. About half of the two-year forecasts had errors between about -3 percent and 3 percent.

CBO's two-year forecasts do not appear to have become more accurate over time—indeed, the largest forecast errors have been in the more recent years—but that may reflect particular hard-to-predict events in the most recent period, rather than a

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10. See Alan J. Auerbach, "On the Performance and Use of Government Revenue Forecasts," *National Tax Journal*, vol. 52, no. 4 (December 1999), pp. 767–782, http://tinyurl.com/pqxq8an; Rudolph G. Penner, "Federal Revenue Forecasting," in Penner, *Handbook of Government Budget Forecasting* (Taylor & Francis, 2008); and George A. Plesko, "The Accuracy of Government Forecasts and Budget Projections," *National Tax Journal,* vol. 41, no. 4 (December 1988), pp. 483–501, http://tinyurl.com/olcmrue.

deterioration in CBO's forecasting accuracy outside of those events. In particular, the largest errors occurred following the 2001 recession and, to an even greater extent, the 2007–2009 recession. The latter was the largest economic downturn since the Great Depression, and the two largest sustained declines in the stock market over the historical period occurred during those recessions. Even apart from those events, the small sample of forecasts makes it difficult to draw conclusions about changes in the accuracy of CBO's forecasts over time.

Over the past few decades, the accuracy of the Administration's revenue forecasts was very similar to that of CBO's forecasts. By CBO's calculation, forecast errors for the Administration's two-year revenue projections averaged 1.7 percent, just slightly higher than CBO's. In addition, the RMSE and mean absolute error of the Administration's two-year forecasts—7.8 percent and 5.5 percent, respectively—are both very similar to those of CBO's forecasts.

Six-Year and Other Forecasts

On average, CBO overestimated revenues in its six-year forecasts for 1987 to 2014 (those published between 1982 and 2009) by 5.3 percent (see Figure 4). The error jumped for the last few of those forecasts as a result of the unexpected 2007–2009 recession. If the forecasts for 2009 to 2014 are excluded—the overestimates for those years averaged 17.5 percent—CBO still, on average, overestimated revenues in its six-year forecasts, but by a much smaller 2.0 percent.

As with the mean error of the two-year forecasts, the mean error of the six-year forecasts includes a substantial amount of offsetting between underestimates and overestimates; unlike the case with forecasts for the shorter period, however, overestimates more clearly dominate those for the longer horizon. In total, about 19 forecasts overestimated revenues and 9 underestimated them. For 14 of the 19 forecasts with overestimates, a recession occurred in the intervening years that affected the amount of revenues collected in the sixth year. About two-thirds of the forecasts—11 overestimates and 7 underestimates—have errors of 13 percent or less, but only about one-third have errors of about 5 percent or less. Of the 8 overestimates that exceed 13 percent, 5 (those for 2009 to 2013) were affected by the 2007–2009 recession. The forecast error of the revenue projection for 2012, which was produced in January 2007, is 23 percent—the largest error of all of CBO's six-year projections.

The mean errors of CBO's forecasts are progressively larger for each additional year of the horizon. On average, CBO's one-year projections—those for the year in progress at the time the forecast was produced—underestimated revenues by only 0.1 percent. However, the average overestimate of 1.1 percent at the two-year horizon grows to 3.7 percent at the four-year horizon, 4.7 percent at the five-year horizon, and 5.3 percent at the six-year horizon.

The RMSE and mean absolute errors also tend to be larger for longer time horizons, although there is some evidence of a leveling off of the errors at the end of the six-year period. The RMSE of CBO's one-year revenue projections is 3.0 percent; it is 7.4 percent for CBO's two-year projections and 10.0 percent for the three-year projections. Although the RMSE continues to grow with each additional year of the projection period through the six-year horizon, it does so at a slower rate, reaching 11.1 percent for the four-year projections, 11.9 percent for the five-year projections, and 12.1 percent for the six-year projections. A similar pattern exists for the mean absolute error.

The RMSE is not as useful a guide to the distribution of the misestimates of the six-year projections as it is for the two-year projections. That is because the six-year projections have a larger mean error than the two-year projections and have misestimated revenues by larger amounts about as often as by smaller amounts: Just over half of the six-year projections have had forecast errors in either direction of less than 12.1 percent, an interval spanning plus or minus one RMSE.

The accuracy of CBO's and the Administration's forecasts, as measured by the mean error and RMSE, was very similar. The Administration's six-year projections, for example, have a mean error of 6.6 percent and an RMSE of 13.4 percent, by CBO's calculation, which are similar to the mean error and RMSE of CBO's six-year projections (5.3 percent and 12.1 percent, respectively). Taking a slightly different approach, CBO calculates that the Administration's projection errors are also similar when the Administration's forecasts are adjusted using the estimates of the revenue effects of major pieces of subsequently enacted tax legislation that were published by the Treasury Department (in a working paper by one of its economists) rather than CBO's estimates.[11] The RMSE of the Administration's six-year projections measures 13.0 percent calculated using those alternative estimates, slightly lower than the 13.4 percent measured using CBO's estimates for the same legislation.[12]

Efficient Use of New Information

One characteristic of CBO's forecast record that has proven difficult to correct is that the agency has tended to revise consecutive revenue forecasts in the same direction. That tendency suggests that CBO may not be efficiently incorporating all new

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11. See Jerry Tempalski, "Revenue Effects of Major Tax Bills, Updated Tables for All 2010 Tax Bills" (supplemental material from June 2011 for *Revenue Effects of Major Tax Bills*, Working Paper 81, Office of Tax Analysis, revised September 2006), http://go.usa.gov/cCuEP (PDF, 93 KB). The legislative estimates are provided for total revenues, not for the components of revenues. Because the estimated effects are not provided beyond the five-year horizon, CBO extrapolated the estimates for the sixth year.

12. In many cases CBO does not have available its own estimates for the separate pieces of enacted legislation, just the sum of effects of legislation enacted between baselines. Therefore, for the purpose of comparison the agency used the Treasury Department's estimate of the revenue effects of a major piece of enacted legislation as if it was the only legislation enacted between two baselines.

information into its forecasts. Forecasts produced in the mid- to late 1980s, in the early 2000s, and between 2007 and 2009 tended to overestimate revenues for shorter horizons and were subject to repeated downward revisions, whereas those from the mid- to late 1990s and from the mid-2000s—periods of economic booms—tended to underestimate revenues and were repeatedly revised upward. To some degree, those forecast errors were related to the business cycle, but even after shifts between expansion and recession in the business cycle became apparent, it still took time for CBO to incorporate that information and the related effects on revenues into its forecasts.

The correlation between revisions to CBO's revenue forecasts was first quantified by Alan Auerbach in 1999 when he analyzed forecasts that the agency made between 1985 and 1999.[13] In the present analysis, CBO found that the correlation of its forecast revisions was smaller over the past 15 years than in the time period that was initially assessed by Auerbach. However, the limited number of forecasts that can be assessed makes it difficult to draw conclusions about any improvement that CBO may have made in incorporating information into its projections over time.

The correlation of forecast revisions has varied a lot over the past 30 years, suggesting that adjusting for the average correlation over the entire period would have improved accuracy for some forecasts and worsened it for others. CBO's overall forecast errors, as measured by the RMSE, would not have been systematically improved if the agency had adjusted its forecasts to incorporate what was known about the pattern of its past forecast revisions at the time each forecast was made; that method would have over adjusted the forecasts in many cases. Despite the lack of a systematic improvement in forecast accuracy from such an approach, CBO continually assesses newly available information for the components of its economic and revenue forecasts to try to ensure that it is using the latest information in the most efficient manner.

Some Sources of Forecast Error

Forecast error in baseline revenue projections can arise from myriad sources. The forecast of GDP, the key input into the revenue projections, can miss short-term movements in the business cycle, longer-term trends in productivity growth, and other important developments that affect revenues. A variety of other unexpected developments can contribute to errors in projections of revenues as a percentage of GDP—and therefore in projections of revenues—including changes in the composition of GDP and national income; the relationship between national income and the associated tax bases; the relative growth rates of asset prices and GDP; the distribution of income among taxpayers; and the effects of recent changes in policies.

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13. See Alan J. Auerbach, "On the Performance and Use of Government Revenue Forecasts," *National Tax Journal*, vol. 52, no. 4 (December 1999), pp. 767–782, http://tinyurl.com/pqxq8an.

The forecast errors for GDP have tended to increase progressively as the horizon lengthens, through six years, resulting from misestimates in both cyclical factors and noncyclical factors such as productivity growth. Forecast errors for revenues as a percentage of GDP have tended to increase through the four-year horizon but then to decline slightly for five- and six-year projections. Misestimates of revenues as a percentage of GDP have tended to increase or decrease along with misestimates of GDP, especially at turning points in the business cycle, when both tend to be larger. Of the forecasts of particular sources of revenues, those of corporate income taxes have exhibited the largest errors (in percentage terms) and those of payroll taxes the smallest.

It is clear from the historical record that forecasts completed around business cycle peaks have had the largest errors in forecasting revenues. For example, the two-year forecasts that CBO released in early 1982, 1990, 2001, and 2008—near the beginning of recessions—significantly overestimated the amount of revenues that were collected in 1983, 1991, 2002, and 2009. (Lags between economic activity and the payment of taxes caused the largest shortfalls in revenues to occur some period after the beginning of the recessions.) The overestimates of revenues for those four forecasts range from 9 percent to 25 percent, yielding an RMSE of 16.8 percent, whereas the RMSE for all of CBO's other two-year forecasts is 4.8 percent (see Figure 5). The Administration's forecasts have exhibited very similar errors.

Errors Related to the Size of the Economy

CBO's revenue projections are critically affected by the projections of the overall size of the economy, typically measured by GDP and national income. Both of those measures include such variables as wages and salaries, corporate profits, and proprietors' income.

CBO regularly assesses its economic forecasts to look for ways in which they might be improved.[14] The following key insights about forecast errors have been gleaned from those assessments:

■ Forecast errors tend to be large around business cycle peaks, just before a recession begins. In some cases, the errors occur because the recessions are prompted by shocks that were unforeseeable at the time the forecasts were made; in others, the recessions occur during periods of especially great economic uncertainty, so widely different forecasts appeared equally probable.

■ Productivity trends can change in unexpected ways. Shifts in capital accumulation and the effects of specific policies on incentives to invest, both important determinants of productivity growth, can be difficult to identify until several years after the fact.

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14. For the latest analysis, see Congressional Budget Office, *CBO's Economic Forecasting Record: 2015 Update* (February 2015), www.cbo.gov/publication/49891.

- Oil prices fluctuate widely for reasons that are very difficult to predict. Sometimes those fluctuations affect the accuracy of overall inflation projections.

- Historical data are subject to revision, making it difficult to discern when forecast errors stem from imperfect data and when they stem from imperfect forecasting approaches.

Errors Attributable to Other Factors

In addition to the size of the overall economy, an array of other factors affect the amount of revenues collected per dollar of GDP. Those other factors appear to have been more significant sources of forecast error for shorter time horizons, but the size of the economy appears to have been at least as important as those factors for longer horizons through six years.

Those errors in projecting the revenue yield on GDP (that is, revenues measured as a percentage of GDP) arise in part because the individual components of national income generated at a given level of GDP can be difficult to predict. The mix of different types of income, as measured in the national income and product accounts compiled by the Bureau of Economic Analysis (BEA), is very important to revenue forecasts because each category of income is taxed at a different effective rate. For example, wages and salaries, which are subject to both the individual income tax and payroll taxes, generate more revenues per dollar of income than do other types of income included in the macroeconomic forecast. Corporate profits, which are taxed at the next highest rates, vary more from year to year than other income sources and thus are especially difficult to forecast accurately. Some sources of income included in the macroeconomic forecast, such as interest income, are effectively taxed at much lower rates than other income because a much larger share of those sources is earned in forms that are not subject to taxation.

In addition, income reported on tax returns, which is generally projected to grow at the rate of the comparable measure in the national income and product accounts, may actually grow at a different rate. For example, the growth rate of wages and salaries reported on tax returns may be different from that of wages measured in national income because of coverage or sampling differences. Similarly, taxable profits reported on corporate tax returns may grow at a different rate than the profits recorded in the national income accounts: BEA calculates profits by subtracting the losses of unprofitable businesses from the profits of profitable ones, but unprofitable businesses do not typically pay corporate income taxes.

Even if the amounts of income reported on tax returns were predicted correctly on the basis of their corresponding categories in the national income accounts, other factors that are difficult to project would still affect the amount of revenues collected. One such factor is the distribution among individual taxpayers of a specific component of income. For instance, wages and salaries may accrue more or less than expected to

high-income taxpayers, who face the highest tax rates. Also, because the national income accounts measure income earned in the current period, errors in projecting components of the tax base that correspond to income from prior periods, such as pension distributions and capital gains realizations, contribute to errors in projecting the revenue yield for a given level of GDP. In recessions, the decline in the revenue yield on GDP contributed to significant revenue shortfalls, when certain categories of taxable income, such as wages and salaries, corporate profits, and capital gains realizations, unexpectedly declined relative to GDP and the highest-earning taxpayers unexpectedly earned a smaller share of overall income, pushing down effective tax rates.

Errors Attributable to Misestimates of the Size of the Economy Versus Other Factors

To examine the relative importance of the size of the economy versus other factors, CBO compared errors in forecasts of GDP with those in projections of revenues as a share of GDP.[15] By that analysis, misestimates of revenues as a percentage of GDP are larger than misestimates of GDP for shorter horizons, but the misestimates of the two measures are closer together for longer horizons:

■ The RMSE of CBO's two-year projections of GDP is 2.5 percent; for projections of revenues as a share of GDP, it is 5.4 percent (see Table 3).[16]

■ At the four-year projection horizon, the forecast errors of each of the two factors are higher than those at the two-year horizon; the RMSE of forecasts of revenues as a percentage of GDP (7.1 percent) exceeds the RMSE of forecasts of GDP (4.8 percent).

■ At the six-year projection horizon, CBO's misestimates of GDP (which have an RMSE of 7.0 percent) and of revenues as a share of GDP (which have an RMSE of 6.4 percent) are very similar. The RMSE of projections of GDP at the six-year horizon is higher than that of projections at the four-year horizon, continuing the pattern of errors increasing with the length of the horizon; the RMSE of projections of revenues as a percentage of GDP, however, was slightly *lower* at the six-year than at the four-year horizon.[17]

Because the measure revenues as a share of GDP is itself a percentage, the forecast errors associated with it can also be expressed in percentage points (that is, as the

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15. To account for the effect of revisions to the historical amounts of GDP, CBO used the projected growth rate of GDP and applied it to current estimates of the historical amounts of GDP to calculate errors in past projections of GDP. The historical amounts of revenues have been revised by only small amounts; therefore, the revenue projections have not been adjusted in the same way.

16. The RMSEs for GDP and for revenues as a share of GDP do not sum to the corresponding RMSE for total revenues because of interactions between the two and the squaring of the errors.

17. The same basic pattern emerges if only the forecasts through January 2009 are included and if the more recent forecasts, for which actual results are known only for the shorter horizons, are excluded so that the same number of forecasts is analyzed for each horizon.

difference between the projected and actual percentages of GDP). CBO's six-year forecasts of revenues as a share of GDP (which averaged 17.2 percent of GDP over the years covered in this report) have an RMSE of 1.1 percentage points and a mean absolute error of 0.9 percentage points. In CBO's January 2015 baseline projections, revenues for 2020, the sixth year of the projection, total 18.0 percent of GDP.[18] On the basis of the mean absolute error of past forecasts, revenues for that year might be expected to be as low as 17.1 percent of GDP or as high as 18.9 percent if there are no changes to current law. (The actual error for that particular projection might still fall outside that range.)

The pattern of errors in CBO's revenue forecasts growing with the length of the horizon has presumably occurred because noncyclical factors that affect the projections of potential (or maximum sustainable) GDP and actual GDP, such as long-term productivity growth, have tended to steadily boost errors in projections of GDP and revenues. It is not surprising that the magnitude of errors in projections of productivity increases for longer horizons because each year's productivity growth rate is uncertain and misestimates of productivity would compound over time.[19]

By contrast, errors for projections of GDP that are related to the business cycle should not continue to grow after the first few years of a particular projection's horizon have passed because, in CBO's estimation, the size of the economy would be expected to return close to its potential after a few years.[20] If potential GDP was projected correctly for those later years, then the forecast errors for GDP would relate to where the economy was in its cycle—overestimates and underestimates would occur, but they would not increase in magnitude for longer forecast horizons unless the nature of the cyclical upturns and downturns changed.

Likewise, cyclically related errors in projections of revenues as a share of GDP should not continue to grow after the first few years of a projection's horizon have passed. That pattern is discernable in CBO's historical forecasting record: The RMSE of CBO's projections for revenues as a percentage of GDP reaches a peak at the four-year horizon and declines slightly at the five- and six-year horizons.

It is unclear whether errors for CBO's revenue projections extending beyond six years— either the small set that the agency has produced in recent years or those that it will produce in the near future—will generally continue to increase beyond those observed at the six-year horizon or if they will instead stabilize or even decline. Indeed, the

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18. See Congressional Budget Office, *The Budget and Economic Outlook: 2015 to 2025* (January 2015), www.cbo.gov/publication/49892.

19. See Alan J. Auerbach, "Fiscal Uncertainty and How to Deal With It," Working Paper 6, Hutchins Center on Fiscal and Monetary Policy, Brookings Institution (December 15, 2014), http://tinyurl.com/knuldte.

20. Because of the nature and depth of the 2007–2009 recession, CBO's projections in recent years have had GDP return toward its potential level more slowly than has occurred historically.

accuracy of CBO's current revenue projections could be quite different from the average accuracy of those projections over the agency's history.

Interactions Between Misestimates of GDP and Other Factors

In CBO's forecasting record, misestimates of GDP have tended to move together with misestimates of revenues as a percentage of GDP, especially at turning points in the business cycle (see Figure 6). In particular, misestimates of revenues as a percentage of GDP have been more cyclical than misestimates of GDP. Given that GDP affects revenues more than revenues affect GDP, it appears that misestimates of GDP can be used to predict misestimates of other factors that determine the amount of revenues. As a result, attributing the errors separately is an oversimplification because improved (or worsened) accuracy in projecting GDP, particularly during turning points, would probably lead in general to improved (or worsened) accuracy in projecting revenues as a percentage of GDP. However, the relationship between accuracy in projecting those measures is complicated and not consistent across time periods.

The relationship between misestimates of GDP and those of other revenue-determining factors appears strongest during business cycle downturns, but it is also evident during cyclical booms. During recessions, CBO has overestimated not only GDP but also key components of the tax base relative to GDP, such as capital gains realizations, pension distributions, and corporate profits. The overestimates of those components, furthermore, have often exceeded, in percentage terms, the overestimate of GDP. Misestimates of GDP and misestimates of revenues as a percentage of GDP have exhibited a similar relationship even when the economy was not experiencing a cyclical downturn. For example, in the late 1990s, an unexpected cyclical boom resulted in CBO's underestimating GDP and, to a greater extent, revenues as a percentage of GDP.

Errors in Projections of Different Sources of Federal Revenues

The amount of uncertainty about factors affecting revenues varies substantially by revenue source. Of CBO's two-year revenue projections, those of corporate income taxes have the highest RMSE—29 percent—and those of payroll taxes, the lowest—3.5 percent (see Figure 7). The RMSE of projections of corporate receipts is enlarged by a few very sizable errors; the median absolute error is much smaller—11 percent—and the mean absolute error is 18 percent.[21]

CBO's projections of individual income tax receipts, the largest source of federal revenues, have an RMSE of 10.2 percent, which falls in the middle of the error rates for the tax sources. The projections of customs duties and of excise taxes have RMSEs of 8.5 percent and 8.8 percent, respectively. And the projections of miscellaneous receipts

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21. The median absolute error is the error that on the basis of magnitude falls in the middle of all errors (when the direction of the errors is ignored). Half of the errors are larger than the median absolute error, and half are smaller.

(fees and fines and Federal Reserve earnings) and of estate and gift taxes have RMSEs of 15.7 percent and 18.0 percent.

For each revenue source, CBO would attribute about the same percentage error to misestimates of GDP, and misestimates of revenues as a percentage of GDP would account for the remaining, generally much larger, part of the total projection error.[22] For example, the RMSE of CBO's two-year projections for GDP was 3 percent, and that for its forecasts of individual income taxes as a percentage of GDP was 8 percent— yielding a total RMSE (including interactions) of 10.2 percent. Correspondingly, for corporate income taxes, the RMSE for GDP of 3 percent combines with that for revenues as a percentage of GDP of 26 percent to yield the total RMSE of 29 percent. For payroll taxes, however, misestimates of GDP and of revenues as a percentage of GDP account for more equal portions of the total RMSE.

The divergence in forecasting outcomes by revenue source is largely explained by the fact that the tax bases for the different revenue sources have varying degrees of predictability. Most notably, the primary tax base for payroll taxes—wages and salaries—tends to increase at more stable rates over time than most other tax bases, making it more predictable. Corporate profits, which fluctuate significantly over the business cycle, are notoriously difficult to project accurately. It is therefore not surprising that projections of payroll taxes have been the most accurate and projections of corporate income taxes the least accurate. The tax base for individual income taxes is made up primarily of wages and salaries, but it also includes much more variable sources of income, such as business income taxed at the individual level and capital gains realizations, which fluctuate significantly with the prices of assets and with taxpayers' decisions about when to sell their assets.

The projections of the smaller sources of revenues, which combined have averaged about the size of receipts from corporate income taxes, depend on factors related to more limited parts of the economy that can vary widely and in unexpected ways. For example, estate and gift taxes are assessed on the wealth of large estates, which can fluctuate widely with asset prices. In addition, miscellaneous fees and fines can vary substantially for industry-specific reasons.

The projections for specific tax sources that contribute the most to the errors in projections of total revenues are not necessarily those with the largest errors. A relatively small error in a projection of a large source of federal revenues can result in a large error in the projection of total revenues, just as a large deviation in a projection of a small source of revenues can result in a small total forecast error.

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22. Misestimates in projecting GDP could affect different revenue sources in different ways, but the effects would be broadly similar among revenue sources. For purposes of this analysis, CBO simplified the calculations by attributing the same percentage error in estimates of GDP to each source so that each 1 percentage-point misestimate of GDP would yield a 1 percentage-point misestimate for each source of revenue.

To determine which source-specific projections have contributed the most to the errors in the projections for total revenues, CBO calculated errors for projections of each tax source relative to total revenues, rather than to revenues from that source alone.[23] By that metric, projections of revenues from the largest source, individual income taxes, with an RMSE relative to total revenues of 4.6 percent, have contributed the most to the forecast errors of CBO's two-year projections of total revenues (see Table 4). The projections for the third largest source, corporate income taxes, have an RMSE relative to total revenues of 2.4 percent, larger than that for the second largest, payroll tax receipts (1.3 percent), even though corporate income tax receipts have averaged less than one-third of the amount of payroll tax receipts over the past few decades. The variability of corporate income taxes over the business cycle magnifies their importance in determining total forecast accuracy. The projections of smaller tax sources have contributed much smaller amounts to forecast errors for total revenues; the RMSE for each of those sources relative to total revenues is 0.6 percent or less.

Another pattern that emerges in the data is that the forecast errors for the largest revenue sources have tended to move together. The errors in projections of individual income taxes and payroll taxes have a correlation coefficient of 0.75, indicating a high degree of correlation.[24] For those two sources of revenues, wages and salaries are a major part of the tax base, so the correlation of the errors in their projections is not a surprise. The correlation coefficient of projection errors for individual income taxes and corporate income taxes is smaller at 0.62, but it still suggests a significant degree of correlation. Errors in projecting the overall size of the economy tend to cause errors in projections of individual and corporate incomes in the same direction, and errors in CBO's projections of individual and corporate income taxes have moved together to some degree. However, misestimates of the shares of total income in the economy that accrue to labor and capital tend to cause forecast errors for individual and corporate income taxes to be negatively correlated—but that effect has not been predominant in CBO's forecasting record. The correlation coefficient of errors in projections of payroll taxes and corporate income taxes is smaller still at 0.39, indicating a weaker positive relationship.

As with the projections of total revenues, the accuracy of the Administration's forecasts of the revenue components has been very similar to CBO's (see Figure 7). For their projections of both individual income taxes and payroll taxes, CBO's and the Administration's RMSEs are virtually the same. For corporate income taxes, the RMSE of

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23. The RMSE of projections for a single tax source relative to total revenues can be approximated by multiplying the RMSE of the projections for a source by that source's average share of total revenues over the period. However, the more that a revenue source's share of total revenues varies over the period, the less precise that approximation becomes. The estimates provided use the precise calculation.

24. The correlation coefficient varies between 1, indicating that the two measures move perfectly in tandem, and -1, indicating that the two measures move completely opposite each other.

the Administration's projections is 32 percent and that of CBO's projections is 29 percent. Likewise, for the smaller sources of revenues, the RMSEs of the Administration's projections generally have been a little higher than those for CBO's projections.

The revenue projections made by state governments from 1987 to 2013 had a degree of accuracy for comparable sources of revenues very similar to CBO's over the slightly longer span examined here.[25] For the two-year forecasts by state governments, projections of corporate income taxes have larger errors (a median absolute error of 11.8 percent) than projections of individual income taxes (which have a median absolute error of 4.4 percent). (The corresponding figures for CBO's projections are about 11 percent and 6 percent.)[26] One factor complicating a comparison is that most states produce their forecasts slightly closer to the start of the subsequent fiscal year than does CBO.

In addition to income taxes, states also derive a substantial share of revenues from sales taxes, which, like payroll taxes at the federal level, are much more predictable than the other revenue sources. Not only do the federal and state revenue forecasts share similarities in the size of errors for projections of particular revenue sources, they also share the characteristic that the errors are especially large for those projections that are made around the time of recessions.

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25. See Donald J. Boyd and Lucy Dadayan, "State Tax Revenue Forecasting Accuracy: Technical Report," The Nelson A. Rockefeller Institute of Government and the State University of New York (September 2014), http://tinyurl.com/pxocc94 (PDF, 1.25 MB).

26. Boyd and Dadayan's assessment of state forecasts, cited above, includes only median errors for those sources of revenues, so CBO cannot compare its mean errors.

About This Document

Each year, typically in January or February, the Congressional Budget Office issues a report on the state of the budget and the economy. This document provides background information on the accuracy of the revenue projections included in those past reports. In keeping with CBO's mandate to provide objective, impartial analysis, this report makes no recommendations.

Mark Booth of CBO's Tax Analysis Division and Logan Timmerhoff (formerly of CBO) wrote the report with guidance from David Weiner. Nathaniel Frentz, Jeffrey Holland, Peter Huether, and Christopher Williams of CBO and Douglas Elmendorf (formerly of CBO) provided helpful comments. Alan Auerbach of the University of California at Berkeley, Dean Croushore of the University of Richmond, and Alec Phillips of Goldman Sachs also reviewed the report. The assistance of external reviewers implies no responsibility for the final product, which rests solely with CBO.

Jeffrey Kling, John Skeen, and Robert Sunshine reviewed the report, Bo Peery edited it, and Maureen Costantino and Jeanine Rees prepared it for publication. This report is available on CBO's website (www.cbo.gov/publication/50831).
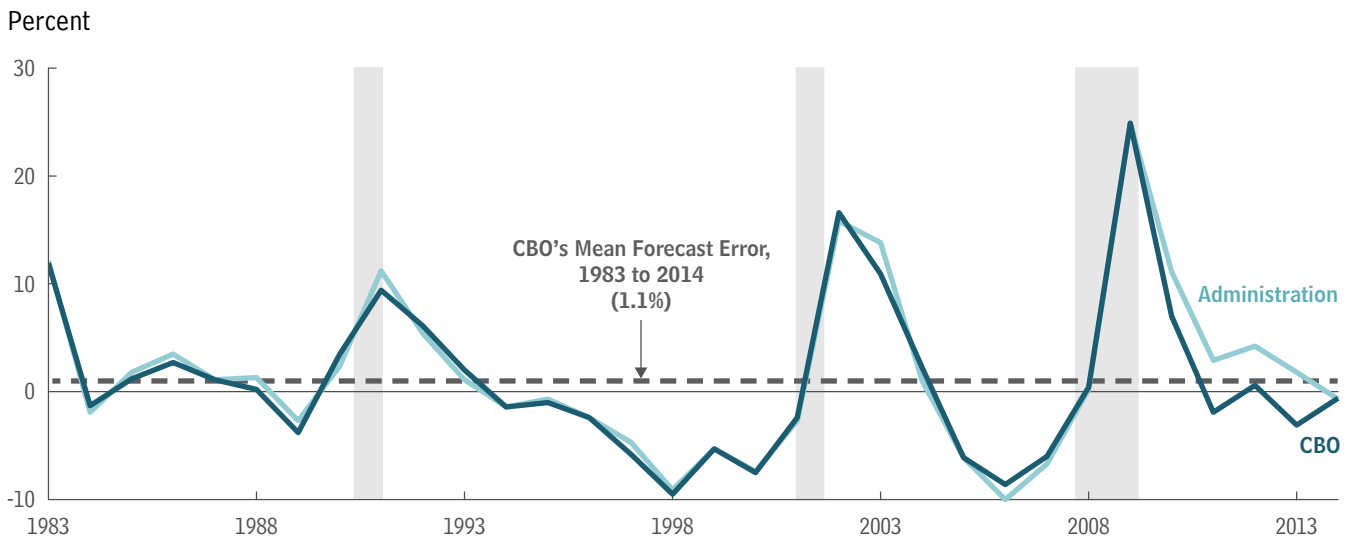
Keith Hall
Director

November 2015

Figure 1.

Forecast Errors for CBO's and the Administration's Two-Year Revenue Projections

Percent

Sources: Congressional Budget Office; Office of Management and Budget.

Notes: The years shown are those for which each forecast was made; CBO's two-year projections were typically published in January or February of the previous year. For example, the value of 11.9 percent for CBO's forecast error for 1983 indicates that the projection published in February 1982 for revenues in fiscal year 1983 overestimated revenues by that amount.

Forecast errors are projected amounts minus actual amounts, expressed as a percentage of actual amounts.

Table 1.

Summary Measures of the Accuracy of CBO's Revenue Projections

Percent

	One-Year	Two-Year	Three-Year	Four-Year	Five-Year	Six-Year
Mean Error	-0.1	1.1	2.4	3.7	4.7	5.3
Mean Absolute Error	2.3	5.2	7.6	9.3	10.1	10.4
Root Mean Square Error	3.0	7.4	10.0	11.1	11.9	12.1

Source: Congressional Budget Office.

Notes: The revenue projections included here are those published between 1982 and 2014, typically in January or February. A one-year projection is for the fiscal year in which it is published, a two-year projection is for the fiscal year beginning eight to nine months after it is published, a three-year projection is for the fiscal year starting one year and eight to nine months after it is published, and so on.
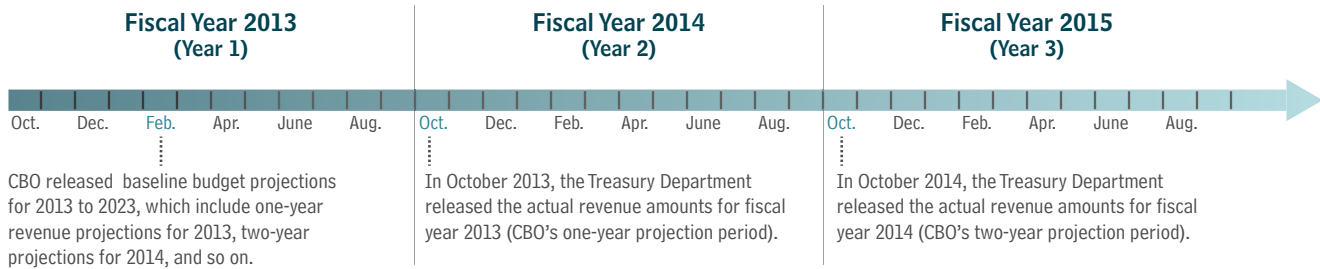
Forecast errors are projected amounts minus actual amounts, expressed as a percentage of actual amounts; thus, a positive error indicates an overestimate.

The mean error is the arithmetic average of the forecast errors. The mean absolute error is the average of forecast errors without regard to direction (the negative signs are removed from underestimates before averaging). The root mean square error is calculated by squaring the forecast errors, averaging those squares, and taking the square root of the average.

Figure 2.

A Timeline for Measuring the Forecast Errors of CBO's Revenue Projections

Fiscal Year 2013 (Year 1)	Fiscal Year 2014 (Year 2)	Fiscal Year 2015 (Year 3)

Oct.   Dec.   Feb.   Apr.   June   Aug.   Oct.   Dec.   Feb.   Apr.   June   Aug.   Oct.   Dec.   Feb.   Apr.   June   Aug.

CBO released baseline budget projections for 2013 to 2023, which include one-year revenue projections for 2013, two-year projections for 2014, and so on.

In October 2013, the Treasury Department released the actual revenue amounts for fiscal year 2013 (CBO's one-year projection period).

In October 2014, the Treasury Department released the actual revenue amounts for fiscal year 2014 (CBO's two-year projection period).

Source: Congressional Budget Office.

Note: Actual dates for the one- and two-year projections for revenues that were published in 2013 (the most recent two-year projection included in this study) are provided here as an example. The timelines for measuring forecast errors are similar for all one- and two-year projections.

Table 2.

CBO's 2009 Revenue Projections Adjusted to Account for Estimates of Subsequently Enacted Legislation

Billions of Nominal Dollars

	Fiscal Year					
	2009 (Year 1)	**2010** (Year 2)	**2011** (Year 3)	**2012** (Year 4)	**2013** (Year 5)	**2014** (Year 6)
January 2009 Baseline Projection of Revenues	2,357	2,533	2,825	3,124	3,353	3,544
Estimated Effects of Subsequent Legislation Enacted in Each Period						
January 2009 to August 2009	-61	-166	2	8	-1	25
August 2009 to January 2010	0	-44	4	7	8	26
January 2010 to August 2010		-9	-2	6	31	74
August 2010 to January 2011		0	-409	-335	-68	16
January 2011 to August 2011			*	*	-3	-2
August 2011 to January 2012			0	-20	-9	-1
January 2012 to August 2012				-70	-21	-37
August 2012 to February 2013				0	-280	-299
February 2013 to May 2013					0	0
May 2013 to February 2014					0	*
February 2014 to August 2014						1
August 2014 to September 2014						0
Total	-61	-219	-405	-405	-343	-198
Adjusted January 2009 Baseline Projection of Revenues	2,296	2,315	2,420	2,720	3,010	3,346

Source: Congressional Budget Office.

Notes: Actual data for the revenue projections that were published in January 2009 (including the most recent six-year projection for which actual amounts are available) are provided here as an example. Adjustments to account for the effects of subsequently enacted legislation (such as those shown in the table) allow for a comparison between projected and actual amounts.

The periods identified for the legislation correspond to the intervals between successive baseline projections, which CBO typically publishes in January or February and updates in August of each year.

The estimated effects on revenues of specific pieces of legislation were generally provided by the staff of the Joint Committee on Taxation near the time of the legislation's enactment.

The three laws that were enacted in the five years after CBO's January 2009 baseline projection that had the largest effects on revenues were the American Recovery and Reinvestment Act of 2009 (enacted in February 2009); the Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act of 2010 (enacted in December 2010); and the American Taxpayer Relief Act of 2012 (enacted in January 2013).
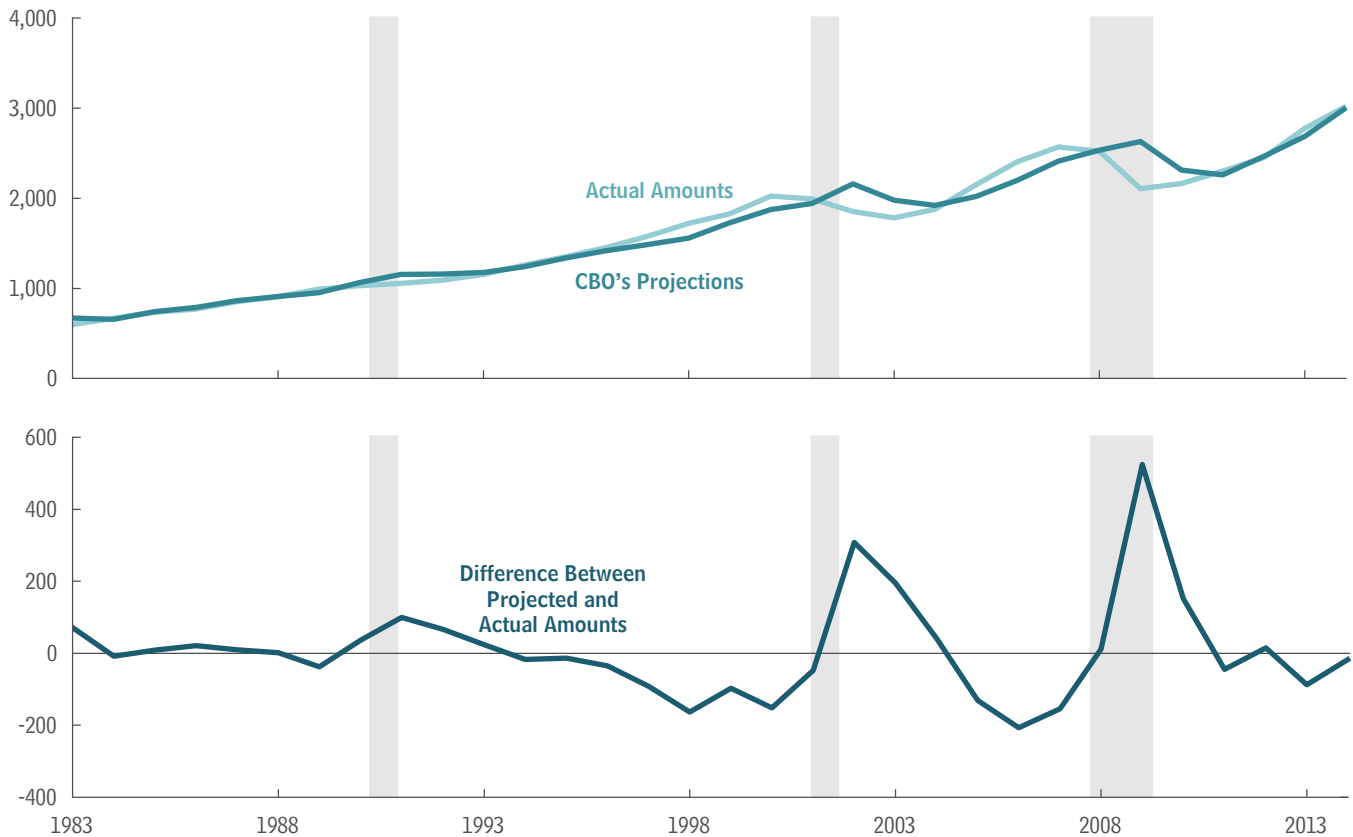
* = between -$500 million and $500 million.

Figure 3.

CBO's Two-Year Revenue Projections Compared With Actual Amounts

Billions of Nominal Dollars

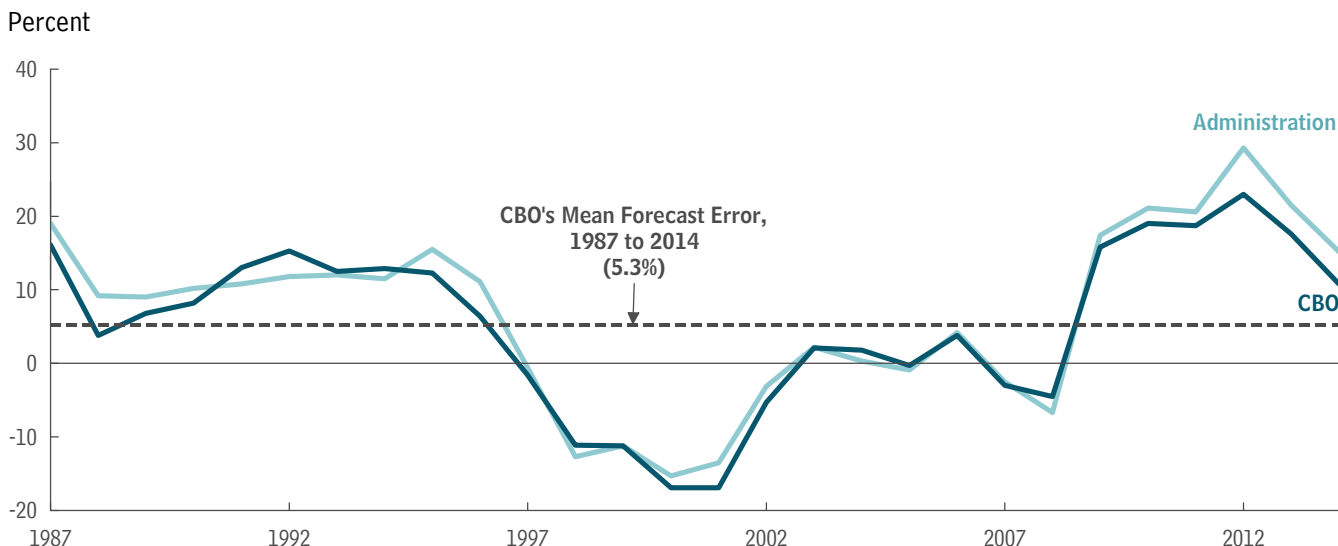Sources: Congressional Budget Office; Office of Management and Budget.

Notes: The years shown are those for which each forecast was made; the two-year projections were typically published in January or February of the previous year. For example, in February 1982, CBO projected that revenues for 1983, the first year shown, would total $672 billion, but the actual amount of revenues for the year was $601 billion. Thus, the projection exceeded the actual amount by $71 billion.

The baseline projections were adjusted to incorporate the estimated effects of legislation enacted after their publication, generally on the basis of the estimated effects of that legislation provided by the staff of the Joint Committee on Taxation near the time of the legislation's enactment.

Figure 4.

Forecast Errors for CBO's and the Administration's Six-Year Revenue Projections

Percent

Sources: Congressional Budget Office; Office of Management and Budget.

Notes: The years shown are those for which each forecast was made. CBO's six-year projections were published five years before the date shown, typically in January or February (that is, four years and eight or nine months before the indicated fiscal year began). For example, the value of 16.1 percent for CBO's forecast error for 1987 indicates that the projection published in February 1982 for revenues in fiscal year 1987 overestimated revenues by that amount.

Forecast errors are projected amounts minus actual amounts, expressed as a percentage of actual amounts.

Figure 5.

Root Mean Square Errors of CBO's and the Administration's Two-Year Revenue Projections Produced Near Business Cycle Peaks Compared With Those Produced at Other Times
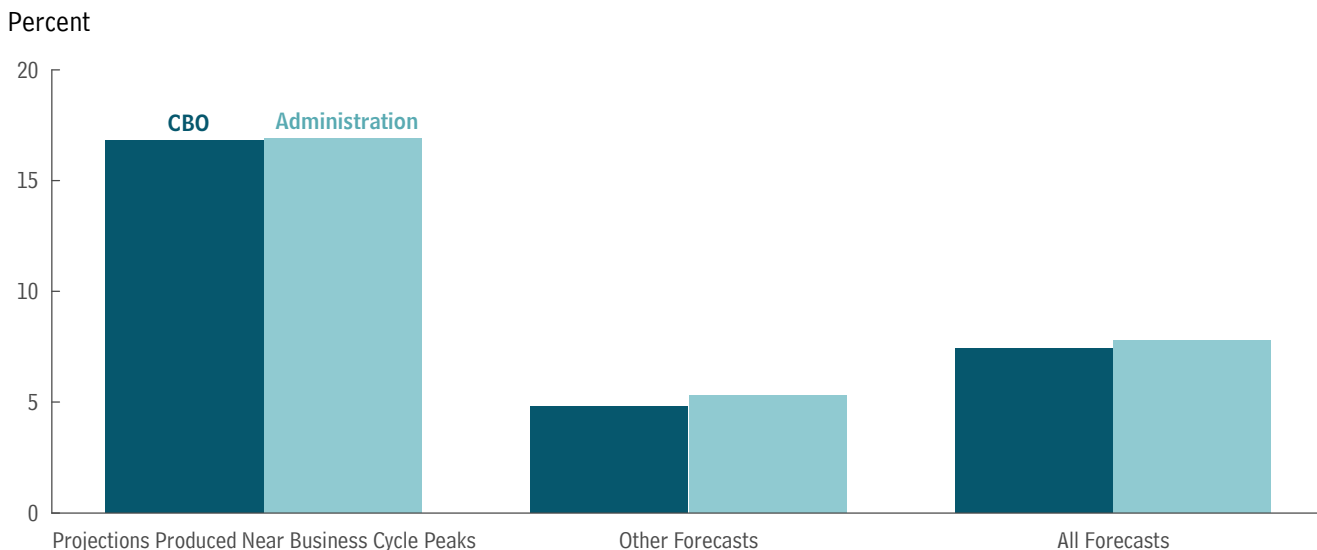
Percent

Sources: Congressional Budget Office; Office of Management and Budget.

Notes: This analysis covers projections published between 1982 and 2013 for fiscal years 1983 to 2014.

The projections produced near business cycle peaks include those published near the beginning of calendar years 1982, 1990, 2001, and 2008 for fiscal years 1983, 1991, 2002, and 2009. The projection published in February 1982, which significantly overestimated revenues for 1983, is included, although the previous business cycle peak occurred in July 1981.

Table 3.

Errors in CBO's Revenue Projections Attributable to Misestimates of GDP and Other Factors

Percent

	Two-Year	Four-Year	Six-Year
GDP			
Mean Error	*	1.7	3.5
Mean Absolute Error	1.9	3.7	5.7
Root Mean Square Error	2.5	4.8	7.0
Revenues as a Percentage of GDP[a]			
Mean Error	0.9	1.7	1.6
Mean Absolute Error	3.9	6.0	5.3
Root Mean Square Error	5.4	7.1	6.4
Total Revenues			
Mean Error	1.1	3.7	5.3
Mean Absolute Error	5.2	9.3	10.4
Root Mean Square Error	7.4	11.1	12.1
Memorandum:			
Revenues as a Percentage of GDP (Percentage points)[b]			
Mean Error	0.1	0.2	0.2
Mean Absolute Error	0.7	1.0	0.9
Root Mean Square Error	0.9	1.2	1.1

Source: Congressional Budget Office.

Notes: CBO typically publishes revenue projections in January or February of each year. A two-year projection is for the fiscal year beginning eight to nine months after it is published, a four-year projection is for the fiscal year beginning two years and eight to nine months after it is published, and the six-year projection is for the fiscal year beginning four years and eight to nine months after it is published. This analysis covers the two-year projections published between 1982 and 2013, the four-year projections published between 1982 and 2011, and the six-year projections published between 1982 and 2009.

Forecast errors are projected amounts minus actual amounts, expressed as a percentage of actual amounts; thus, a positive error indicates an overestimate.

The mean error is the arithmetic average of the forecast errors. The mean absolute error is the average of forecast errors without regard to direction (the negative signs are removed from underestimates before averaging). The root mean square error (RMSE) is calculated by squaring the forecast errors, averaging those squares, and taking the square root of the average.

The errors for projections of GDP and for projections of revenues as a percentage of GDP do not add up to the corresponding errors for projections of total revenues because of interactions between the two and, in the case of RMSEs, also because of the squaring of the errors.

GDP = gross domestic product; * = between zero and 0.05 percent.

a. Projections of revenues as a percentage of GDP reflect the factors other than misestimates of GDP that contribute to forecast errors, such as the composition of national income among different types of labor and capital income and the distribution of different types of income among higher- and lower-income taxpayers.

b. This measure is simply the difference between the projection for revenues as a percentage of GDP and the actual percentage of GDP, whereas the standard forecast error for projections of revenues as a percentage of GDP is that difference divided by the actual percentage of GDP.

Figure 6.

Forecast Errors for CBO's Two-Year Projections of GDP and of Revenues as a Percentage of GDP
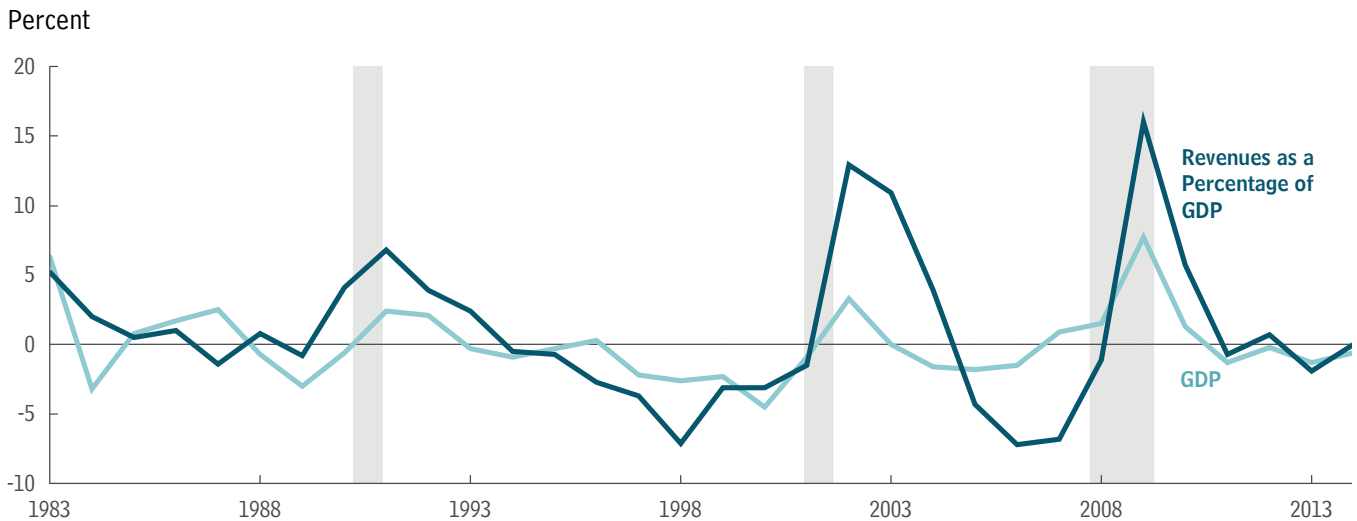
Percent

Source: Congressional Budget Office.

Notes: The years shown are those for which each forecast was made; CBO's two-year projections were typically published in January or February of the previous year. For example, the values of 6.3 percent for the forecast error of CBO's projection of GDP in 1983 and of 5.2 percent for the forecast error of its projection of revenues as a percentage of GDP in that year indicate that the projections published in February 1982 for fiscal year 1983 overestimated GDP and revenues as a percentage of GDP by those amounts.
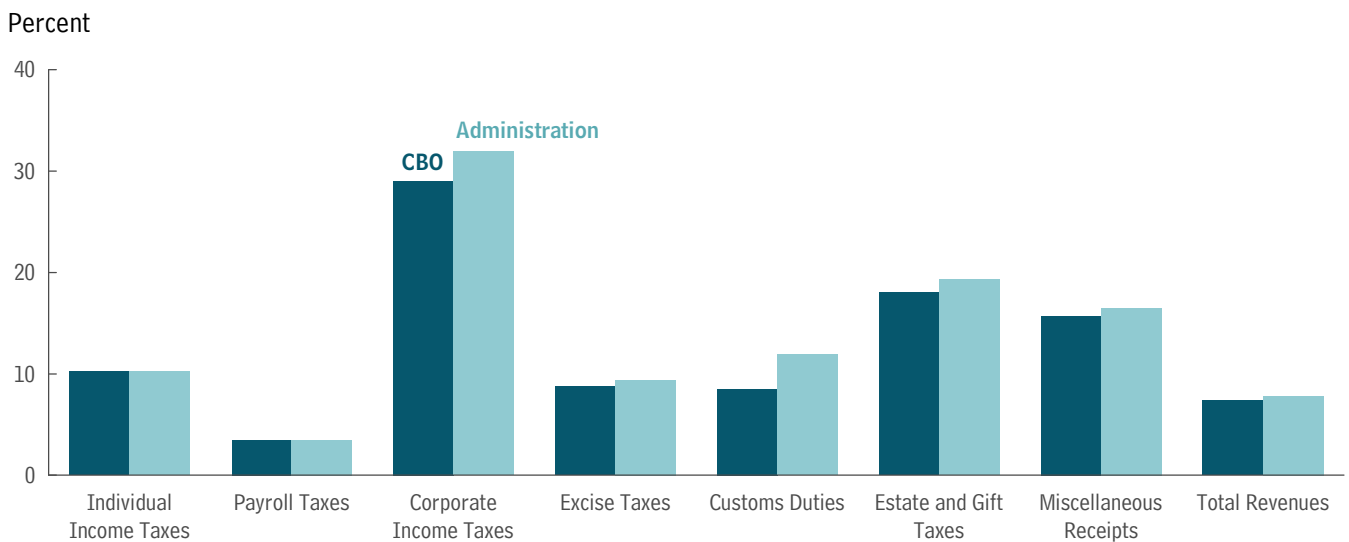
Forecast errors are projected amounts minus actual amounts, expressed as a percentage of actual amounts.

GDP = gross domestic product.

Figure 7.

Root Mean Square Errors of CBO's and the Administration's Two-Year Projections, by Source of Revenues

Percent

Sources: Congressional Budget Office; Office of Management and Budget.

Notes: This analysis covers projections published between 1982 and 2013 for fiscal years 1983 to 2014.

Forecast errors are projected amounts minus actual amounts, expressed as a percentage of actual amounts. The root mean square error is calculated by squaring the forecast errors, averaging those squares, and taking the square root of the average.

"Miscellaneous Receipts" includes fees, fines, and remittances from the Federal Reserve System.

Table 4.

Root Mean Square Errors of CBO's Two-Year Projections, by Source of Revenues

Percent

	Root Mean Square Error	Average Share of Total Revenues	Root Mean Square Error, Relative to Total Revenues
Individual Income Taxes	10.2	45.4	4.6
Payroll Taxes	3.5	36.1	1.3
Corporate Income Taxes	29.0	9.9	2.4
Excise Taxes	8.8	3.7	0.4
Customs Duties	8.5	1.3	0.1
Estate and Gift Taxes	18.0	1.1	0.2
Miscellaneous Receipts	15.7	2.4	0.6
Total Revenues	7.4	100.0	n.a.

Source: Congressional Budget Office.

Notes: This analysis covers projections published between 1982 and 2013 for fiscal years 1983 to 2014.

Errors for projections of a specific tax source are projected amounts for that source minus actual amounts, expressed as a percentage of the actual revenues from that source. Errors for projections of a specific tax source relative to total revenues are projected amounts for that source minus actual amounts, expressed as a percentage of actual total revenues. The latter measure allows the errors of projections for each source to be compared with one another.

The root mean square error (RMSE) is calculated by squaring the forecast errors, averaging those squares, and taking the square root of the average.

The RMSE of projections for a single tax source relative to total revenues can be approximated by multiplying the RMSE of the projections for a source by that source's average share of total revenues over the period. However, the more that a revenue source's share of total revenues varies over the period, the less precise that approximation becomes.

''Miscellaneous Receipts'' includes fees, fines, and remittances from the Federal Reserve System.

n.a. = not applicable.