



An Overview of CBOLT: The Congressional Budget Office Long-Term Model

To help the Congress understand the nation's long-term fiscal challenges, the Congressional Budget Office produces projections of the economy and federal budget that extend beyond its standard 10-year projection window. The Congressional Budget Office Long-Term model—known as CBOLT—is the main analytical tool that the agency uses to make those projections.

CBOLT was created in the early 2000s to produce long-term projections of Social Security's finances, and CBO has continually expanded the model's capabilities and uses since then. Today, CBOLT is used to make long-term projections of the federal budget and economy; the size and composition of the population; the distribution of Social Security benefits and taxes among various groups; the effects of proposed changes to the Social Security system; and the effects of uncertainty about economic, budgetary, and demographic factors. Those projections and others underlie several recurring CBO products, including *The Long-Term Budget Outlook*, *Long-Term Projections for Social Security: Additional Information*, *Social Security Policy Options*, and selected options from *Options for Reducing the Deficit*.

CBOLT is complex, and this report will not cover all of its aspects in detail. For example, it will not explain how marital status, labor force participation, earnings, the claiming of Social Security auxiliary benefits, or spending for major federal health care programs are projected.¹ Instead, it will focus on several key topics:

- CBOLT's four components—the demographic model, the microsimulation model, the long-term budget model, and the policy growth model—and how they relate to one another;

- The data used in CBOLT;
- How CBOLT's demographic model is used to make projections of the population;
- How CBOLT's microsimulation model works, including how it is used to project demographic characteristics and to estimate the claiming of Social Security benefits;
- How CBOLT is used to produce long-term projections of the overall federal budget; and
- How CBOLT is used to project long-term economic outcomes.

The Structure of CBOLT

CBOLT consists of four components:

- The demographic model projects the population by age and sex, using annual projections of the number of births, deaths, immigrants, and emigrants.
- The microsimulation model projects year-to-year changes in demographic characteristics and economic outcomes for individuals in a representative sample of the population.
- The long-term budget model projects federal outlays, revenues, deficits, and debt beyond CBO's standard 10-year budget window.
- The policy growth model simulates how demographics, fiscal policy, and economic factors affect the U.S. economy and, in turn, the federal budget.

1. For more information about CBOLT, see Congressional Budget Office, *CBO's Long-Term Model: An Overview* (June 2009), www.cbo.gov/publication/20807.

Those four components interact in a variety of ways. For example, the demographic model projects how many

people are in the population in a given year, the microsimulation model projects the characteristics of people in a representative sample of the population, the long-term budget model projects how that population would affect federal spending and revenues, and the policy growth model projects how that population and the federal budget would affect the economy.

The Data Used in CBOLT

CBOLT uses data from a variety of sources. A large portion of the data is drawn from CBO's own projections—primarily its 10-year projections of the federal budget and the economy (known as baseline projections), but also longer-term projections made using other models the agency has developed (revenue projections, for example). In addition, CBOLT incorporates information from outside entities, such as the Census Bureau and the Social Security Trustees.

CBOLT's microsimulation model starts with information drawn from the Social Security Administration's Continuous Work History Sample (CWHHS). The CWHHS is based on a 1 percent sample of people with Social Security numbers; CBO selects a 10 percent subsample from the CWHHS to create a sample in which each person represents 1,000 people in the U.S. population. The CWHHS includes data on people's sex, birth year, earnings, and type and amount of Social Security benefits, but it does not provide all of the information about people needed by the microsimulation model. CBO therefore uses data from other sources—including the Census Bureau's Survey of Income and Program Participation (SIPP) and Current Population Survey (CPS)—to impute, or fill in, additional initial characteristics. Imputed characteristics include educational attainment, number of children, marital status, and family structure. Data from the SIPP and CPS are also used to estimate people's annual probabilities of experiencing demographic and economic changes.

How CBOLT Is Used to Project the Population

CBOLT's demographic model is used to project the population—both the Social Security area population, which is used to calculate Social Security payroll taxes and benefits, and the civilian noninstitutional population, which is used to project the size and composition of the labor force. For each year of a simulation, CBO applies the following formula to calculate the population for the next year:

$$\begin{aligned} & \text{Population}_{\text{year}} \\ & + \text{Births}_{\text{year}} \\ & - \text{Deaths}_{\text{year}} \\ & + \text{Immigrants}_{\text{year}} \\ & - \text{Emigrants}_{\text{year}} \\ \hline & \text{Population}_{\text{year}+1} \end{aligned}$$

That is, the population is projected to increase each year by the number of births and immigrants, offset in part by the number of deaths and emigrants.

CBO makes its own projections of overall fertility, mortality, and net immigration (immigration minus emigration) rates, and it uses some data from the Social Security Trustees.² For example, CBO projects the total fertility rate, and it uses the Social Security Trustees' projections to determine the number of births among women in different age groups for any given year.

How CBOLT Is Used to Project Demographic Characteristics and Economic Outcomes

CBOLT's microsimulation model projects annual demographic changes—known as transitions—and economic outcomes for each person in the representative sample. Those demographic transitions and economic outcomes include marriage, childbearing, death, emigration, labor force participation, unemployment, earnings, and claiming of Social Security benefits.

The microsimulation model is longitudinal—that is, it keeps a record of each representative person's characteristics for each year. That structure allows for consistency on two levels. First, people's characteristics in the past year are used to project their transitions and outcomes in the current year. That practice reflects real-world continuity. For example, a person's participation in the labor force last year will influence his or her participation in the labor force this year, because people who worked last year are more likely to work this year than those who did not. Second, the longitudinal structure allows for consistency between multiple outcomes for one person. For example, in CBOLT, a person's payroll taxes while working and Social Security benefits in retirement are

2. For more about CBO's projection of demographic trends, see Congressional Budget Office, *The 2017 Long-Term Budget Outlook* (March 2017), Appendix A, www.cbo.gov/publication/52480.

both based on that person's earnings. That provides an advantage over modeling approaches that project benefits and earnings separately, which may be inconsistent.

The microsimulation model also keeps track of links between individuals and their spouses (current, former, and deceased), parents, and children. Those family links are used to determine whether an individual can claim Social Security benefits that are awarded on the basis of familial relationships, as well as to project other variables, such as a person's likelihood of participating in the labor force in a given year.

The individual records used in the microsimulation model can generate both aggregate and distributional outcomes. The model can show, for example, how a particular policy change might affect people who have low earnings compared with high earnings, or people who were born in later years compared with people who were born earlier.

How CBOLT Is Used to Project Demographic Characteristics

Whereas the demographic model is used to project the number of people who will die, emigrate, or have a child in a given year, the microsimulation model is used to project *which* people will experience those events. Selecting which people will experience a demographic transition is a two-step process. First, the microsimulation model calculates the probability that each person in a representative sample of the population will die, emigrate, or have a child.³ That probability depends on a person's characteristics.

Second, the microsimulation model specifies which people are selected for demographic transitions using a mathematical function that combines the estimated probability of a transition with a random number.⁴ For each person, that function produces a single number that represents the chance of being selected. The model ranks the people in a particular group by that number and uses those rankings to select the appropriate number of people in that group (as determined by the demographic model) for a given transition.

3. Babies and new immigrants are added to the microsimulation sample each year.

4. Specifically, CBOLT uses a logit function to produce a number between 0 and 1 that is the result of a nonlinear combination of a person's estimated probability and a random number.

For example, assume that in a given year, there are 2 million 30-year-old women (represented as 2,000 women in the sample), and the demographic model projects that 230,000 of those women (230 women in the sample) will give birth. Each of the 30-year-old women in the sample is assigned a probability of giving birth, which depends on her age, education, marital status, birth cohort, whether or not she is an immigrant, and, if she already has any children, the time elapsed since her last child's birth. The microsimulation model then combines those probabilities with random numbers to select the 230 specific 30-year-old women in the sample who are projected to give birth that year.

That method ensures that the correct number of representative people is selected for each transition—including some people with a low probability of experiencing a given transition. It therefore accounts for both the overall frequency and the individual chance of events in the real world. For example, in any particular year, many 30-year-old women who give birth will have a high probability of doing so, but some of them will not.

After the characteristics of the sample are projected for a given year, the microsimulation model uses those characteristics to project outcomes such as labor force participation and the claiming of Social Security benefits for people in the sample. Those individual outcomes are then scaled up to project aggregate economic outcomes for that year.

How CBOLT Is Used to Project the Claiming of Social Security Benefits

CBOLT is used to project many types of Social Security benefits, but this discussion will focus on the largest category of benefits—those claimed by retired workers. More than two-thirds of all Social Security benefits are paid to retired workers, and those benefits influence other types of benefits. For example, an eligible spouse of a retired worker is entitled to benefits that are based on a percentage of the retired worker's benefit.

For every year of a simulation, the microsimulation model checks whether each person in the representative sample is eligible to claim retired-worker benefits on the basis of his or her age (62 or older) and work history (number of years in employment covered by Social Security). Each eligible worker is then assigned a probability of claiming those benefits, which varies according to his or her age, sex, and earnings and the

average replacement rate (or benefits relative to earnings) for people born in the same year. However, those characteristics alone are not sufficient to simulate observed claiming behavior. To better reflect real-world patterns, the probability of claiming benefits is increased for individuals at particular ages:

- The early eligibility age (age 62),
- The Medicare eligibility age (age 65),
- The full retirement age (ages 65–67, depending on birth year), and
- The age at which the delayed retirement credit stops increasing (age 70).

Those adjustments are based on the rules governing the Social Security system and can be changed in response to changes in law.

The number of workers in the sample who will claim benefits is calculated by summing the probability of claiming for all eligible workers in various age and sex groups. For example, imagine that 1,000 workers in the sample (representing 1 million people) are eligible to claim benefits, and each has a 30 percent chance, or 0.3 probability, of doing so. The sum of all of the workers' probabilities—300—would be the number of workers in the sample who would claim benefits. The microsimulation model would therefore select 300 of those 1,000 representative workers.⁵

To calculate Social Security benefit amounts, CBO applies the Social Security program's benefit formula to the earnings history of each person who claims benefits. The benefit amount is then adjusted for inflation in each subsequent year until the person dies or his or her Social Security benefits are recalculated because of demographic transitions or changes in earnings. By summing those benefits across groups, CBO can analyze their distribution by birth year, sex, and lifetime earnings.

CBO calculates total Social Security benefits by scaling up the sum of benefits paid to all beneficiaries in the representative sample. For example, because each person

in the sample represents 1,000 people in the population, if a total of \$600 million in benefits is paid to retired workers in the sample, that amount would be scaled up by a factor of 1,000 to \$600 billion.

How CBOLT Is Used to Project Long-Term Budgetary Outcomes

The first 10 years of CBOLT's long-term budget projections are set to follow CBO's most recent 10-year baseline projections, which are published in *The Budget and Economic Outlook* each year. For example, *The 2017 Long-Term Budget Outlook*, released in March 2017, was based on *The Budget and Economic Outlook: 2017 to 2027*, released in January 2017.

Beyond the first 10 years, CBOLT's long-term budget model projects the budget's path under most of the same policy assumptions that the agency uses, in accordance with statutory requirements, in constructing its 10-year baseline. Both the baseline and long-term projections incorporate the assumptions that current law generally remains unchanged—but some mandatory programs are extended after their authorizations lapse—and that spending for Medicare and Social Security continues as scheduled even if their trust funds are exhausted.⁶

Projections of some types of spending and revenues are determined simply as a percentage of gross domestic product (GDP)—for example, discretionary spending, mandatory spending other than that for Social Security and the major health care programs, and corporate income taxes.⁷

Other budget categories are projected using more sophisticated methods. For example:

- For Social Security, spending is projected using CBOLT's microsimulation model.

5. This is an example in which the microsimulation model, rather than the demographic model, determines the number of people from the sample to be selected.

6. Mandatory spending is governed by statutory criteria and is not normally controlled by the annual appropriation process. For more about the assumptions about spending and revenues underlying CBO's long-term projections, see Congressional Budget Office, *The 2017 Long-Term Budget Outlook* (March 2017), Table 2, www.cbo.gov/publication/52480.

7. Discretionary spending is controlled by annual appropriation acts that specify the amounts that are to be provided for a broad array of government activities, such as defense, law enforcement, and transportation.

- For the major health care programs, projected spending depends on estimates of the number of beneficiaries and health care costs per beneficiary.
- For individual income taxes, projected revenues are estimated using a model that applies tax rules as scheduled under current law to the population, adjusted for expected demographic and economic changes.

To complete its budget projections, CBO sums the annual projections for all categories of federal spending and revenues and calculates outlays for net interest on outstanding federal debt.

How CBOLT Is Used to Project Long-Term Economic Outcomes

Like the long-term budget projections, the long-term economic projections follow CBO's baseline projections for the first 10 years. For subsequent years, CBO uses a simplified growth model—the policy growth model—to project economic output and interest rates.⁸ Annual projections of labor, capital, and productivity are input into the policy growth model to produce projections of the economy for each year. Combined with projections of federal spending and revenues, those projections determine the amount of capital available for production in the following year.

Thus, the next year's economic projections incorporate the macroeconomic effects of the current year's fiscal policy. For example, suppose that a change to fiscal policy reduced the federal deficit (the amount by which the government's outlays exceed its revenues) in a given year. Federal borrowing would decrease, and fewer funds

would be invested in federal debt and more would be invested in private capital. Accordingly, in the next year, capital, economic growth, earnings, and the labor supply would increase, and interest rates would be lower than would otherwise be the case.

With its final projections of spending, revenues, the deficit, debt, and the economy, CBO can calculate measures of the budget's sustainability. One such measure is the ratio of federal debt held by the public to GDP. That ratio is useful for comparing amounts of debt in different years because it accounts for changes in prices, the population, economic output, and income—all of which affect the nation's ability to finance the debt. It also places the effects of potential adjustments to the budget within the context of the nation's resources.

This report was prepared to enhance the transparency of the work of the Congressional Budget Office. In keeping with CBO's mandate to provide objective, impartial analysis, the report makes no recommendations.

Stephanie Hugie Barelo and Charles Pineles-Mark prepared the report with guidance from Julie Topoleski and David Weaver. Molly Dahl, Sebastien Gay, Joseph Kile, Kevin Perese, Robert Shackleton, and Michael Simpson provided helpful comments.

Wendy Edelberg, Mark Hadley, Jeffrey Kling, and Bob Sunshine reviewed the report; Christine Browne edited it; and Casey Labrack prepared it for publication. An electronic version is available on CBO's website (www.cbo.gov/publication/53667).



Keith Hall
Director



8. For more about the policy growth model, see Congressional Budget Office, *How CBO Analyzes the Effects of Changes in Federal Fiscal Policies on the Economy* (November 2014), www.cbo.gov/publication/49494, and *How the Supply of Labor Responds to Changes in Fiscal Policy* (October 2012), www.cbo.gov/publication/43674. In those documents, the policy growth model is referred to as a Solow-type growth model. For details about CBO's forecasting growth model, which provides projections that serve as key inputs to the policy growth model, see Robert Shackleton, *Estimating and Projecting Potential Output Using CBO's Forecasting Growth Model*, Working Paper 2018-03, Congressional Budget Office (February 2018), www.cbo.gov/publication/53558.