the budget lab

The Budget Lab Small Macro Model (BLSMM): Model Documentation

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Purpose

This documents contains the algebraic specification of The Budget Lab's Small Macro Model (BLSMM, "blossom"), version 1.0. The model is intended to be

- parsimonious,
- have reasonable, albeit simple, linkages and properties,
- allow for a range of macroeconomic and fiscal simulation experiments incorporating economic, financial, and budget feedback.

Model Overview

The model encompasses:

1. a relationship whereby the output gap (GDP relative to potential) evolves dynamically with impacts from the federal budget deficit and real interest rates;
2. contributions to potential GDP growth from potential productivity and the labor force, both of which are exogenous;
3. an Okun's Law relationship that relates the unemployment gap to the output gap;
4. an expectations-augmented Phillips Curve that is vertical in the long run;
5. endogenous, adaptive inflation expectations, with the flexibility to include a long-run anchor to the inflation target (e.g., 2%) to reflect a degree of Fed credibility;
6. a Taylor-type policy rule that determines the overnight interest rate (fed funds rate);
7. a 10-year Treasury yield as the sum of the expected short rate over 10 years and a term premium;
8. an equation for the expected future short-term interest rate that reflects its current level and longer-run determinants, including inflation expectations and long-run real interest rates;

9. an effective interest rate on government debt that evolves gradually to market interest rates, consistent with the gradual turnover in the stock of debt as existing debt is refinanced and new debt is issued;
10. identities for government net interest, the primary budget deficit, the overall budget deficit, and the change in publicly held debt;
11. feedback from potential GDP growth to the primary budget balance as a percentage of GDP;
12. a real neutral interest rate influenced by potential growth and fiscal factors;
13. interest rates in both the short run and the long runs that are influenced by fiscal stance.

Among the exogenous variables are

1. contributions to potential real GDP growth from growth in productivity and the labor force,[1]
2. the ratios of federal government receipts and primary outlays (excluding net interest) to nominal GDP,
3. the inflation target,
4. the non-accelerating inflation rate of unemployment (NAIRU),
5. the real neutral federal funds rate, and
6. the term premium.

Several behavioral relationships, including those that determine the output gap, inflation, and interest rates, are associated with exogenous shock terms to provide additional flexibility for running simulation experiments.

In the interests of parsimony and tractability and to facilitate external use, some sectors are omitted from the model, including:

- international trade, capital flows, and exchange rates,
- state and local government sectors,
- the financial sector beyond the structure described in this document, and
- capital stocks.

Baseline Scenarios and User Alternatives

Baseline values of exogenous variables and residual terms are set to be consistent with the most recent 10-year baseline fiscal and economic projections from the Congressional Budget Office (CBO). To start, we map historical and forecasted economic and budget series into the model's exogenous inputs. These include potential labor-force and productivity growth, the NAIRU, receipts and primary outlays as shares of potential nominal GDP, debt, deficits, net interest, and key rate paths. Survey or judgmental assumptions (e.g., from the Summary of Economic Projections) are used where CBO does not directly forecast a variable analogous to a model variable. Given these exogenous paths and fixed structural parameters, the model solves the baseline forecast and backs out the add-factors, or residuals, needed for each endogenous variable equation to match the CBO-consistent path. These calibrated residuals are then stored as the baseline residual path and used as exogenous inputs in baseline simulations; forecasting BLSMM using these residuals exactly reproduces the baseline. Alternative scenarios are

implemented as changes to exogenous paths or residuals relative to this calibrated baseline, rather than by re-calibrating the model.

Model Specification

Preliminaries

- A unit of time corresponds to one (fiscal) year, denoted by (t).
- Interest rates, inflation, growth rates, and the unemployment rate are specified in percent, e.g., 5.00%, not 0.05. Interest, inflation, and growth rates are at annual rates.
- The output gap (real GDP relative to potential real GDP) is specified in percent of potential real GDP.
- Budget quantities are expressed in nominal dollars and as ratios to nominal GDP and potential nominal GDP.
- Budget surpluses are positive; deficits are negative.
- GDP is expressed in both inflation-adjusted (real) and nominal terms; when necessary for clarity, a dollar sign ($) is used to distinguish nominal from real quantities, as in $\mathrm{GDP\$}$ to represent nominal GDP.
- An asterisk (*) denotes a long-run anchor or potential level or growth rate of a variable. Such variables are generally exogenous in model simulation.
- A subscript 0, as in $\mathrm{TP10}_0$ denotes an exogenous constant.
- Interest rates begin with R.
- Parameters are generally denoted with Greek letters; their values are listed separately.
- A variable followed by (L) indicates a finite polynomial in the lag operator, as in $\sigma(L)$. Individual elements of such polynomials are denoted by numerical subscripts, as in σ_1.
- A lower case ε denotes a shock or residual term, which for model purposes is treated as exogenous, as in $\varepsilon_{\mathrm{xgap}}(t)$.

GDP and Potential GDP (Real and Nominal)

Let GDP denote real GDP and $\mathrm{GDP\$}$ nominal GDP. Let $g^*(t)$ denote growth in potential real GDP, in %, as indicated in (1).

$$g^*(t) \equiv 100(\mathrm{GDP}^*(t)/\mathrm{GDP}^*(t-1) - 1). \tag{1}$$

To decompose contributions to potential real GDP growth, we first note that real GDP can be expressed as the product of total employment and productivity, where employment reflects all employed persons (civilian employment) and productivity is measured as real GDP per employed person. Continuing to let potential quantities be denoted with an asterisk, we let $\mathrm{CE}^*(t)$ denote potential civilian employment and $\mathrm{LQ}^*(t)$ potential labor productivity. The latter is assumed to be exogenous, with a growth rate $lq^*(t)$ as in

$$\mathrm{LQ}^*(t)/\mathrm{LQ}^*(t-1) \equiv 1 + 0.01\, lq^*(t). \tag{2}$$

The potential labor force $[\mathrm{LF}^*(t)]$, an important determinant of potential employment, grows at an exogenous rate denoted by $lf^*(t)$, as in

$$\mathrm{LF}^*(t)/\mathrm{LF}^*(t-1) \equiv 1 + 0.01\, lf^*(t). \tag{3}$$

Potential employment $[\mathrm{CE}^*(t)]$ is equal to the potential labor force less potential/structural unemployment identified with the NAIRU $[un(t)]$, as in

$$\mathrm{CE}^*(t) = \mathrm{LF}^*(t) \cdot (1 - 0.01\, un(t)). \tag{4}$$

The NAIRU is exogenous and expressed in percent of the labor force.

As described above, potential real GDP is equal to the product of potential productivity and potential employment, as in

$$\mathrm{GDP}^*(t) = \mathrm{LQ}^*(t) \cdot \mathrm{CE}^*(t). \tag{5}$$

Combining the two previous expressions,

$$\mathrm{GDP}^*(t) = \mathrm{LQ}^*(t) \cdot \mathrm{LF}^*(t) \cdot (1 - 0.01\, un(t)). \tag{6}$$

From (6) we derive at an expression for potential GDP growth that reflects contributions from potential productivity growth, potential labor force growth, and the NAIRU,

$$g^*(t) = 100[(1 + 0.01 \cdot lq^*(t))(1 + 0.01 \cdot lf^*(t))(1 - 0.01\, un(t)) \\ /(1 - 0.01\, un(t-1)) - 1]. \tag{7}$$

For purposes of computation we use (7). A compact approximation useful for expository purposes is

$$g^*(t) \approx lq^*(t) + lf^*(t) - [un(t) - un(t-1)]. \tag{8}$$

Expressions (7) and (8) show that the growth rate of potential GDP is closely approximated by the sum of potential growth in productivity and the labor force, less the first-difference of the NAIRU, where growth rates are measured in annualized percentage rates and the NAIRU is measured in percent of the labor force. As a quantitative matter, estimates of the NAIRU typically change at most slightly from year to year, in which case growth in potential real GDP is approximately equal to growth in potential plus growth in the potential labor force: $g^*(t) \approx lq^*(t) + lf^*(t)$.[2]

Letting PGDP denote the GDP price level, which is indexed to 100 in the base year, we have expressions for potential *nominal* GDP and *nominal* GDP.[3]

$$\mathrm{GDP\$}^*(t) = (\mathrm{PGDP}(t)/100)\, \mathrm{GDP}^*(t) \tag{9}$$

$$\mathrm{GDP\$}(t) = (\mathrm{PGDP}(t)/100)\, \mathrm{GDP}(t). \tag{10}$$

Government Receipts, Outlays, and Budget Balance

The total budget balance of the federal government, expressed in nominal dollars, is denoted by $\mathrm{BUD\$}(t)$. Positive values indicate surplus and negative values indicate deficit. The primary budget balance, which is equal to receipts

less primary (non-interest) outlays, is denoted by $\mathrm{BUDP\$}(t)$. Receipts and primary outlays are denoted by $\mathrm{GFR}(t)$ and $\mathrm{GFOP}(t)$, respectively.

We let $\mathrm{rbudp}^*(t)$ denote the primary budget deficit (BUDP) as a percent of potential nominal GDP, as in

$$\mathrm{rbudp}^*(t) \equiv 100\,\mathrm{BUDP}(t)/\mathrm{GDP\$}^*(t). \tag{11}$$

Similar expressions for the ratios of total receipts and primary outlays to potential nominal GDP are shown in the next two expressions, respectively.[4]

$$\mathrm{rgfr}^*(t) \equiv 100\,\mathrm{GFR}(t)/\mathrm{GDP\$}^*(t). \tag{12}$$

$$\mathrm{rgfop}^*(t) \equiv 100\,\mathrm{GFOP}(t)/\mathrm{GDP\$}^*(t). \tag{13}$$

Clearly, the following identity also holds among these ratios to potential nominal GDP:

$$\mathrm{rbudp}^*(t) \equiv \mathrm{rgfr}^*(t) - \mathrm{rgfop}^*(t). \tag{14}$$

Output gap

Let $\mathrm{xgap}(t)$ denote the output (real GDP) gap to potential, in percent:

$$\mathrm{xgap}(t) \equiv 100\,(\mathrm{GDP}(t)/\mathrm{GDP}^*(t) - 1). \tag{15}$$

The output gap evolves according to a simple linear relationship with impacts from the real bond yield and from the change in the ratio of the primary budget balance as a percentage of potential nominal gross domestic product.

The nominal bond yield is denoted with $\mathrm{R10}(t)$ and expected inflation with $\pi^e(t)$. The term $\mathrm{r10bar}$ is the level of the real 10-year bond yield that would be consistent with no output gap in the absence of primary budget deficits or other shocks. It can also be interpreted as a constant that appears in a linear approximation of a more complex, nonlinear model of the output gap. Pre-multiplying by $\sigma(L)$ allows it to be dimensioned in percentage points for ease of interpretation. The output gap is determined by (16).

$$\begin{aligned}\mathrm{xgap}(t) = \eta\,\mathrm{xgap}(t-1) - \theta(L)\,\mathrm{rbudp}^*(t) - \sigma(L)(\mathrm{R10}(t) \\ - \pi^e(t) - \mathrm{r10bar}(t)) + \varepsilon_{\mathrm{xgap}}(t),\end{aligned} \tag{16}$$

where $\sigma(L)$ and $\theta(L)$ are functions in the lag operator, L.[5] The variable $\varepsilon_{\mathrm{xgap}}(t)$ is an exogenous residual term.

Okun's Law

A dynamic version of Okun's Law relates the unemployment gap to the current and lagged output gap, where $u(t)$ denotes the unemployment rate (in %), $un(t)$ denotes the NAIRU, $\alpha(L)$ denotes a function in the lag operator, and $\varepsilon_u(t)$ denotes a residual for this relationship.

$$u(t) - un(t) = -\alpha(L)\,\mathrm{xgap}(t) + \varepsilon_u(t). \tag{17}$$

Inflation, Inflation Expectations, and the Price Level

Let $\pi(t)$ denote inflation, let $\pi^e(t)$ denote long-run expected inflation (over 10 years), and let $\pi^*(t)$ denote the inflation target that influences monetary policy and expectations of monetary policy.

Inflation evolves according to a Phillips curve that is vertical in the long run:

$$\pi(t) = \gamma_1 \, \pi(t-1) + (1-\gamma_1) \, \pi^e(t-1) + \gamma_2 \, (un(t) - u(t)) + \varepsilon_\pi(t). \tag{18}$$

Long-run inflation expectations respond gradually to actual inflation. The form of the expression allows for the flexibility to anchor long-run inflation expectations to the inflation target when $\lambda_3 \in (0, 1]$.

$$\pi^e(t) = \lambda_1 \, \pi^e(t-1) + \lambda_2 \, \pi(t) + \lambda_3 \, \pi^*(t) + \varepsilon_{\pi^e}(t). \tag{19}$$

The weights on expected inflation, actual inflation, and the inflation target sum to one: $\lambda_1 + \lambda_2 + \lambda_3 = 1$.

The price level (PGDP) evolves according to inflation, as in

$$\mathrm{PGDP}(t) \equiv \mathrm{PGDP}(t-1) \, (1 + 0.01 \, \pi(t)). \tag{20}$$

Monetary Policy

The short-term interest rate, $\mathrm{RF}(t)$, (federal funds rate) is determined with a Taylor-type policy rule that includes a real "r-star" term appropriate to that interest rate, $rf^*(t)$, and impacts from inflation and unemployment gaps relative to the inflation target and the NAIRU, respectively.

$$\mathrm{RF}(t) = rf^*(t) + \pi(t) + \mu_1[\pi(t) - \pi^*(t)] + \mu_2[\pi^e(t) - \pi^*(t)] + \mu_3[un(t) - u(t)] + \varepsilon_{\mathrm{RF}}(t). \tag{21}$$

The inflation target, $\pi^*(t)$, is set to 2.0 in the baseline to match the Fed's announced target.[6]

In simulation RF may take on negative values (breech the zero lower bound), which may be interpreted as an indication that the Federal Reserve would consider non-traditional tools including large-scale asset purchases and forward guidance that are not present in the model.

Long-term Interest rate

The long-term interest rate in the model ($\mathrm{R10}(t)$) is identified with the 10-year Treasury Note yield, which appears in the expression for the output gap shown above. The 10-year yield is equal to the sum of contributions from the expected future short-term interest rate, $\mathrm{MPE10}(t)$, and the term premium, $\mathrm{TP10}(t)$:

$$\mathrm{R10}(t) = \mathrm{MPE10}(t) + \mathrm{TP10}(t). \tag{22}$$

The average expected future short-term interest rate over the 10-year life of the Treasury note, $\mathrm{MPE10Y}$, is influenced by the current level of the overnight policy rate, $\mathrm{RF}(t)$ and by its longer-run determinants, including $rf^*(t)$ and expected inflation.

$$\mathrm{MPE10}(t) = \phi_1 \, \mathrm{RF}(t) + (1-\phi_1)\{rf^*(t) + \pi^e(t) + \phi_2[\pi^e(t) - \pi^*(t)]\} + \varepsilon_{\mathrm{MPE\,10}}(t). \tag{23}$$

At one extreme, if ϕ_1 were set to unity, the average expected future short-term interest rate would equal its current level. At the opposite extreme, if ϕ_1 were set to zero, the average expected short rate would be equal to

$rf^* + \pi^e$ plus an adjustment for the gap between long-run inflation expectations and the inflation target, $\phi_2[\pi^e(t) - \pi^*(t)]$.

In a steady state—inflation and inflation expectations equal to target, no unemployment gap, and zero residual terms, $\mathrm{RF}(t)$ and $\mathrm{MPE10}(t)$—both the current federal funds rate and the average expected federal funds rate will equal the sum of the inflation target and rf^*. More generally, $\mathrm{MPE10}(t) - \mathrm{RF}(t)$ can be either positive or negative. Combining the policy rule and the expression for $\mathrm{MPE10}$,

$$\begin{aligned}\mathrm{MPE10}(t) - \mathrm{RF}(t) = (1-\phi_1)\{&(1+\phi_2-\mu_2)[\pi^e(t)-\pi^*(t)] \\ &-(1+\mu_1)[\pi(t)-\pi^*(t)] - \mu_3[un(t)-u(t)] - \varepsilon_{\mathrm{RF}}(t)\} + \varepsilon_{\mathrm{MPE\,10}}(t). \qquad (24)\end{aligned}$$

When the residuals (the ε's) are zero, the sign of $\mathrm{MPE10} - \mathrm{RF}$ is equal to the sign of $(1+\phi_2-\mu_2)[\pi^e(t)-\pi^*(t)] - (1+\mu_1)[\pi(t)-\pi^*(t)] - \mu_3[un(t)-u(t)]$. As an example, $\mathrm{MPE10}$ will be lower than RF when actual inflation is sufficiently high relative to expected inflation and/or when the unemployment rate is sufficiently far below the NAIRU.

The other contribution to the long-term interest rate is its term premium, $\mathrm{TP10}(t)$, which is set equal to the sum of its long run level, $\mathrm{TP10}_0$, and an exogenous residual.

$$\mathrm{TP10}(t) = \mathrm{TP10}_0(t) + \varepsilon_{\mathrm{TP10}}(t). \qquad (25)$$

Real neutral interest rate

Baseline assumptions

When we pre-populate the workbook with 10-year macroeconomic and budget projections, we do so with assumptions for the neutral level of the real federal funds rate, rf^*, and the term premium, $\mathrm{TP}(t)$, to be consistent with baseline projected paths of interest rates, inflation, and the output gap. In the baseline, the real neutral federal funds rate is exogenous, as is the reference level for the real 10-year yield, $\mathrm{r10bar}(t)$ that appears in the expression for the output gap, (13). Baseline assumptions for both are chosen to be consistent with baseline projections for interest rates informed by the most recently published set of baseline economic and budget projections from the Congressional Budget Office (CBO).

Updates to reflect User deltas

Feedback onto the primary budget balance from user assumptions for potential growth of productivity and the labor force

User assumptions that alter potential GDP growth are allowed to influence primary budget ratios to nominal GDP, loosely based on budgetary feedback channels estimated by the Congressional Budget Office.[7] In CBO's modeling, increases in potential productivity raise the primary budget balance ratio to nominal GDP (smaller deficits as a % of nominal GDP), as do increases in the potential labor force. The impacts on the primary budget ratio reflect decreases in primary outlays as a percent of nominal GDP; the ratio of government receipts to nominal GDP is little affected by changes in potential productivity and labor force growth in CBO's modeling.

When users input alternative assumptions for potential labor force and productivity growth, those assumptions are allowed to influence the ratio of primary outlays to nominal GDP and hence the primary budget balance as a ratio to nominal GDP as described in this section. For simplicity and because the effects are not quantitatively substantial according to CBO's modeling, BLSMM does not automatically update the revenue ratio to GDP.

However, users have the option of directly altering both the receipts and primary outlays ratios through respective user deltas.

Let superscripts denote the baseline scenario (B) and a user scenario (U), respectively. With this notation $lf^{*U}(t) - lf^{*B}(t)$ represents the user delta for potential growth of the labor force in year t. Similarly, $lg^{*U}(t) - lg^{*B}(t)$ represents the user delta for potential productivity growth. Let ψ_1 and ψ_2 denote coefficients that represent the feedback of these user deltas onto the ratio of primary outlays to nominal GDP in percentage points. The feedback onto the primary outlays ratio accumulates according to

$$\begin{aligned}\text{rgfop}^{*U}(t) - \text{rgfop}^{*B}(t) = [\text{rgfop}^{*U}(t-1) - \text{rgfop}^{*B}(t-1)] \\ + \psi_1[lf^{*U}(t) - lf^{*U}(t)] + \psi_2[lq^{*U}(t) - lq^{*U}(t)] \qquad (26)\end{aligned}$$

Based on CBO's modeling, we set $\psi_1 = -0.13$ and $\psi_2 = -0.23$.

As an example, a permanent increase in potential productivity growth (user delta) of 0.1 percentage point relative to baseline would lower the ratio of primary outlays to nominal GDP by $0.1 \times (-0.23) = -0.023$ percentage point in the first year, and by an additional -0.023 percentage point each year thereafter, so that after 10 years the ratio of primary outlays to nominal GDP would be 0.23 percentage point below its baseline value, all else equal. According to CBO, the decline in the primary outlays ratio to nominal GDP mostly reflects a higher trajectory for the latter, slightly offset by small increases (relative to baseline) in nominal primary outlays.

In percentage-point terms, the impact onto the primary outlays ratio from labor force growth is about one-half as large as the impact from productivity growth because of a smaller impact on GDP from the former than from the latter.

Feedback from growth and debt onto the real neutral interest rate

User assumptions that determine potential GDP growth and the evolution of government debt influence the real neutral interest rate, $rf^*(t)$. Let lowercase d represent debt as a % of nominal GDP: $d(t) \equiv 100 * D(t)/\text{GDP\$}(t)$. The term that appears below in the user adjustment to the real neutral funds rate, $[\text{dhat}^U(t) - d^B(t)]$, is a model-based proxy for the change in the debt/GDP ratio (in \%) for the user scenario.[8] With that notation, rf^* is adjusted to reflect assumptions that determine potential growth and debt/GDP according to the following expression.

$$\begin{aligned}rf^{*U}(t) = rf^{*B}(t) + \kappa_1[lf^{*U}(t) - lf^{*B}(t)] + \kappa_2[lg^{*U}(t) - lg^{*B}(t)] \\ + \kappa_3[\text{dhat}^U(t) - d^B(t)]. \qquad (27)\end{aligned}$$

The parameters κ_1, κ_2 and κ_3 are set to 0.667, 0.667 and 0.02, respectively. Those values imply that the neutral federal funds rate will adjust up or down by two-thirds of the sum of user deltas for potential growth of the labor force and labor productivity, and by 2 basis points for each percentage point of debt as a % of GDP implied by the user's assumption that determines the path of the primary budget balance ratio, rbudp^{*u}.

Adjustments are made to r10bar^U to reflect user deltas for potential growth of real GDP and for changes in the debt ratio that result from user deltas that influence potential growth of nominal GDP. The same parameter values for $\kappa_{1,}\kappa_2$ and κ_3 are employed to update r10bar^U.

Fiscal Block

The fiscal block includes expressions that govern the evolution of government debt, total and primary budget balances, net interest, and the average effective interest rate on publicly held federal debt. Debt, budget balances, and net interest are expressed in current dollars and as percentages of nominal GDP.

The average effective interest rate on publicly held federal debt responds gradually to market interest rates, recognizing that a fraction of government debt matures in a typical year and is refinanced or is newly issued.

$$\mathrm{RG}(t) = \delta_1 \,\mathrm{RG}(t-1) + (1-\delta_1)[\delta_2 \,\mathrm{RF}(t) + (1-\delta_2)\,\mathrm{R10}(t)]. \tag{28}$$

We set δ_1 at 0.8333 (5/6), implying that approximately one-sixth of the existing stock of debt is either newly issued or refinanced each year.

Net interest payments by the federal government are at the average effective interest rate applied to average level of publicly held debt during the year, proxied by the average of its beginning- and end-of-year levels

$$\mathrm{NI}(t) = 0.5 * (\mathrm{D}(t) + \mathrm{D}(t-1)) * (\mathrm{RG}(t)/100). \tag{29}$$

The level of primary budget surplus or deficit, BUDP(t) can be computed by unwinding the identity for the ratio to potential nominal GDP, as in

$$\mathrm{BUDP}(t) = (\mathrm{rbudp}^*(t)/100) * \mathrm{GDP\$}^*(t). \tag{30}$$

Nominal receipts and nominal primary outlays can be uncovered by unwinding the relevant identities as shown in the next two expressions.

$$\mathrm{GFR}(t) = (\mathrm{rgfr}^*(t)/100) * \mathrm{GDP\$}^*(t). \tag{31}$$

$$\mathrm{GFOP}(t) = (\mathrm{rgfop}^*(t)/100) * \mathrm{GDP\$}^*(t). \tag{32}$$

The total budget balance is denoted by BUD(t).

$$\mathrm{BUD}(t) = \mathrm{BUDP}(t) - \mathrm{NI}(t). \tag{33}$$

Debt accumulates according to the total budget surplus or deficit,[9]

$$\mathrm{D}(t) = \mathrm{D}(t-1) - \mathrm{BUD}(t). \tag{34}$$

In a post-simultaneous block, various budget ratios to actual nominal GDP are computed, such as $\mathrm{rbudp}(t) \equiv 100$ $\mathrm{BUDP}(t)/\mathrm{GDP\$}(t)$.

List of Variables

Variable	Description
Exogenous	
rgfr*(t)	ratio of government receipts to potential nominal GDP, in percent
rgfop*(t)	ratio of government primary outlays (outlays net of net interest) to potential nominal GDP, in percent
lq*(t)	exogenous growth in labor productivity (real GDP per employee), in % at annual rate
lf*(t)	exogenous growth in the labor force, in % at annual rate
un(t)	non-cyclical unemployment rate (NAIRU) in %
π*(t)	inflation target in percent
$rf^{*B}(t)$	"r-star" for the real federal funds rate in the baseline, in % at annual rate
$r10bar^{B}(t)$	reference value for the real 10-year yield appearing in the IS curve, in the baseline, in % at annual rate
$TP10_0(t)$	anchor for the 10-year term premium in percentage points of annual yield
Exogenous variables updated to reflect user deltas for potential growth and fiscal policy	
$rf^{*U}(t)$	"r-star" for the real federal funds rate in a user scenario
$r10bar^{U}(t)$	reference value for the real 10-year yield appearing in the IS curve, in a user scenario
$rgfop^{*U}(t)$	ratio of government primary outlays (outlays net of net interest) to potential nominal GDP, in percent, in a user scenario
Endogenous	
rbudp*(t)	ratio of primary surplus(+)/deficit(-) to potential nominal GDP, in percent
rbudp(t)	ratio of primary surplus(+)/deficit(-) to nominal GDP, in percent
g*(t)	potential real GDP growth, in % at annual rate
LF*(t)	potential labor force, in millions
CE*(t)	potential employment, in millions
LQ*(t)	potential productivity measured as potential real GDP per potential employed
GDP(t)	real GDP, level, in chain-type dollars
GDP$(t)	nominal GDP, level, current dollars
GDP*(t)	potential real GDP, level, in chain-type dollars
GDP$*(t)	potential nominal GDP, level, current dollars

xgap(t)	real GDP gap, in % of real potential GDP
RF(t)	federal funds rate, nominal, in percent
MPE10(t)	average expected federal funds rate over the current and next 9 years
R10(t)	10-year Treasury note yield, in percent
u(t)	unemployment rate, in % of the civilian labor force
$\pi(t)$	inflation, in percent
$\pi^e(t)$	expected inflation, in percent
TP10(t)	10-year term premium, in annualized percentage points of yield
BUDP(t)	primary surplus, in billions of dollars (negative values indicate deficit)
GFR(t)	government receipts, in billions of dollars
GFOP(t)	government outlays net of interest, in billions of dollars
RG(t)	average effective interest rate on publicly held federal government debt, in % at annual rates
NI(t)	net interest expenditures by the federal government, in billions of dollars
BUD(t)	total budget surplus (negative values indicate deficit), in billions of dollars
D(t)	publicly held federal government debt, in billions of dollars

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Parameter values

Parameter	Value	In equation for	Right-hand-side variable
η	0.4	xgap	xgap(-1)
σ_0	1.2	”	real R10 - r10bar
σ_1	2.0	”	(real R10 - r10bar)(-1)
σ_2	0.9	”	(real R10 - r10bar)(-2)
σ_3	0.8	”	(real R10 - r10bar)(-3)
σ_4	0.5	”	(real R10 - r10bar)(-4)
σ_5	0.25	”	(real R10 - r10bar)(-5)
θ_0	1.3	”	rbudp*
θ_1	0.4	”	rbudp*(-1)
θ_2	0.4	”	rbudp*(-2)
θ_3	0.3	”	rbudp*(-3)
θ_4	0.2	”	rbudp*(-4)
θ_5	0.1	”	rbudp*(-5)
α_1	0.4	U	xgap
α_2	0.2	”	xgap(-1)
γ_1	0.50	π	lagged inflation vs expected
γ_2	0.25	”	unemployment gap
λ_1	0.6	π^e	weight on expected infl.
λ_2	0.3	”	weight on current infl.
λ_3	0.1	”	weight on inflation target
μ_1	1	RF	inflation gap
μ_2	0	”	expected infl. gap
μ_3	1	”	unemployment gap
φ_1	0.25	MPE10	current federal funds rate
φ_2	0.25	”	expected inflation gap
δ_1	0.833	RG	RG(-1)

Parameter	Value	In equation for	Right-hand-side variable
δ_2	0.4	”	weight on RF vs R10
ψ_1	-0.134	rgfop*^{U}(t)	user delta, potential labor force growth
ψ_2	-0.229	”	user delta, potential productivity growth
κ_1	0.667	rf*^{U}	user delta, potential labor force growth
κ_2	0.667	rf*^{U}	user delta, productivity growth
κ_3	0.02	”	user delta, debt % GDP (proxy)

Parameter values are chosen based on historical relationships and in consideration of model simulation properties. They are subject to change by The Budget Lab.

Table: The Budget Lab • Source: BLSMM v1.0 • Created with Datawrapper

Footnotes

1 To limit complexity and promote solvability, we treat the contributions to potential real GDP growth from potential growth rates for the labor force and productivity as exogenous. This specification is more defensible over the short and medium run and for moderate interest rate changes, where “crowding out effects” are likely to be small. For long-run simulations or those that entail large interest-rate responses, crowding-out effects on capital accumulation and labor productivity could be a significant consideration.

2 In their February 2026 economic projections, the Congressional Budget Office estimates that the noncyclical rate of unemployment will decline by 0.22 percentage point cumulatively over the 10-year period ending in 2036, implying an average contribution to annualized potential GDP growth from this source of just +0.02 percentage point. Over the same span, it projects potential GDP growth will average 1.96%, reflecting labor force growth of 0.43% and productivity growth of 1.52%. These estimates square with relevant expressions for potential real GDP growth in the text above after allowing for the effects of rounding.

3 The base year matches that used by the Bureau of Economic Analysis in the construction of the National Income and Product Accounts.

4 For some purposes, the primary budget balance, receipts, and primary outlays are scaled by potential nominal GDP instead of actual nominal GDP to reduce feedback that may complicate finding a numerical solution. The quantitative impact in simulation of scaling by potential nominal GDP instead of simulated nominal GDP is very small.

5 Parameter values are shown in a later section.

6 In the current version of the model, the weight on the gap of expected inflation to the inflation target (μ_2) is set to zero. The model contains a single inflation rate and a single corresponding price level interpreted as the price index for GDP denoted by PGDP. The Fed’s inflation target is identified with the annualized rate of change in the price index for personal consumption expenditures. Since the Federal Reserve formally adopted an inflation target in 2012, the two inflation rates for PCE and GDP have differed, on average, by 0.2 percentage point, with a correlation coefficient of 0.99.

7 See ”How Changes in Economic Conditions Might Affect the Federal Budget: 2025 to 2035,” March 2025 and the accompanying spreadsheet from the Congressional Budget Office.

8 We use a model-based proxy instead of the simulated path of debt/GDP to make numerical solution more tractable. The path for the proxy closely approximates the simulated path of debt to nominal GDP.

9 The model abstracts from changes in net federal assets, such as cash flows associated with loans to businesses or individuals that would be associated with changes in publicly held debt.