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MACROECONOMIC MODELING OF TAX POLICY: A COMPARISON OF CURRENT METHODOLOGIES

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The macroeconomic effects of tax reform are a subject of significant discussion and controversy. In 2015, the House of Representatives adopted a new "dynamic scoring" rule requiring a point estimate within the budget window of the deficit effect due to the macroeconomic response to certain proposed tax legislation. The revenue estimates provided by the staff of the Joint Committee on Taxation (JCT) for major tax bills often play a critical role in Congressional deliberations and public discussion of those bills. The JCT has long had macroeconomic analytic capability, and in recent years, responding to Congress' interest in macrodynamic estimates for purposes of scoring legislation, outside think tank groups — notably the Tax Policy Center and the Tax Foundation — have also developed macrodynamic estimation models. The May 2017 National Tax Association (NTA) Spring Symposium brought together the JCT with the Tax Foundation and the Tax Policy Center for a panel discussion regarding their respective macrodynamic estimating approaches. This paper reports on that discussion. Below each organization provides a general description of their macrodynamic modeling methodology and answers five questions posed by the convening authors.

Keywords: revenue estimation, dynamic scoring, macrodynamic estimates, tax reform

JEL Codes: H20, H30

I. INTRODUCTION

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The macroeconomic effects of tax reform are a subject of significant discussion and controversy. Although uncertain, most estimates tend to find these macroeconomic effects to be non-trivial in many types of tax reform proposals. Policymakers' interest

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in such estimates, and "macrodynamic scoring" of tax reform proposals, has increased markedly in recent years.

Responding to this interest, the staff of the Joint Committee on Taxation (JCT) began developing macroeconomic analysis capabilities in 1995. Starting in 2003, the JCT staff was required to provide a macroeconomic impact analysis of all tax legislation reported by the House of Representatives' Ways and Means Committee.[1] For most tax bills, the expected effects were so small that a brief statement sufficed. However, legislation that involved large policy changes required more detailed analysis.

Forecasted macroeconomic impacts are sensitive to assumptions about taxpayer responsiveness, fiscal and monetary policy, and the modeling framework that is adopted. The JCT staff developed a range of estimates in its macroeconomic analyses to account for different assumptions regarding taxpayer responsiveness, as well as to reflect different outcomes driven by different modeling frameworks. However, in their "conventional" estimates, the figure given for the effect of the legislation on the federal budget historically excluded those behavioral responses that would have macroeconomic effects (e.g., altering overall output, employment, or similar variables).

In 2015, the House of Representatives adopted a new "dynamic scoring" rule,[2] which was then incorporated into a joint Concurrent Budget Resolution for the 114th Congress.[3] This new rule required a point (single) estimate within the budget window of the deficit effect due to the macroeconomic response to certain proposed legislation. Using language that suggests an intent to account for a range of direct and indirect channels through which legislation affects the economy, the rule specifically provides that the JCT's estimates shall, "to the greatest extent practicable," incorporate the "changes in revenues, direct spending outlays, and deficits," resulting from "changes in economic output, employment, capital stock, and other macroeconomic variables" that would result from major proposed legislation.[4] The requirement applied to bills with gross budget effects equal to or greater than 0.25 percent of GDP (about $49 billion in 2017) in any year. It also required qualitative analysis for 20 years after the budget window. The House of Representatives again imposed this rule for the current (115th) Congress.[5] The Senate adopted a comparable rule as part of the budget resolution passed on October 19, 2017 (as this article went to press).

The revenue estimates provided by the JCT for major tax bills often play a critical role in Congressional deliberations and public discussion of those bills. Because revenue estimates can be important to the legislative outcome for major tax proposals, as Congress moved towards using macrodynamic estimates for purposes of scoring legislation, outside think tank groups — notably the Tax Policy Center and the Tax Foundation — also developed macrodynamic estimation models. The Tax Policy Center and the Tax

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[1] H.R. Res. 5, 108th Cong. § 2(j) (2003). Note that while it is the responsibility of the JCT to evaluate tax proposals, the underlying "baseline" levels of tax revenues, gross domestic product (GDP), and other aggregates on which such evaluations by the JCT are based are provided by the Congressional Budget Office.

[2] H.R. Res. 5, 114th Cong. § 2(c)(1) (2015).

[3] H.R. Rep. No. 114-96, at 32 (2015) (Conf. Rep.). For previous academic discussion of macrodynamic scoring, see e.g., Auerbach (2005). See also Mankiw and Weinzierl (2006).

[4] *Id*. at 32–33.

[5] H.R. Res. 5, 115th Cong. (2017).

Foundation currently provide the macrodynamic estimates that outside analysts rely on most frequently as points of comparison against the JCT estimates.[6]

Business tax reform now sits near the top of the American political agenda, and macro-dynamic estimates could have an important effect on that agenda. Thus, for the May 2017 National Tax Association (NTA) Spring Symposium we brought together the JCT with the Tax Foundation and the Tax Policy Center for a panel discussion regarding their respective macrodynamic estimating approaches. The goal of the discussion, moderated by Alan Auerbach, was to highlight important similarities and differences in the estimating approaches taken by the JCT and the outside groups.

In advance of the panel discussion at the Spring 2017 NTA meeting, we asked the JCT and the two external tax modeling organizations to answer five questions that help illuminate the choices those groups have made in building their macrodynamic estimating models. The questions related to the long-run budget constraint assumptions in their models, as well as the effect of tax reform on cross-border profits shifting, their view of dividend taxation, the relevance and impact of exchange rates, and the respective models' approach to the corporate and pass-through sectors. We also encouraged each of the groups to provide whatever general remarks to preface their answers that they deemed appropriate.

In the following sections we have reproduced the illuminating responses we received from each of the JCT, the Tax Policy Center, and the Tax Foundation. Section II provides each organization's general description of its macrodynamic modeling methodology. Section III gives the answers they provided to the five specific questions we posed. As should be clear from the discussion, the practice of macrodynamic modeling is rapidly evolving, with multiple models being developed simultaneously and continually modified to deal with important issues that arise as new tax proposals must be evaluated.

II. GENERAL REMARKS

A. Joint Committee on Taxation

Nicholas Bull, Pamela Moomau, Rachel Moore, Brandon Pecoraro, and Thomas Barthold, staff of the Joint Committee on Taxation, United States Congress.[7]

Modeling the macroeconomic consequences of tax law requires grappling with two very difficult features of economic and tax policy modeling. First, economic models used for the analysis must be sufficiently nuanced to deal with the most important aspects of

[6] Other institutions also have macrodynamic estimation capabilities. For instance, the American Enterprise Institute's Open Source Policy Center's "TaxBrain" project includes an open-source dynamic overlapping generations model of the US economy that enables interested persons to interact with the model and alter its assumptions in ways they believe is appropriate or wish to assess. See http://www.ospc.org/taxbrain/. However, analysts tend to look to the Tax Foundation and the Tax Policy Center as points of comparison against the JCT estimates because at the current time these are the two non-government organizations that consistently produce estimates in the same time interval as the JCT, or when debate is taking place regarding a given proposal.

[7] Our contribution to this paper reports on work undertaken for the staff of the Joint Committee on Taxation, but as members of both parties and both houses of Congress comprise the Joint Committee on Taxation, this work should not be construed to represent the position of any member of the Committee.

our highly complex tax law and proposed changes to it. Second, while there is a reasonable degree of common understanding among economists about the basic building blocks of economic behavior, there is less unanimity when it comes to characterizing how these building blocks should be aggregated to predict whole-economy responses to policies affecting decision-making of individuals. To address the first concern, the JCT makes use of a number of separate models that have been developed and refined over a long period for the purpose of producing conventional revenue estimates.[8] To address the second, the JCT has developed a modeling capacity with three types of macroeconomic models to inform our macroeconomic analysis of tax policy proposals. This approach enables us to get a better idea of the range of possible modeling outcomes, as well as to explore the sensitivity of results to modeling frameworks and parameter assumptions.

Given its role in the tax policy process, the JCT has focused on ensuring that the details of proposed changes to tax policy are represented as faithfully as possible in modeling their macroeconomic effects. This effort starts with maximizing the information about the policy provided by conventional estimates. An array of tax models, including separate modeling of the individual income tax, the corporate tax, taxation of pass-through entities, taxation of foreign activity of U.S. multinationals, and a number of other, smaller taxes, are brought into play in producing conventional estimates. Of course, the level of detail in these models cannot tractably be included in models that are designed to represent the general equilibrium interactions of consumers, producers, workers, and investors in various sectors of an economy — at least not within the short-run timeframe required for producing analysis in time for legislative consideration. Any macroeconomic model used by the JCT necessarily requires significant simplifying assumptions about the economy and the tax sectors in it. Because all economic models make simplifying assumptions, no one specific model will automatically be ideally configured to analyze each future policy proposal. The three different macroeconomic models used by the JCT differ in which sectors are simplified as well as in other modeling respects.

The three models that the JCT uses are our Macroeconomic Equilibrium Growth model (MEG), an Overlapping Generations model (OLG),[9] and a Dynamic Stochastic General Equilibrium model (DSGE). All three models start with the standard, neoclassical production framework in which the amount of output is determined by the quantity of labor and capital used by firms, and the productivity of those factors of production; long-run aggregate demand equals aggregate supply at full employment. Both individuals and firms are assumed to make decisions based on observed characteristics of the economy, including wages, prices, interest rates, tax rates, and government spending levels. In particular, the amount of labor available to the economy is affected by individuals' understanding of their after-tax returns to working, which depends on both wage rates and tax rates. Similarly, the amount of capital available to the economy is determined by

[8] Conventional revenue estimates incorporate many microeconomic behavioral responses, including shifting transactions over time and between sectors in response to tax policy changes. See Joint Committee on Taxation (2011) for more information on conventional estimating at the JCT.

[9] The OLG model currently used by the JCT is leased from Tax Policy Advisors, LLC.

investors' predictions of after-tax returns to capital, which depend on anticipated gross receipts, costs of factor inputs, and tax rates that affect those factors. The underlying structure of the MEG model relies more on reduced form behavioral response equations, while the OLG and DSGE models incorporate more theoretical microeconomic foundations. A summary of the economic models and estimating practices the staff of the JCT uses for both conventional and macroeconomic estimation is available at Joint Committee on Taxation, *Summary of Economic Models and Estimating Practices of the Staff of the Joint Committee on Taxation* (JCX-46-11), September 19, 2011.[10]

The degree to which we rely more heavily on the results of one model versus the others depends on the specifics of the proposal being analyzed. The MEG model, which does not require a fiscal balance assumption, is better suited to analyze proposals that produce large, conventionally estimated deficit effects.[11] This model allows for the modeling of four separate types of labor, and of separate marginal and average tax rates for all major individual and business income tax sources, while the other two models treat average and marginal rates the same for individual income other than wages. The availability of investment capital to firms is determined by individuals' savings response to changes in the after-tax rate of return on investment as well as by foreign capital flows. Also in the MEG model, monetary policy conducted by the Federal Reserve Board is explicitly modeled, with delayed price adjustments to changes in economic conditions allowing for the economy to be temporarily out of equilibrium in response to fiscal and monetary policy. The myopic expectation framework in the MEG model represents the extreme case of no foresight about future economic conditions, in which individuals assume in each period that current economic conditions will persist permanently.

At the other end of the foresight spectrum, in the OLG model, individuals are assumed to make consumption and labor supply decisions to maximize their lifetime well-being given the resources they can foresee will be available to them. They are assumed to have complete information, or "perfect foresight," about economic conditions, such as wages, prices, interest rates, tax rates, and government spending, over their lifetimes. The OLG represents a class of models with "micro-foundations" and life-cycle effects modeled separately for each of a number of "generations" (in this case 55). Taxes on labor affect the decisions of each cohort by impacting the trade-off between consumption and leisure. Individuals substitute between labor and leisure both contemporaneously and over time. The OLG model includes a more differentiated business sector than the other two models. Firms' investment decisions respond to the effects of tax policy on the projected future value of the firm. Changes in marginal tax rates on firm profits, and changes in the value of deductions for investment affect this future valuation.

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[10] Joint Committee on Taxation (2011).

[11] The other models require a fiscal balance assumption when modeling policies that may cause deficits to grow faster than the growth rate of the economy. The Joint Committee staff attempts to mitigate potential distortions from imposition of a fiscal balance assumption in the OLG model by deferring the implementation of any such assumption. Deferring implementation reduces the present value of the effects of the policy changed imposed to return the deficit to a stable trajectory. Research on the effectiveness of this approach in reducing the impact of the closing assumption within the budget window is ongoing.

The stochastic feature of the DSGE model allows for some analysis of the effects of uncertainty about future fiscal policy on the modeling outcome, representing a less extreme foresight assumption than either of the other models. As the uncertainty about future fiscal conditions is allowed to persist over a limited period of time, the DSGE is closer to the OLG than to the MEG on this spectrum. The DSGE model includes a monetary authority that implements a Taylor rule for a monetary policy reaction function. In the DSGE there are two types of individuals who make decisions about labor supply, only one of whom has the liquidity to make investment decisions ("savers and non-savers"). As in the OLG model, these two types of individuals make consumption and labor supply decisions to maximize their discounted present value of consumption over time, including consumption of leisure. The savers supply investment capital to the economy, and receive income from investment returns. The non-savers are liquidity constrained, and are unable to invest. The existence of these two types of individuals allows for some explicit distributional analysis of taxes on investment versus taxes on labor. In addition, changes to transfers and taxes on the non-saving households will have direct effects on current period consumption and the current level of output. These features of the DSGE model allow the model to interpret real short-run effects of economic policy changes.

B. Tax Policy Center

Benjamin Page

The Urban-Brookings Tax Policy Center (TPC) has partnered with the Penn Wharton Budget Model (PWBM) to develop dynamic estimates of tax proposals. This approach makes it possible to estimate how tax policy affects the national economy and how changes in the national economy, in turn, affect federal revenues.

The TPC uses its large-scale microsimulation model to estimate the revenue effects of tax policy changes. Those "conventional" revenue estimates reflect changes in microeconomic behavior, such as consumption of taxed goods, realizations of capital gains, claiming of deductions, and reporting of taxable income. However, conventional estimates exclude macroeconomic responses, such as changes in the size of the economy, the overall price level, investment, and employment.

Dynamic analysis expands conventional analysis by incorporating the macroeconomic effects of policy proposals. For example, reducing marginal tax rates on labor earnings may encourage people to work more, thereby increasing overall labor supply and output. Or, a policy that increases deficits may push up interest rates and crowd out private capital investment, lowering the capital stock and output. Macroeconomic changes in turn can affect revenues, because changes in output generally imply changes in taxable incomes.

In theory, by incorporating macroeconomic effects, dynamic analysis could improve revenue forecasts. However, predicting economic effects requires us to make assumptions about very uncertain economic relationships and behavioral responses. For our base case estimates, the TPC and the PWBM have incorporated assumptions that we

consider to lie within the central range of opinion of economists. However, we also show how alternative assumptions, reflecting the (sometimes wide) range of uncertainty about key parameters, can affect the estimates.

We find that our approach to dynamic estimates generally has limited impact on our revenue estimates, compared with our conventional analysis. Tax policies that result in large revenue losses when estimated conventionally typically result in large revenue losses when estimated dynamically, using our models and the range of assumptions that we consider reasonable. In addition, conventional scoring is the method most often used by the JCT, the official government scorekeeper for tax legislation. For those reasons, conventional scoring remains an important tool in evaluating tax policy, and the TPC will continue to display traditional analysis alongside dynamic estimates.

To estimate macroeconomic effects, analysts generally rely on models of the economy — equations that represent economic relationships. Those models attempt to capture the effects that policy changes may have on such activities as household consumption, labor supply, and business investment. Changes to those activities affect the economy and, in turn, revenues.

Different economic models can capture different types of effects on the economy. For our analysis, we include results from three different models: the TPC's Keynesian model, which captures short-run effects on aggregate demand, and two models that capture longer-term effects on the economy's potential output: the TPC's neoclassical model and the PWBM's overlapping generations model.

The three models use different approaches in producing estimates. The Keynesian and neoclassical models both consist of equations that relate aggregate variables such as consumption, investment, and output. Those relationships are based largely on how those variables have behaved in the past. The Keynesian and neoclassical models differ, however, in their assumptions about how output is determined. The Keynesian model assumes that economic output is driven by the level of overall demand in the economy — for example, that output will rise when demand increases as firms gear up production and hiring to meet the demand. Historical evidence suggests that this assumption is likely to hold in the short run — over a year or two. Qualitatively, the predictions of the Keynesian model are fairly simple: policies such as tax cuts that increase aggregate demand are estimated to boost output, while policies such as tax increases have the opposite effect. The effects on output estimated using the Keynesian model can be viewed as shifts in actual output relative to its potential level — for example, shifts that would result in changes in the unemployment rate.

The neoclassical model also uses a framework based on equations relating aggregate variables. However, it assumes that output is determined by the economy's potential, which depends on the level of productive capital in the economy, the quantity of labor employed, and the level of productivity. The Neoclassical model estimates that policies that boost the capital stock or increase the supply of labor will increase output by raising the economy's potential. That type of effect is likely to be most relevant beyond the first couple of years after a policy change. The Neoclassical model is based on relationships between current and past economic and policy variables, so anticipated future developments have no explicit effect on the model estimates. However, the model's equations

incorporate some ways that current policies may affect expectations, on average — for example, the extent to which current deficits lead people to expect future increases in taxes, which leads them to save more in preparation.

In contrast to the Keynesian and neoclassical models, the PWBM is based on choices by households of how much to work and save in order to maximize their well-being. (The Neoclassical model incorporates analogous effects on work and saving, but they are based on simple mathematical relationships rather than by explicitly modeling household decision-making.) Those households are forward-looking, so their choices depend on both current and future levels of wages and interest rates, as well as government policies. Because the PWBM incorporates forward-looking households, future policy changes can affect the current economy. However, in the PWBM output is always at its potential level and unemployment is always at its natural rate — the rate consistent with full employment and stable inflation — so, like the neoclassical model, the model is less well-suited to estimate short-term fluctuations in output.

Those different approaches can lead to very different results. The Keynesian model, for example, shows that tax policies that increase the deficit will tend to boost economic output, all else being equal, because they increase aggregate demand. By contrast, the neoclassical and the PWBM models show that policies that increase the deficit dampen output in the absence of other changes in marginal incentives to work, save, or invest because higher deficits crowd out investment in productive capital goods. Those estimates need not be contradictory, because they apply over different time horizons. In fact, in its dynamic analysis the TPC combines the estimates of the Keynesian and neoclassical models into one projection that captures both short- and long-run effects by gradually transitioning from the results of the Keynesian model to those of the neoclassical model.[12]

C. Tax Foundation

W. Gavin Ekins and Kyle Pomerleau

The challenge of modeling the economic impact of tax policy changes is determining the extent to which taxes affect individual and institutional decision-making. Most economists agree that individuals' economic behavior is impacted by the distortionary effects of tax policy on prices, but the effects of tax policy on international markets and central bank behavior are less established. For these reasons, the Tax Foundation has developed a model to measure the economic effects of tax policy that makes as few assumptions about institutional reactions as possible, choosing to err on the side of passive rather than reactionary institutional economic behavior.

The Taxes and Growth (TAG) Model is a neoclassical, comparative-statics economic model coupled with a tax return simulator. The tax return simulator uses the IRS's public use file, which is a representative sample of nearly 150,000 tax returns, to estimate the

[12] For a more detailed summary of the macrodynamic model and estimating practices employed by the Tax Policy Center see Page and Smetters (2017).

distribution of the tax burden, tax collections, and several other descriptive statistics under both current law and a simulation. In particular, the simulator calculates marginal tax rates by income type, which feeds into the economic model to affect the supply of labor and the cost of capital.

The TAG model has four sectors in the economic model: corporate, non-corporate, households and institutions, and government enterprises. Each sector uses a Cobb-Douglas production function to estimate the economic output given the capital and labor in that sector. The supply of capital is determined by the user cost of capital method established by Jorgenson and Hall (1969), which includes taxes and type of capital specific to that sector. We assume that the after-tax return to capital is constant in the long run. As such, the capital stock will grow or shrink to the point that the after-tax rate of return to capital goes back to its pre-policy change level. The supply of labor is shared by all sectors and is determined by the change in after-tax wage, which is endogenous, and the elasticity of labor, which is a parameter. In practice, the elasticity of labor is set to 0.3, which is within the range of estimates found in the economic literature (Congressional Budget Office, 2012).

Estimates of wage and capital income growth from the Cobb-Douglas production function are fed back into the tax return simulator via growth factors. This allows us to measure changes in individuals' marginal and effective tax rates due to income growth. This is done for each type of income: wages and salaries, business income, capital income, and other income.

After determining the new level of output in equilibrium, the TAG model estimates, through backwards induction, the growth path to reach this new level. These economic changes are overlaid on the CBO's 10-year revenue and economic projections (Congressional Budget Office, 2017) to estimate the change in revenues and GDP over the next decade. Backward induction to the baseline year of the policy change avoids errors that can arise from changing both the tax policy effects and predicting the growth path simultaneously.[13]

Although tax policy directly affects the supply of labor and capital, tax policy could also affect decision-making of influential institutions. The central bank has a strong influence on market interest rates, which in some models can influence the cost of capital. If the central bank reacts to a tax policy change, the growth or contractionary effect of the policy could be mitigated. However, central banks operate within a complex political economy where the influence of political actors has a bearing on the decisions of a central bank to accommodate tax policy changes.

The goal of a dynamic score is to estimate the economic influences of taxes, not to predict the institutional decision-making of a central bank. As such, the TAG model assumes that the central bank can maintain its targeted inflation rate in the long run and does not react to short-run fluctuations. Similarly, the TAG model assumes that nominal exchange rates can be affected by tax policy, but real exchange rates stay constant.

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[13] For a more detailed summary of the macrodynamic model and estimating practices employed by the Tax Foundation, see Tax Foundation (2017).

The TAG model assumes a constant population when calculating economic growth effects of tax changes, relying on the Congressional Budget Office budget projections to capture changes in demographics. Demographic changes could be influenced by tax policy changes, but predicting demographic patterns is beyond the scope of a dynamic score. Incentives for foreign citizens to immigrate or American citizens to emigrate could have an impact on economic growth. However, the effect would be small, and the myriad of other influences affecting migration warrants caution; the error introduced by adding such elements may exceed the increased precision of the tax effect. Similarly, shifts in savings between young and old are affected by tax policy, but capturing these shifts versus the aggregate change may only introduce unwarranted error into the model without any meaningful improvement in accuracy.

The TAG model assumes free access to the world capital markets for the U.S. Treasury and domestic borrowers, and a fair degree of flexibility in the supply of saving to the U.S. economy. For these reasons, the TAG model does not consider the impact of more deficit spending on the economic growth of the economy.

There has been considerable debate regarding the relationship between the U.S. economy and the rest of the world. The U.S. GDP has gradually declined from nearly one-third of the world economy after WWII to 17 percent in 2015 (World Bank, 2017). This suggests that the U.S. economy behaves as a small open economy, where domestic investment is not constrained by domestic savings. This has particularly important implications when considering tax revenue reductions funded by deficit spending. If the U.S. economy is sufficiently small compared to the rest of the world, an increase in U.S. demand for investment capital and government bonds does not deplete the savings of the rest of the world, and does not increase the required return on investment projects. Thus, deficit spending, while increasing government borrowing, will not necessarily "crowd out" the savings available for capital investment.

Several empirical studies using data from the 1990s and 2000s support this assumption. These studies found that for each dollar of additional deficit spending a combination of increased domestic savings and greater investment from abroad offsets the increased federal government's debt as discussed by Chinn and Prasad (2003), Chinn and Ito (2005, 2007), and Chinn et al. (2011). Earlier studies using data from the 1970s and 1980s have found that there was not enough additional savings to offset the increased debt as discussed in Edward (1996), Loayza et al. (2000), Lopez et al. (2000), and Giavazzi et al. (2000), which throttled capital formation. However, these studies did not account for capital flows from abroad and used data from a period where the U.S. economy was a much larger portion of the world economy.

III. SPECIFIC QUESTIONS

This section provides the five questions posed to the three organizations in advance of the NTA Symposium, along with the answers provided. For each question, we also give a brief motivation for its inclusion on our list.

A. Long-Run Budget Constraint Assumption

Do your respective model(s) assume long-run fiscal sustainability? In particular, do you incorporate any fiscal changes beyond those specified in the legislation to reflect the government's long-run budget constraint?

Over the long term, the federal government may need to make fiscal adjustments not specified in a given proposal in order to maintain some measure of fiscal balance. Such future adjustments are typically irrelevant for traditional modeling approaches. However, for macrodynamic models, particularly for models that incorporate expectations about future fiscal variables, some assumptions regarding these future fiscal adjustments may be needed even to produce short-term forecasts.

1. Joint Committee on Taxation

• *MEG:* Because this model has myopic agents, it can solve for a substantial period of time even when changes in the deficit are growing more quickly than changes in the GDP. Thus, it is generally not necessary to assume long-run fiscal sustainability to analyze the GDP changes within the typical ten-year budget window, and usually for at least another ten years beyond that.

• *OLG:* The policy is simulated as proposed, allowing debt to endogenously grow or shrink for 10 to 40 years. Thereafter we phase in adjustments to transfer payments until debt stabilizes and grows at the same rate as aggregate income. Business capital gets crowded out the larger the debt is allowed to grow, so there are limits to how far out we push the closing assumption. We are currently experimenting with other closing assumptions, such as government spending adjustments.

• *DSGE:* Decision rules are calculated by giving agents 100 percent certainty over the policy as specified in the legislation for the first 2.5 years of the budget window. Every quarter thereafter they apply some small but increasing probability that fiscal policy returns to steady state. Under the simulation, shocks are set to model the policy as-is for the entire ten-year window, and then return to steady state thereafter. Unlike the OLG, the DSGE results within the budget window are not sensitive to pushing the closing window past year ten because agent expectations regarding policy were set during the decision rule stage. The amount of time to steady state convergence depends on the parameterization, and can be adjusted for sensitivity analysis.

2. Tax Policy Center

In its tax analyses, the PWBM holds the debt-GDP ratio to its 2040 level, consistent with the simulated policy, for the years after 2040, via changes in government purchases. The Keynesian and Neoclassical models do not assume long-run sustainability.

3. Tax Foundation

Our model does not expand government spending as the economy expands but does track the increase in debt and the cost of servicing the debt. Our model uses the CBO baseline for government spending, and we assume that this is held constant in real terms. We layer on the CBO estimates of the economic and tax revenue changes predicted by our model. We do not have any endogenous mechanism that changes government spending as a function of tax policy changes.

We do track the expansion of the debt and the additional cost of servicing that debt over the ten-year budget window. However, we assume interest rates for government debt do not fluctuate with economic growth or tax policy.

B. Cross-Border Profit Shifting Effects

Do your respective model(s) include the effects of tax reform on cross-border shifting of profits and real activities in estimating dynamic changes in tax revenue? If so, do they distinguish between the two types of shifting (that is, changes in the actual scale of U.S. production vs. changes in reported U.S. profits)?

Models vary in their sophistication about cross-border activities of multinational companies, a complex area of potential taxpayer responses that has taken on increased importance over the years and is central to the evaluation of business tax reform proposals.

1. Joint Committee on Taxation

Under our fixed GNP convention, the JCT's conventional estimates incorporate effects of tax policy changes on the location of reported U.S. profits that are not associated with changes in actual economic activity.

• *MEG:* Cross-border flows are modeled in the form of changes in imports and exports between the United States and a generic international sector, and associated changes in capital flows. These flows respond to the effects of tax policy on consumption demand and return to investment. These changes flow through to changes in labor, capital investment, and GDP.

• *OLG:* This model includes both the shifting of profits and of productive capital in response to a change in tax policy. Changes to profit shifting do not have first-order effects on domestic production, as the associated revenue effects from conventional estimates enter the government's budget constraint exogenously (to avoid double counting the conventionally estimated effects). Changes in the location of productive capital, both ordinary and intellectual property, directly affect domestic production in the multinational corporate sector. The degree to which the location of intellectual property matters for production is not generally agreed upon in the literature, so we often report results with various intellectual property shifting elasticities.

• *DSGE:* This is a closed economy model, but revenue from profit shifting can be incorporated as an exogenous revenue component of the government's budget.

2. Tax Policy Center

While not explicitly modeled, the TPC's revenue estimates incorporate effects of changes in the tax base, including cross-border shifting of profits, to produce estimates similar to those produced by government estimators (JCT and the U.S. Treasury Department's Office of Tax Analysis). Cross-border shifting of capital is incorporated in the PWBM via a weighted average of closed and small open economy results, and in the Neoclassical model by a response of international capital flows to changes in national saving.

3. Tax Foundation

We have a switch to turn on or off an assumption of profit shifting and have a parameter we can change that determines the presumed amount of reported earnings per percentage point differential between the U.S. tax rate and the average effective foreign tax rate, the semi-elasticity approach. The scale effects are captured by the normal service price equations, which depend only on domestic factors.

C. View of Dividend Taxation

In your model(s), how do changes in dividend taxation influence U.S. business investment? In particular, does the dividend tax rate affect the incentive to invest, either through the user cost of capital or through effects of dividend payouts on liquidity?

There is a long-standing controversy in the economics literature about the extent to which different types of capital income taxation affect business investment, and the channels through which such effects occur. There is a particularly large potential range of effects associated with changes in dividend taxation.

1. Joint Committee on Taxation

• *MEG:* Dividend taxation influences U.S. business investment through its effects on the user cost of capital. It is possible to adjust how much of changes in dividend taxation flow through to the user cost of capital. Generally, the default assumption is about 50 percent.

• *OLG:* Corporate firms finance their desired quantity of investment from new share issues to households when retained earnings are insufficient. Since dividend payouts to shareholders are assumed to be an exogenous portion of after-tax profits, a change in the tax rate on dividends will alter shareholders' after-tax portfolio return. The implied change in corporate firms' user cost of capital will then influence their desired level of business investment. The strength of this effect will depend on the exogenous dividend payout ratio and leverage ratio parameters, which can be specified as policy-dependent.

• *DSGE:* Dividends are not modeled explicitly. This kind of policy change would be modeled by a change to the marginal tax rate on capital income, which would affect investment through its effects on savings incentives, as well as revenues.

2. Tax Policy Center

The TPC's measure of the marginal tax rate on capital income (used as an input in both the PWBM and the neoclassical models) incorporates dividend taxation — it takes the "old view."

3. Tax Foundation

Yes, shareholder-level taxes are part of the service price (user cost).

D. Does the Exchange Rate Affect the Economy?

Do your respective model(s) incorporate the effects of tax reform on the dollar exchange rate? If so, how is the exchange rate determined and through what channels does the exchange rate affect the U.S. economy?

Exchange rate responses are particularly relevant to business tax reforms that influence incentives to import and export, such as the destination-based cash-flow tax. But there is a wide range of potential approaches to modeling exchange rate responses.

1. Joint Committee on Taxation

• *MEG:* Exchange rates eventually adjust to achieve purchasing power parity; this adjustment feeds back to changes in the flows of goods, services, and capital. Exchange rate adjustments can be modeled with a lag.
• *OLG:* As a real model, the OLG does not incorporate the dollar exchange rate. The model maintains purchasing power parity for tradable goods across borders in all periods. This is effectively equivalent to instantaneous exchange rate adjustment.
• *DSGE:* This is a closed economy model, so there are no exchange rate effects.

2. Tax Policy Center

Effects on the exchange rate are incorporated on a case-by-case basis. The TPC's estimate of the effects of a destination-based cash flow tax — such as the one included in the House GOP tax blueprint of 2016 — assumes (in the long run) full adjustment of exchange rates, limiting the real effects of that provision. The TPC's Keynesian model estimates of the House GOP blueprint did not incorporate a wealth effect of revaluation of foreign-denominated assets, but that effect could be included in future analyses.

3. Tax Foundation

Yes and no. It is a comparative-static, long-run model that assumes the Federal Reserve maintains stable domestic prices. Hence, we assume that any tax changes that leave real terms of trade untouched after price adjustments (as with border-adjusted taxes) will have no long-run effect on real activity. We are currently working on an international sector of the model that explicitly tracks these capital flows and should be reporting them in the future.

E. Combined Business Sector or Separate Corporate and Pass-Thru Sectors

Do your respective model(s) distinguish separately the investment behavior of pass-through entities and C corporations, or do you model a combined business sector?

As the share of business activity undertaken by companies outside the traditional C corporate sector has grown, so has the importance of considering separately the behavior of different types of business entities. This is especially true when evaluating proposals that treat C corporations and pass-through entities quite differently.

1. Joint Committee on Taxation

The revenue effects of shifting in entity form between pass-through entities and C corporations are included in conventional estimates.

• *MEG:* Pass-through entities and C corporations are modeled as a combined business sector; taxes applied to this sector are a weighted average of corporate and pass-through rates. Housing is modeled as a separate sector. These weights in the baseline are drawn from tax data, and are shifted as indicated by the conventional estimate in simulated proposals.

• *OLG:* Corporate multinational, corporate domestic, and non-corporate firms are modeled separately, with each firm type making its own investment decisions. Each sector has different tax rates, deductions, and credits determined by production and finance decisions, all of which affect investment incentives for the respective sector, such that baseline receipts match the JCT baseline receipts as closely as possible. In modeling tax policy changes, these tax variables are altered from their baseline values as indicated by the changes produced by conventional estimating models.

• *DSGE:* This model has a combined business sector; taxes applied to this sector are a weighted average of corporate and pass-through rates. These weights in the baseline are drawn from tax data, and are shifted as indicated by the conventional estimate in simulated proposals.

2. Tax Policy Center

The PWBM and the TPC macro models are based on a combined business sector. The PWBM is currently being updated to separately treat pass-throughs and C corporations.

3. Tax Foundation

Yes. The pass-throughs and the C corporations are modeled in separate sectors, each having their own capital stock, labor supply, and service price. Taxes affecting corporations, such as the corporate income tax, dividends tax, and capital gains taxes, are applied to the corporate sector while taxes affecting non-corporate entities, such as the marginal rate on individual business income, are applied to the non-corporate sector.

DISCLOSURES

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REFERENCES

Auerbach, Alan, 2005. "Dynamic Scoring: An Introduction to the Issues." *American Economic Review* 95 (2), 421–425.

Chinn, Menzie D., and Eswar S. Prasad, 2003. "Medium-Term Determinants of Current Accounts in Industrial and Developing Countries: An Empirical Exploration." *Journal of International Economics* 59 (1), 47–76.

Chinn, Menzie D., and Hiro Ito, 2005. "Current Account Balances, Financial Development and Institutions: Assaying the World 'Savings Glut.'" NBER Working Paper 11761. National Bureau of Economic Research, Cambridge, MA.

Chinn, Menzie D., and Hiro Ito, 2007. "Current Account Balances, Financial Development and Institutions: Assaying the World 'Saving Glut.'" *Journal of International Money and Finance* 26 (4), 546–569.

Chinn, Menzie D., Barry Eichengreen, and Hiro Ito, 2011. "A Forensic Analysis of Global Imbalances." NBER Working Paper 17513. National Bureau of Economic Research, Cambridge, MA.

Congressional Budget Office, 2001. CBO's Method for Estimating Potential Output: An Update, www.cbo.gov/publication/13250.

Congressional Budget Office, 2012. A Review of Recent Research on Labor Supply Elasticities, www.cbo.gov/sites/default/files/cbofiles/attachments/10-25-2012-Recent_Research_on_Labor_Supply_Elasticities.pdf.

Congressional Budget Office, 2014. The Long-Run Effects of Federal Budget Deficits on National Saving and Private Domestic Investment, www.cbo.gov/sites/default/files/113th-congress-2013-2014/workingpaper/45140-NSPDI_workingPaper_1.pdf.

Congressional Budget Office, 2017. The Budget and Economic Outlook: 2017 to 2027, https://www.cbo.gov/publication/52370.

Edwards, Sebastian, 1996. "Why Are Latin America's Savings Rates So Low? An International Comparative Analysis." *Journal of Development Economics* 51 (1), 5–44.

Engen, Eric M., and R. Glenn Hubbard, 2005. "Federal Government Debt and Interest Rates." In Gertler, Mark, and Kenneth Rogoff (eds.), *NBER Macroeconomics Annual 2004*, vol. 19, 83–160. National Bureau of Economic Research), Cambridge, MA.

Giavazzi, Francesco, Tullio Jappelli, and Marco Pagano, 2000. "Searching for Non-Linear Effects of Fiscal Policy: Evidence from Industrial and Developing Countries." *European Economic Review* 44 (7), 1259–1289.

Hall, Robert E., and Dale W. Jorgenson, 1969. "Tax Policy and Investment Behavior: Reply and Further Results." *American Economic Review* 59 (3), 388–401.

Joint Committee on Taxation, 2011. "Summary of Economic Models and Estimating Practices of the Staff of the Joint Committee on Taxation." Joint Committee on Taxation (JCX-46-11), Washington, DC, https://www.jct.gov/publications.html?func=startdown&id=4373.

Laubach, Thomas, 2009. "New Evidence on the Interest Rate Effects of Budget Deficits and Debt." *Journal of the European Economic Association* 7 (4), 858–885.

Loayza, Norman, Klaus Schmidt-Hebbel, and Luis Servén, 2000. "What Drives Private Saving Across the World." *Review of Economics and Statistics* 82 (2), 165–181.

Lopez, J. Humberto, Klaus Schmidt-Hebbel, and Luis Servén, 2000. "How Effective Is Fiscal Policy in Raising National Saving?" *Review of Economics and Statistics* 82 (2), 226–238.

Mankiw, N. Gregory, and Matthew Weinzierl, 2006. "Dynamic Scoring: A Back-of-the-Envelope Guide." *Journal of Public Economics* 90 (8), 1415–1433.

Tax Foundation, 2017. "Overview of the Tax Foundation's Taxes and Growth Model." Washington, DC, https://taxfoundation.org/overview-tax-foundation-s-taxes-and-growth-model/.

Page, Benjamin R., and Smetters, Kent, 2017. "Dynamic Analysis of Tax Plans: An Update." Tax Policy Center, Washington, DC, http://taxpolicycenter.org/sites/default/files/publication/140016/2001217-dynamic-analysis-of-tax-plans-an-update.pdf.

The World Bank, World Development Indicators, 2017. GDP, current US$ [Data file]. Retrieved from http://data.worldbank.org/indicator/NY.GDP.MKTP.CD?view=chart.