Dynamic Scoring for Tax Legislation: A Review of Models

Updated June 20, 2023

Congressional Research Service
https://crsreports.congress.gov
R43381

Congressional Research Service
Informing the legislative debate since 1914

Dynamic Scoring for Tax Legislation: A Review of Models

SUMMARY

R43381

June 20, 2023

Jane G. Gravelle
Senior Specialist in Economic Policy

Dynamic scoring (or revenue estimating) for tax legislation has been discussed for more than two decades. Beginning in 2003, House Rule 13 required that the Joint Committee on Taxation (JCT) provide a macroeconomic impact analysis of legislation to amend the Internal Revenue Code or a statement explaining why it is not calculable. In 2015, that requirement was for a point estimate of feedback effects, a rule suspended in 2019 but restored in 2023. These estimates are not part of the official revenue estimate, but they could affect views on legislative proposals.

Official revenue estimates include many behavioral changes, but hold output (in their case, gross national product or GNP) constant. Dynamic scoring allows for changes in GNP. Models for estimating effects on output (GNP or gross domestic product, that is, GDP) that government agencies and academics use are complicated. To those interested in dynamic feedback effects on output, these models may appear to be "black boxes." This report, although necessarily technical itself, examines the models used for dynamic scoring, their reflective effects, and their response consistency with empirical evidence. The following points summarize the major findings of the report:

- Revenue neutral income tax reform that lowers statutory income tax rates through broadening the base, although assumed by some to spur growth, can potentially contract the economy. The base broadening, by making more income subject to tax, increases effective rates and offsets statutory rate reductions. Models must consider these effects to estimate effects of tax reform.
- When taxes increase or decrease, some effects that have been estimated may be less appropriate than others to include in the analysis. Some models estimate demand side stimulus effects, which are transitory and matter only when there is unemployment in the economy. These may not be appropriate to consider in evaluating permanent tax policies. Questions may also be raised about including effects of deficits or surpluses in reducing or increasing investment due to changes in government borrowing. In both cases, these effects apply to spending as well as to tax changes.
- Sometimes claims are made that the feedback effects from reducing taxes will largely offset the revenue loss through "supply side" effects that increase output and the tax base. No reasonable estimate of the responses of labor supply or savings to tax changes can produce such offsets. The feedback effect from a simple and flexible growth model is less than 10%, given empirical evidence of supply responses, which are small and of uncertain direction.
- More complex models for studying supply side effects (intertemporal models), which are based on a more rigid theoretical structure, produce similar results for changes in taxes on wages if the assumptions of the models are consistent with the empirical evidence on labor supply. A review of models currently or recently used by government agencies and academics suggests that is not generally the case (an exception is the JCT's model).
- Effects of tax cuts on capital income can be large in these more complex models, reflecting shifting of consumption and leisure to periods far in the future. These shifts, which can induce large short-run increases in labor supply and saving, are generally not supported empirically and may be unlikely. An important question is whether the benefits of formal theory in these models outweigh their empirical weaknesses.

Contents

Tables

Appendixes

Contacts

Dynamic scoring (or dynamic revenue estimating) for tax legislation has been an issue of interest for at least the past 25 years.[1] Beginning in 2003, House Rule 13 required that the Joint Committee on Taxation (JCT) provide a macroeconomic impact analysis of legislation to amend the Internal Revenue Code or a statement explaining why it is not calculable; the first analysis was in 2003.[2] In 2015, the rules required a point estimate to be included in revenue estimates. An estimate was provided in 2017 for the Tax Cuts and Jobs Act (P.L. 115-97). No estimates were required in 2019-2022, but these rules were restored in 2023 and the JCT has since posted two dynamic estimates, one for the House-passed version of the Build Back Better Act (BBBA; H.R. 5376) and the other for an expansion of the child tax credit. The rule requires dynamic revenue estimates for tax legislation that has an impact of 0.25% of gross domestic product (GDP). These analyses and estimates are not part of the official score but rather provide projected feedback effects, although some may argue that feedback effects should be included in revenue estimates.

Many uncertainties arise with respect to dynamic scoring, which depend on the type of model used, the behavioral responses built into the models, and assumptions about activities of other agents or supplemental policies that are necessary to solve some types of models. The complexity is expanded in the case of tax reform, because base broadening can also have effects on effective tax rates that could offset part or all of the behavioral effects due to changes in statutory rate reduction.

This report first explains dynamic scoring, including the types of effects incorporated and the types of models used, as well as what groups conduct or have conducted macroeconomic analyses of tax changes. The following section discusses the specific issues associated with tax reform. The final section discusses general issues surrounding the use of various models and reviews the empirical evidence on supply side responses (labor supply and savings or investment) and how these effects are incorporated in current models used by JCT, the Congressional Budget Office (CBO), the Department of the Treasury, and nongovernmental researchers.

The discussion of economic modeling is necessarily more technical than that in most Congressional Research Service (CRS) reports. The first section, therefore, provides an overview with a less technical summary of the analysis and findings in this report. The main body of the report follows.

Overview

Dynamic scoring, as a general term, is revenue estimation that accounts for behavioral changes. When referring to tax legislation, the term dynamic revenue estimating is also used. The legislative requirements cited above, however, have a narrower effect because many behavioral responses are already included in conventional revenue estimates. The rules commonly referred to as requiring a dynamic score require macroeconomic effects, incorporating the effects of

[1] See CRS Report R46233, *Dynamic Scoring in the Congressional Budget Process*, by Megan S. Lynch and Jane G. Gravelle, for a more detailed history. The first CRS report on this issue, CRS Report 94-1000, *Dynamic Revenue Estimating*, by Jane G. Gravelle (December 14, 1994, now archived but available to congressional clients from the author upon request) linked the growing interest in the past years to the greater importance of revenue estimates under budget rules that provided additional constraints on tax cuts and spending changes. For example, the Budget Enforcement Act of 1990 provided for PAYGO rules. See CRS Report R41901, *Statutory Budget Controls in Effect Between 1985 and 2002*, by Megan S. Lynch, for a discussion of these rules.

[2] See excerpt from *Congressional Record*, 149 Cong. Rec. H3829-H3832, at https://www.jct.gov/publications.html?func=startdown&id=1191. Other JCT documents relating to macroeconomic analysis are available at https://www.jct.gov/publications.html?func=select&id=4.

legislative changes on aggregate economic output. Dynamic scoring as used in this report refers to incorporating those macroeconomic effects. It is often discussed in connection with revenue legislation because tax revisions may cause "supply side" effects (i.e., changes in labor supply and savings) due to changes in effective average and marginal tax rates.

How Dynamic Scoring Differs from Conventional Scoring Methods for Tax Legislation

The Joint Committee on Taxation's current revenue estimates include a variety of microeconomic behavioral responses that affect revenue yields.[3] For example, increasing capital gains taxes is assumed to cause a reduction in realizations that reduces the potential revenue gain. Various other behavioral responses are considered in preparing estimates. These estimates, however, keep total output (i.e., GNP) fixed. Effects on output have been provided in some cases, but they are not included in formal scorekeeping.[4]

What Determines the Economic Effects from Dynamic Scoring?

The effects of dynamic scoring on revenues depend on numerous factors: the types of effects included, the types of models used, and the magnitude of behavioral responses (elasticities) incorporated in the model.[5] JCT and CBO studies have considered three types of effects: (1) the short-run stimulus effect where a tax cut increases demand and output in an underemployed economy, while a tax increase reduces output; (2) the effect of deficits or surpluses on crowding out or crowding in investment due to government borrowing; and (3) the supply side effects (i.e., increases or decreases in labor supply, domestic savings, and net investment from abroad in response to changes in effective tax rates).

Reasons exist to consider only the supply side effects, because the other two effects also occur with spending changes. There are especially strong reasons to exclude stimulus effects, because permanent changes in the tax code should not depend on fiscal timing. That is, a permanent tax code change should not be evaluated more or less favorably because it is enacted during a recession. Moreover, the Federal Reserve System may offset the short-run stimulus effect.

Supply side effects from tax cuts are often presumed to increase output. However, they can either increase or decrease output because of offsetting income and substitution effects. A tax cut, by increasing income, causes an increase in consumption, including consumption of leisure, which reduces labor supply. This effect is the income effect. A tax cut that affects marginal earnings will cause leisure to be more costly relative to consumption, which will increase labor supply. This effect is the substitution effect. Income and substitution effects also occur for savings. A reduction in the tax rate on the return to savings, and the higher return, means that an individual can consume more now and more in the future, reducing savings. This effect is the income effect. At the same time, the lower tax rate (and higher yield) makes the price of future consumption lower and increases savings, the substitution effect. These effects are typically measured as an elasticity:

[3] Conventional scoring and macroeconomic analysis are discussed in Joint Committee on Taxation (JCT), *Summary of Economic Models and Estimating Practices of the Staff of the Joint Committee on Taxation*, JCX-46-11, September 19, 2011, at https://www.jct.gov/publications.html?func=startdown&id=4373.

[4] JCT's documents relating to macroeconomic analysis are available at https://www.jct.gov/publications/?searchWithin=&category_name=Macroeconomic+Analysis&find-publication=Find+a+Publication.

[5] Elasticities measure the underlying supply side relationship, for example, by what percentage does labor supply increase or decrease for a given percentage change in wages. In some models they are explicit, whereas in others they must be derived from other parameters.

the percentage change in quantity divided by the percentage change in price or income. For example, if the labor supply elasticity with respect to the wage rate is 0.2, a 10% increase in wages will cause a 2% (0.2 times 10%) increase in labor supply.

The projected effects of a tax change on output and revenues depend on the design of the tax change, the type of model, and the magnitude of income and substitution elasticities. Two very different types of models for estimating supply side response are a *simple growth model* with labor and savings supply responsive to wages and rates of return and an *intertemporal model* with a complex theoretical structure in which individuals allocate leisure and consumption over time. The behavioral responses rely on many aspects of these intertemporal models, which are not always transparent.

During the budget horizon, labor supply is likely to be the dominant factor, in part, because additional capital tends to accumulate slowly. Output increases when the labor supply or the capital stock increases, with labor supply the larger input. A tax change affects the capital stock by affecting savings or investment, which is typically only 2% to 3% of the capital stock. Even if the saving rate increased by 50% in the first year, the capital stock would increase by only about 1%. Outside the budget window, capital accumulation may become more important and, for some reforms, can dominate the effects on labor.

Special Issues with Revenue Neutral Tax Reform

With a revenue neutral tax reform, where base broadening finances rate cuts, the focus is generally on supply side effects, because the effects on short-term demand or the deficit and crowding out should be negligible. Moreover, in a revenue neutral change, there are no income effects in the aggregate to reduce supply as would be the case in a rate cut alone. If the change is also distributionally neutral, any effects arising from these factors are even less likely. Thus, the focus of dynamic effects is on substitution effects.

In a tax reform, it is crucial to recognize that the behavioral response cannot be measured solely by statutory rate changes. The *effective* marginal tax rate determines this behavioral response and changes in the income base that change the share of income taxed at the margin also affect this marginal effective tax rate. It is possible for base broadening provisions to raise effective marginal tax rates more than enough to offset the effects of a cut in statutory tax rates, leading to a contraction rather than an expansion in output.

This potential for base broadening to affect marginal effective rates means that it is not possible to project the effects of a base broadening tax reform that specifies the rates but does not specify how the revenue is to be offset by base broadening. Many models, including those used by the JCT, use a microsimulation model to calculate marginal effects of tax revisions that include both rate and base changes.

Expected Supply Side Effects of Dynamic Models

When there is a revenue loss or gain or when marginal effective tax rates change, there can be supply side responses. The following points can be made:

- In simple transparent supply side models that directly incorporate labor supply and savings responses as indicated by empirical evidence, feedback effects on revenues are expected to be small, in the neighborhood of 3% to 8%. That is, a revenue loss will be reduced by 3% to 8% and a revenue gain will be increased by 3% to 8% in an overall tax cut. Effects might be slightly larger in open economies.

- More complex intertemporal models can yield similar results with respect to wage tax cuts, if similar elasticities are embedded in the models. In these models, spending must match taxes in the long run, so the results depend on how deficits or surpluses are addressed. An examination of models currently or recently used indicates that many of these models have implicit behavioral responses for labor supply that are much larger than those that are contained in simpler growth models or those that can be supported with empirical evidence.
- Responses in intertemporal models to changes in taxes on capital income can be large, depending on how the revenues are offset and the size of elasticities. These models have a rigid structure that causes responses in savings that reflect reducing consumption today for more consumption many years in the future to a degree that is unlikely and not empirically studied. In addition, they cause an increase in labor supply to shift leisure from the present to many years in the future that is also not likely or supported by empirical evidence. An important question is whether the more desirable theoretical structure of these models balances the lack of empirical justification.

The remainder of this report provides a more detailed analysis.

Types of Effects and Types of Models

Dynamic scoring normally employs models of the aggregate economy. Some of these models have a single rate of return and a single type of saving and supply of capital; changes in taxes that affect the rate of return directly or indirectly can lead to changes in savings.

These models typically do not address certain features of the corporate tax. Although corporate tax revenues are relatively small compared with individual tax revenues, corporate changes could have significant effects on the overall rate of return. Aggregate economy models capture these effects on savings rates. Corporate taxes, however, may also have immediate and larger effects on capital, because they may affect flows of capital to and from the rest of the world. This process could occur more quickly than the effects (if any) on increased domestic saving. Most aggregate models have relatively primitive (if any) adjustment for this effect, although corporate models that focus separately on international capital flows exist.

Aggregate Models of the Economy

The three types of revenue feedback effects are

1. short-run stimulus, or Keynesian (demand side) effects;
2. crowding out effects of deficits on investment (and crowding in effects of surpluses); and
3. supply side effects.

Stimulus effects, such as those in a tax cut, can increase output temporarily in an underemployed economy by increasing income and spending. This increase in demand leads to the return of some unemployed individuals and resources to production. Crowding out occurs because the increase in federal borrowing due to increased deficits displaces capital that would otherwise be used for private investment. The magnitude of the effect depends on how much government borrowing is from foreign sources.

The third type of effect, which is often of the most interest, is commonly called a supply side effect because it refers to the effects of tax or other policies on the amount of labor supplied or the amount of savings or investment (which would affect the size of the capital stock). This effect is more closely associated with tax changes, although it could apply to some spending programs as well. (For example, spending on infrastructure such as bridges or highways would affect productivity, and means-tested transfer payments can affect work incentives.)

These different effects may not be precisely separated (for instance, deficits increase interest rates, which can cause a change in savings that is a supply side effect, and tax cuts could simultaneously cause demand side and supply side effects). All three effects can be isolated by sensitivity analysis that includes policies to control for stimulus and deficit effects (as the JCT often has done).

There are three basic types of economic models (plus combinations) that vary in whether and how they reflect the three types of effects.

- Short-run models (also referred to as IS-LM models) with underemployed resources typically used for short-run forecasting and to estimate short-run stimulus effects on aggregate demand, but they are not effects of deficits or supply side effects. They can be solved only by assuming some particular monetary policy of the Federal Reserve System. These models are often used in the private sector for forecasting and tend to have multiple sectors.
- Basic neoclassical growth models (also called Solow models) with direct estimates of labor and savings supply responses. This type of model, in its pure form, assumes full employment and does not capture short-run stimulus, but can capture crowding out effects and supply side effects. Its effects are driven by the labor supply elasticities (the percentage change in labor divided by the percentage change in wages) and savings elasticities (the percentage change in savings rates with a percentage change in after-tax rate of return).
- Intertemporal growth models, where individuals allocate leisure and consumption within periods and across time. These actions give rise to changes in labor supply and savings responses. These models capture only supply side responses, as full employment is assumed and deficits are offset by some other policy change.[6] The models are of two forms. One form is the Ramsey, or infinite horizon, model where people are represented by an infinitely lived agent.[7] The other form is the overlapping generation (OLG) life-cycle model where agents have finite lives (typically around 55 years to cover the working period and retirement), and a new generation is born each year, while an old one dies (hence the term overlapping generations). Agents in intertemporal models often have perfect foresight (i.e., know all of the wage rates and rates of return in the future as well as the consequences of responses on those variables), although they can be constructed to allow risk and uncertainty. While the basic intertemporal model

[6] The offset of deficits is not a choice, but a requirement in these forward-looking models, as a solution requires solving for a steady-state or a long-run solution that is asymptotically approached. Deficits can exist in these models, but they must have a stable debt-to-GDP ratio. An OLG model with myopia can be solved with deficits.

[7] The original Ramsey model was a planning model that was then adapted to the study of tax and other policies in a steady state growth model as a descriptive model. Macroeconomists adapted this model to the study of business cycles due to exogenous shocks, which is referred to as a real business cycle model, which claims to explain business cycles without involuntary unemployment. A term for a more general class of these models is dynamic stochastic general equilibrium (DSGE) models, which can be designed to allow unemployment. Tax economists have tended to favor the life-cycle form of the intertemporal model, perhaps because it allows distribution across generations that is an important aspect of shifting to consumption taxes. This model is very difficult to construct. Macroeconomists tend to favor the simpler infinite horizon model, in part because they are often interested in business cycles and in intertemporal shifts of labor in response to wage rates.

has agents with perfect foresight, and can be myopic, meaning that they know expected wage and interest rates, they do not account for how actions will affect those measures.[8] Intertemporal models (other than myopic models) cannot indefinitely have deficits or surpluses, and in the Ramsey model even temporary deficits have no effects. Because these models have a relatively rigid structure, they include a labor supply response to changes in the rate of return. For some tax changes, this response to the rate of return may be the major source of a short-term labor response.

- Hybrid models combine short-term stimulus effects with growth models. For example, an IS-LM model can be combined with a Solow model. Hybrid models that allow unemployment through sticky wages (i.e., wages do not immediately adjust to changes in demand) can combine with a Ramsey infinite horizon model. These types of models are also referred to as dynamic stochastic general equilibrium (DSGE) models. DSGE models may have a single representative agent or more than one type of agent; for example, some agents in the economy may be liquidity constrained (cannot borrow).

The alternative models can produce different results both due to the model choice and to the elasticities, or assumed responsiveness, embedded in the model. In addition, some models can (but may not) allow capital flows to and from the rest of the world. In general, these models do not include an explicit modeling of open economy effects but may include open economy effects on supply in a variety of ways. The infinite horizon model, however, is incompatible with perfectly mobile international capital. Rule-of-thumb offsets against crowding out are used in some of the Solow growth models to assign part of borrowing to foreign sources.

Corporate Models

Corporate models of a closed economy have long existed, but they have not generally been used to measure feedback effects. These models, in fact, often simplified the requirements of aggregate modeling because the standard analysis concluded that the corporate tax fell on capital in general, given a fixed capital stock. For purposes of a dynamic model, the corporate tax could then be treated no different from a general tax on the rate of return. In addition, even though changes in the corporate tax rate could shift capital between the corporate and non-corporate sectors, the corporate tax base would be unlikely to change, because, although the capital stock in the corporate sector decreases with a higher corporate rate, the rate of return rises and these two effects tend to be offsetting.[9]

Open economy considerations suggest that the corporate tax should be considered differently from other types of taxes on capital income. The tax on corporate equity, which is effectively or at least partly a source-based tax, unlike individual income taxes on interest and dividends, can directly affect capital flows into and out of the country, thereby increasing output through another route (rather than indirectly affecting the rate of return to savings). Indeed, given the evidence

---

[8] Risk causes individuals to have precautionary savings, which tend to be less responsive to changes in the rate of return. It is possible to construct a life-cycle model with myopia, where agents assume current wages and returns will continue and re-optimize their labor supply and savings each period. Other things equal, myopia results in larger responses to changes in tax rates because agents do not recognize the feedback effects of their responses on these variables.

[9] Certain types of production functions and utility functions indicate a perfect offset and a constant share of total output in corporate revenues; for others, the effect is likely small. Corporate taxes produce distortions, but those distortions do not affect aggregate output in a significant way.

that saving is relatively unresponsive to rates of return and tends to accumulate slowly, capital flows from abroad could be one of the more important dynamic issues to consider.

The Organizations and Researchers That Study Dynamic Effects

Several government organizations have prepared dynamic scores or macroeconomic analyses of effects that would permit estimates of dynamic feedback effects. In addition, numerous academic researchers have constructed models that estimate macroeconomic effects.

Joint Committee on Taxation

The JCT is the most important source of dynamic estimates for U.S. legislative proposals, because it is responsible for official scoring of most tax legislation. The JCT also provides macroeconomic analysis as required by the House Rules. The JCT has been preparing and then performing macroeconomic analyses since 1997, when they commissioned numerous researchers to estimate the overall effects on output, labor, savings and other variables of the same proposal using a variety of different modeling approaches. This modeling exercise, along with others done over the years, is on its website.[10] In their first analysis in 2003, researchers used three types of models to analyze macroeconomic effects: macroeconomic short-term effects based on commercial models, a Solow growth/hybrid model, and an OLG life-cycle model. They added a Ramsey hybrid (DSGE) model in 2006, but that model was subsequently revised. The OLG life-cycle model has recently been revised to include corporate tax modeling. Currently, the JCT uses the Solow hybrid model (called the Macroeconomic Growth Model, or MEG), the OLG model, and the DSGE model, which were all used in estimating the effects of the Tax Cuts and Jobs Act (P.L. 115-97).[11] The JCT has developed a new OLG model, which has been used to estimate the effects of some proposals, including the Build Back Better Act (BBBA; H.R. 5376) as passed by the House of Representatives, posted in 2023.[12]

The MEG is basically a Solow growth model that allows short-term stimulus effects, effects of deficits and surplus, and includes a direct labor supply elasticity and savings response that reflects results from a myopic Ramsey model. In many ways, MEG could be viewed as a pragmatic combination of labor supply responses, short-run stimulus effects, crowding out effects, and a savings response from consumption with the same type of microeconomic foundations as intertemporal models but without the labor supply response to the interest rate. Meaning, there is intertemporal substitution in consumption but not in leisure. The JCT studies prior to the point estimate requirements frequently provided sensitivity analyses that allow a separation of stimulus and crowding out effects from supply side effects.[13]

[10] The Joint Committee's documents relating to macroeconomic analysis are posted on its website at https://www.jct.gov/publications/?category_name=Macroeconomic%20Analysis.

[11] JCT, *Overview of Joint Committee Macroeconomic Modeling*, JCX-33-18, April 23, 2018, https://www.jct.gov/publications/2018/jcx-33-18/.

[12] JCT, *Macroeconomic Analysis Of H.R. 5376, The "Build Back Better Act," As Passed By The House Of Representatives, On November 19, 2021*, December 6, 2021, https://www.jct.gov/publications/2021/macroeconomic-analysis-of-h-r-5376/.

[13] Stimulus effects can be eliminated by assuming an offsetting policy of the Federal Reserve. Deficit effects can be eliminated by assuming offsetting changes in spending.

The JCT has tended not to use the short-term macroeconomic models after the first study, and in some estimates has used only MEG. Its recent estimates include inputs from all three models: MEG, OLG, and DSGE. The analysis of the $1.5 trillion Tax Cuts and Jobs Act (P.L. 115-97) gave a weight of 40% to MEG, 40% to OLG, and 20% to DSGE. It estimated that the macroeconomic effects would offset 26% of revenue.[14] In the estimate of the effects of the Protecting Family and Small Business Tax Cuts of 2018 (H.R. 6760), it gave a weight of 40% to MEG, 30% to OLG, and 30% to DSGE.[15]

The recent estimate of the House-passed BBBA assigned a weight of 35% to MEG, 35% to the OLG model, and 30% to the DSGE model. The most recent estimate, for an expansion of the child tax credit, assigned a weight of 50% to MEG and 50% to the OLG model.[16] As noted above, the OLG model used in these simulations is from a new in-house model.

Until 2017, the JCT prepared dynamic analyses that provided sensitivity analysis and separate effects of the different types of models, so that the effect of different assumptions could be shown. Under the single point estimate effect adopted in 2015, none of the separate effects were reported.

Congressional Budget Office

CBO has provided estimates of the economic effects of the President's budget, which includes tax provisions, from 2003 to 2016. It also provides economic effects of budget projections of different types. CBO is charged with the responsibility for dynamic estimates, assisted by the JCT.

The first CBO study employed the same four types of models that JCT has used, although it introduced its own supply responses into the macroeconomic short-term models.[17] CBO ultimately dropped one of its models (the Ramsey infinite horizon) in its later analyses[18] and did not use any intertemporal model in its 2014 analysis of budget options.[19] The CBO OLG model has recently been revised.[20] CBO transitions from the short-run effects in macro model to the longer-term effects in its Solow and OLG models.[21] CBO does not generally perform dynamic

[14] JCT, *Macroeconomic Analysis Of The Conference Agreement For H.R. 1, The Tax Cuts And Jobs Act*, JCX-16-19, December 27, 2017, https://www.jct.gov/publications/2017/jcx-69-17/.

[15] JCT, *Macroeconomic Analysis Of H.R. 6760, The "Protecting Family And Small Business Tax Cuts Act Of 2018" As Reported By The Committee On Ways And Means*, JCX-79-18, September 26, 2018, https://www.jct.gov/publications/2018/jcx-79-18/.

[16] JCT, *Macroeconomic Analysis Of A Permanent Child Tax Credit Expansion*, October 5, 2022, https://www.jct.gov/publications/2022/macroeconomic-analysis-of-a-permanent-child-tax-credit-expansion/.

[17] The initial analysis is described in *How CBO Analyzed the Macroeconomic Effects of the President's Budget*, April, 2003, at http://www.cbo.gov/sites/default/files/cbofiles/ftpdocs/44xx/doc4454/07-28-presidentsbudget.pdf.

[18] The most recent analysis of the President's budget was in *The Economic Impact of the President's 2013 Budget*, April 20, 2012, at http://www.cbo.gov/publication/42972.

[19] See *Macroeconomic Effects of Alternative Budget Paths*, February 2013, at http://www.cbo.gov/publication/43769.

[20] This model was presented in Shinichi Nishiyama, *Fiscal Policy Effects in a Heterogeneous-Agent Overlapping-Generations Economy With an Aging Population*, Congressional Budget Office, Working Paper 2013-07, December 2013, http://www.cbo.gov/sites/default/files/cbofiles/attachments/44941-Nishiyama.pdf.

[21] CBO, *How CBO Analyzes the Effects of Changes in Federal Fiscal Policies on the Economy*, November 2014, https://www.cbo.gov/sites/default/files/113th-congress-2013-2014/reports/49494-FiscalPolicies.pdf. See also *The Long-Term Budget Outlook Under Alternative Scenarios for Fiscal Policy*, August 2018, https://www.cbo.gov/publication/54325.

scores for tax legislation, although it included its own estimates of economic growth in a discussion of the effects of the 2017 tax cut.[22]

Department of the Treasury Office of Tax Analysis

The Office of Tax Analysis (OTA) performed two dynamic analyses in 2006, one on the President's Advisory Panel on Tax Reform's proposals[23] and one on the extension of the 2001-2003 tax cuts.[24]

For the first analysis, OTA used a Solow model, a Ramsey model, and an OLG model. The Solow model had a fixed labor supply but a positive savings response to higher returns. In its analysis of the tax cuts, it used only the OLG model.

Treasury provided a one-page analysis of the Tax Cuts and Jobs Act ahead of the Senate vote that projected the tax bill would raise revenue of $0.3 trillion. No models were cited and the analysis was apparently based on a specified increase in the growth rate.[25]

Other Models and Researchers

The Solow growth model is the simplest of the models to construct, and government agencies and think tanks have used it primarily to examine the effects of tax changes, largely in the longer run. The Urban Brookings Tax Policy Center uses a Solow model and a short-term macroeconomic model, as well as partnering with the Penn Wharton Budget Center on an OLG model. The Tax Foundation uses a model similar to the Solow model, which projects the long-run capital stock assuming a fixed after tax return, and then solves backward to determine savings over time.[26]

Short-term macroeconomic models are largely used by commercial forecasters and government agencies, such as central banks; many central banks also have a hybrid model that couples short-

---

[22] CBO, *The Budget and Economic Outlook: 2018 to 2028*, Appendix B, April 9, 2018, https://www.cbo.gov/publication/53651. See also *The Long-Term Budget Outlook Under Alternative Scenarios for Fiscal Policy*, August 2018, https://www.cbo.gov/publication/54325, where CBO examined the effects of retaining the temporary tax cuts.

[23] Robert Carroll, John Diamond, Craig Johnson, and James Makie III, *A Summary of the Dynamic Analysis of the Tax Reform Options Prepared for the President's Advisory Panel on Federal Tax Reform*, U.S. Department of the Treasury, Office of Tax Analysis, May 25, 2006, prepared for the American Enterprise Institute Conference on Tax Reform and Dynamic Analysis, May 2006. This analysis was discussed in CRS Report RL33545, *The Advisory Panel's Tax Reform Proposals*, by Jane G. Gravelle.

[24] U.S. Office of Management and Budget, *Fiscal Year 2007 Mid-Session Review*, Budget of the U.S. Government, July 11, 2006. This analysis is discussed in CRS Report RL33672, *Revenue Feedback from the 2001-2004 Tax Cuts*, by Jane G. Gravelle.

[25] Department of the Treasury, *Analysis of Growth and Revenue Estimates Based on the U.S. Senate Committee on Finance Tax Reform Plan*, December 11, 2017, https://www.crapo.senate.gov/imo/media/doc/2017DEC_TreasuryGrowthMemo.pdf; and https://oig.treasury.gov/sites/oig/files/Audit_Reports_and_Testimonies/Response%20to%20Requests%20for%20Inquiry%20Re%20Analysis%20of%20Tax%20Reform%20Bill.pdf.

[26] For example, see Robert Carroll and Gerald Prante, "Long-Run Macroeconomic Impact of Increasing Tax Rates on High-Income Taxpayers in 2013," Ernst & Young LLP, July 2012, http://s-corp.org/wp-content/uploads/2012/07/EY-Study-Long-run-macroeconomic-impact-of-increasing-tax-rates-on-high-income-taxpayers-in-2013-2012-07-16-FINAL1.pdf. Steve Entin and William McBride, *Simulating the Economic Effects of Romney's Tax Plan*, Tax Foundation, Fiscal Fact No. 330, http://taxfoundation.org/article/simulating-economic-effects-romneys-tax-plan used a neoclassical growth model, but reported effects in the long run steady state, and not the transition. Benjamin R. Page and Kent Smetters, "Dynamic Analysis of Tax Plans," Tax Policy Center, April 5, 2017, https://www.urban.org/sites/default/files/publication/89456/2001217-dynamic-analysis-of-tax-plans-an-update.pdf; Stephen J. Entin, Huaqun Li, and Kyle Pomerleau, "Overview of the Tax Foundation's General Equilibrium Model," April 2018, https://files.taxfoundation.org/20180419195810/TaxFoundaton_General-Equilibrium-Model-Overview1.pdf?_gl=1.

run unemployment with a Ramsey infinite horizon model, the DSGE model.[27] Some of these models are very complex, with many sectors and interactions. JCT's MEG model and DSGE model allow for short-term demand effects. CBO relies on macro forecasting models (Macroeconomic Advisers and IHS Global Insight), as well as a macroeconomic model developed by the Federal Reserve.[28]

The Ramsey infinite horizon model is generally straightforward to construct, and there are numerous modeling efforts in academia and government. These models are more frequently used by macroeconomists interested in business cycles and the effects of shocks to the economy, rather than modeling tax changes. Tax economists interested in intertemporal models are more likely to turn to the OLG life-cycle model, which can capture intergenerational income shifts, even though this model is more difficult to construct. Because of this difficulty in construction, only a limited number of researchers have done life-cycle modeling. The pioneers in this effort were Alan Auerbach and Laurence Kotlikoff, and their associates, including those who constructed a variation of the OLG life-cycle model at CBO.[29] The JCT and the Treasury both used an OLG model created by John Diamond through a contract with Tax Policy Advisors, LLC.[30] JCT has now developed an in-house OLG model.[31]

[27] For a discussion of these models, see CRS Report R42700, *The "Fiscal Cliff": Macroeconomic Consequences of Tax Increases and Spending Cuts*, by Jane G. Gravelle; and Felix Reichling and Charles Whalen, *Assessing the Short-Term Effects on Output of Changes in Federal Fiscal Policies*, CBO Working Paper 2012-08, May 2012, at http://www.cbo.gov/sites/default/files/cbofiles/attachments/WorkingPaper2012-08-Effects_of_Fiscal_Policies.pdf.

[28] Congressional Budget Office, *How CBO Analyzes the Effects of Changes in Federal Fiscal Policies on the Economy*, November 2014, https://www.cbo.gov/sites/default/files/113th-congress-2013-2014/reports/49494-FiscalPolicies.pdf, and *The Economic Impact of the President's 2013 Budget*, April 2012, at http://www.cbo.gov/sites/default/files/cbofiles/attachments/04-20-Economic_Budget.pdf.

[29] The details of a typical OLG model were presented in Alan J. Auerbach and Laurence J. Kotlikoff, *Dynamic Fiscal Policy*, Cambridge University Press, New York, New York, 1987. A version of their model with additional coauthors Kent Smetters and Jan Walliser was included in the Joint Committee On Taxation *Tax Modeling Project And 1997 Tax Symposium Papers*, Joint Committee Print, November 20, 1997, posted on the JCT website at https://www.jct.gov/publications.html?func=startdown&id=2940. Another more detailed study with more sectors was David Altig, Alan J. Auerbach, Laurence J. Kotlikoff, Kent A. Smetters, and Jan Walliser, Simulating Fundamental Tax Reform in the United States, *American Economic Review*, vol. 91, no. 3, June 2001, pp. 575-595, at http://www2.wiwi.hu-berlin.de/institute/wpol/html/jprof/aer.pdf. The CBO model was initially developed by Shinichi Nishiyama and Kent Smetters, Consumption Taxes and Economic Efficiency in a Stochastic OLG Model, Technical Working Paper 2002-6, December 2002, at http://www.cbo.gov/sites/default/files/cbofiles/ftpdocs/40xx/doc4007/2002- \6.pdf. It includes risk and different types of households. The JCT symposium included two other life-cycle models, one by Don Fullerton and Diane Rogers (now Diane Lim), which had multiple sectors and households and one by Eric Engen and Bill Gale, which included risk. Including the discussant Charles Ballard, input was provided from all the multiple generation life-cycle modelers at that time. The JCT symposium also included one infinite horizon model, by Dale W. Jorgenson and Peter J. Wilcoxin, along with five models that were Solow-type models or hybrid macroeconomic/Solow models. Kotlikoff and his colleagues subsequently developed a multi-country OLG model which recently was used to estimate a shift to a cash flow tax. See Seth G. Benzell, Laurence J. Kotlikoff, Guillermo LaGarda & Victor Yifan Ye, *Simulating Business Cash Flow Taxation*, NBER Working Paper 23675, August 2017, https://www.nber.org/papers/w23675. This model is driven largely by international capital flows as it assumes immediate reallocation of capital assuming perfect substitution of capital across countries, in a one-sector model. Also, while there is significant detail about the OLG part of the model, the corporate model that tends to drive short-run effects is of a limited form that does not account for noncorporate sectors or adjustment periods.

[30] John Diamond is the CEO of Tax Policy Advisors, and is at the James A. Baker III Institute for Public Policy at Rice University.

[31] See Joint Committee on Taxation, *An Overview Of A New Overlapping Generations Model With An Example Application In Policy Analysis*, JCX-22R-20, October 22, 2020, https://www.jct.gov/publications/2020/jcx-22r-20/. A technical explanation can be found in Rachel Moore and Brandon Pecoraro, "Macroeconomic Implications of Modeling the Internal Revenue Code in a Heterogeneous-Agent Framework," *Economic Modeling*, vol. 87 (May 2020), pp. 72-91.

Researchers at Ernst and Young have an OLG model that is similar to the Diamond model, but with an open economy, and estimated the effects of the Tax Cuts and Jobs Act.[32] Two academic researchers—George Zodrow and John Diamond—often estimate the effects of policies using OLG models. Zodrow and Diamond have examined tax changes,[33] and Diamond most recently provided an estimate of the effect of the Inflation Protection Act (P.L. 117-169).[34] The Penn Wharton Budget Model uses an OLG model and frequently provides analysis of tax proposals.[35] For example, it estimated the economic effects of the White House Build Back Better proposal.[36] Researchers can use the Penn Wharton and input their own parameters. This OLG model allows for uncertainty and for closed, fully open, and partially open economies. DeBacker, Evans, and Philips also have an OLG model.[37]

Special Issues Associated with Revenue-Neutral Income Tax Reform

Some argue tax reform should be revenue neutral. Others believe that it should raise revenue. A revenue neutral, or largely revenue neutral, tax reform that lowers the rate and broadens the base is unlikely to have a large effect on the economy. It could contract, rather than expand, the economy, depending on the design.

All of the effects that might be considered in a dynamic estimate, including short-run stimulus, long-run crowding out or crowding in investments through deficits, and supply side responses, would likely be eliminated or dampened in a revenue neutral tax reform.

Short-Run Stimulus, or Demand Side, Effects

Because there would be no change in income under a revenue neutral reform, there would be no effects on aggregate demand, unless there was a shift in the distribution of the tax burden. For example, if the relative burden shifts to high-income individuals, there may be a small stimulus because lower-income individuals tend to spend more. Likewise, a shift to low-income

---

[32] Brandon Pizzola, Robert Carroll and James Mackie, *Analyzing the Macroeconomic Impacts of the Tax Cuts and Jobs Act on the US Economy and Key Industries*, https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/growth/growth-pdfs/ey-tax-reform-projected-to-grow-us-economy.pdf.

[33] John Diamond, *The Economic Effects of the Romney Plan*, Rice University's Baker Institute for Public Policy, August 3, 2012, at https://www.bakerinstitute.org/research/the-economic-effects-of-the-romney-tax-plan. John Diamond and George Zodrow, *The Dynamic Effects of Eliminating or Curtailing the Home Mortgage Interest Deduction*, December 7, 2012, https://scholarship.rice.edu/bitstream/handle/1911/91695/TEPP-pub-DiamondZodrowHomeMortgageInterestDeduction-120712.pdf?sequence=1&isAllowed=y; John W. Diamond and George R. Zodrow, *Dynamic Macroeconomic Estimates of the Effects of Chairman Camp's 2014 Tax Reform Proposal*, Tax Policy Advisers LLC, prepared for the Business Roundtable, http://businessroundtable.org/sites/default/files/reports/Diamond-Zodrow%20Analysis%20for%20Business%20Roundtable_Final%20for%20Release.pdf.

[34] John Diamond, *Macroeconomic Effects of the Inflation Reduction Act*, Working Paper, Rice University's Baker Institute for Public Policy, August 4, 2022, https://www.bakerinstitute.org/research/macroeconomic-effects-inflation-reduction-act.

[35] Penn Wharton Budget Model, *Dynamic OLG*, https://budgetmodel.wharton.upenn.edu/dynamic-olg.

[36] Penn Wharton Budget Model, *Macroeconomic Effects of the White House Build Back Better Budget Reconciliation Framework*, November 4, 2021, https://budgetmodel.wharton.upenn.edu/issues/2021/11/4/macro-effects-of-build-back-better-reconciliation-package.

[37] Jason DeBacker, Richard W. Evans, and Kerk L. Phillips, "Integrating Microsimulation Models of Tax Policy into a DGE Macroeconomic Model," *Public Finance Review*, vol. 47, no. 2 (2019), pp. 207-275.

individuals would provide a small contraction. A distributionally and revenue neutral tax revision should have virtually no short-run stimulus effect.

Deficits and Crowding Out or Crowding In

A tax revision that is revenue neutral would have no direct effects on crowding out or crowding in because there is no change in the deficit. If the analysis extends beyond the budget window, then a tax reform that is revenue neutral in the short run may not be neutral in the long run. Some base broadening provisions (such as slowing depreciation deductions) have a larger revenue gain in the short run than in the long run. In addition, flattening the individual income tax rate structure leads to lower revenues in the long run by reducing real bracket creep (i.e., the rise in the average effective tax rate in a progressive tax system as real incomes rise). Thus, crowding out could occur in the longer run.

Supply Side Responses

The supply side responses are frequently the major focus of dynamic scoring for taxes.[38] In a revenue neutral income tax reform, there are no aggregate income effects. There could be effects on labor and saving if there are distributional effects across income classes and if the model reflects those effects, but a distributionally neutral income tax reform would not have those effects.[39] Thus, it is the substitution effect that is the driver of supply side responses to a revenue neutral tax cut. A rate reduction financed by base broadening cannot be analyzed by looking solely at marginal statutory rates. The base broadening provisions, which increase tax burdens, can affect effective marginal tax rates that may have effects on supply side responses of labor, savings, and investment.[40]

Corporate Tax Reform

This effect on effective marginal tax rates is perhaps most clear when discussing corporate tax reform. Moreover, in an open economy, changing tax burdens at the corporate level is more important for investment (because the corporate tax directly affects international capital flows, whereas taxes on interest and dividends apply to both domestic and foreign investment). Most of the major provisions that could be used for base broadening in a revenue neutral corporate tax reform directly offset effects on investment incentives of lowering rates. One of the largest, accelerated depreciation, if traded for a statutory rate reduction, would increase the effective tax rate on new investment and discourage investment.[41] This effect arises because the rate cut has a

[38] See, for example, Curtis S. Dubay, *Tax Reform is about Economic Growth*, The Heritage Foundation, October 11, 2012, http://www.heritage.org/research/commentary/2012/10/tax-reform-is-about-economic-growth; and Dylan Matthews, "Why Tax Reform Could Help Growth," *Washington Post*, October 16, 2012, http://www.washingtonpost.com/blogs/wonkblog/wp/2012/10/16/why-tax-reform-could-help-growth/.

[39] In OLG models, a revenue neutral shifts from an income tax to a consumption tax, a subject that has been a primary focus of modeling using OLG models, can have pronounced effects due both to intergenerational distribution and the timing of tax payments. This type of reform, however, is not the type currently under discussion.

[40] Alan Auerbach and Joel Slemrod indicated that the Tax Reform Act of 1986 left incentives roughly unchanged. See "The Economic Effects of the Tax Reform Act of 1986," *Journal of Economic Literature*, vol. 35, no. 2, June 1997, pp. 589-632. Alan Viard, in "Statutory and Effective Tax Rates: Part 1," *Tax Notes*, August 20, 2012, pp. 943-947, and Bruce Bartlett, "Misunderstanding Tax Expenditures and Tax Rates," Tax Notes, November 22, 2010, pp. 931-932, also make the general point that revenue neutral tax reform is unlikely to alter work incentives.

[41] See Jane G. Gravelle, "Reducing Depreciation Allowances to Finance a Lower Corporate Tax Rate," *National Tax Journal*, vol. 64, December 2011, pp 1039-1053, and Statement of Jane G. Gravelle Before The Committee on Finance (continued...)

windfall benefit for old capital whereas accelerated depreciation does not.[42] Accelerated depreciation, however, is being phased out, in large part, after 2022. Assuming corporate tax reform is neutral in the long-run estimates suggests that eliminating all tax expenditures other than accelerated depreciation could reduce statutory corporate tax rates by about 6 percentage points, from 21% to 13%.[43] Out of that amount, about half would be due to eliminating international preferences. The preferences that favor treatment of corporate income relating to international activities would have a relatively neutral effect on overall investment but would encourage more investment in the United States. Most of the other important tax expenditures would have similar effects to accelerating depreciation and raise the cost of capital used to reduce tax rates.

The JCT used a version of the OLG model, which reflected the shift of intellectual property from foreign countries to the United States, as reported in a simulation of former Ways and Means Committee Chairman Camp's tax reform proposal.[44] This model and the intellectual property shift is no longer used by the JCT.[45]

Individual Tax Reform

Taxes can cause three supply side effects: labor supply, domestic savings, and net inflows of capital from the rest of the world. Individual income tax reform can affect labor supply and savings.

In a revenue neutral change, there is generally no change in overall income and income effects are negligible. Thus, an analysis of revenue neutral tax reform that relied only on cuts in marginal statutory rates would find larger supply side effects than a rate cut that was not revenue neutral. Labor supply would unambiguously increase from cuts in marginal rates on labor income. In intertemporal models, labor supply also responds to the rate of return. The substitution effect

---

United States Senate, March 6, 2012 on Tax Reform Options: Incentives for Capital Investment and Manufacturing, at http://www.finance.senate.gov/hearings/hearing/?id=7ef25099-5056-a032-52a2-7e15cca1ba5d.

[42] A similar effect would occur if research and development costs were expensed rather than capitalized.

[43] See CRS Report RL34229, *Corporate Tax Reform: Issues for Congress*, by Jane G. Gravelle, for a translation of base broadening provisions into the rate reductions they could finance.

[44] JCT, *Macroeconomic Analysis of the "Tax Reform Act of 2014,"* JCX-22-14, February 26, 2014, https://www.jct.gov/publications.html?func=startdown&id=4564. The JCT indicates that this modeling follows that of Michael P. Devereux and Ruud de Mooij in "An Applied Analysis of ACE and CBIT Reforms in the EU," *International Tax and Public Finance*, vol. 18, no. 1 (2011), pp. 93-120, and Leon Battendorf et al., "Corporate Tax Harmonization in the EU," *Economic Policy*, vol. 63 (2010), pp. 537-590. The authors do not present any empirical evidence to support entering what they refer to as firm-specific capital into the production function, or the importance of it in the economy.

[45] This channel of growth is questionable, because intellectual capital is not located physically. Once it exists it can be used everywhere. For example, when a firm discovers Lipitor, it uses the formula no matter where the pills are made. When a firm develops the technology for a smart phone, or a search algorithm, that knowledge can be applied costlessly to production everywhere. It does not matter if the patent is held in country A and licensed to country B, or vice versa. Therefore, shifting ownership of intellectual property to the United States cannot increase productivity in the United States because that input is already in existence. Shifts in intellectual property may alter revenues, but not output. The case is similarly weak for marketing intangibles. For general property such as trademarks, firms like Starbucks and products like Coca-Cola share the benefits of trademarks regardless of which country holds ownership rights. A similar critique was made by William McBride, *Some Questions Regarding the Diamond and Zodrow Modeling of Camp's Tax Plan*, Tax Foundation, March 17, 2014, http://taxfoundation.org/blog/some-questions-regarding-diamond-and-zodrow-modeling-camps-tax-plan. The intangibles effect in the JCT simulation in the OLG model also reflected a much higher elasticity (the percentage shift in profits divided by the percentage point change in the tax rate differential), 8.6, than the consensus elasticity of 0.8. See Dhammika Darmapala, "What Do We Know About Base Erosion and Profit Shifting? A Review of the Empirical Literature," Illinois Public Law and Legal Theory Research Papers Series No. 14-23, December 2013.

means that, with a higher rate of return, future consumption, including future leisure, becomes cheaper so agents work more in the present to save and have more leisure in the future. This behavior would directly increase output in the short run through increases in labor input and would cause a larger savings response and increase in the capital stock.[46]

This approach would overstate supply side effects because individual income tax reforms that broaden the base could also have effects on the marginal effective tax rates. Depending on the provision, a revenue neutral change could increase or decrease labor supply and savings because these behaviors are affected by the change in the share of the income at the margin subject to tax.

The most straightforward example of how base broadening provisions could affect marginal effective tax rates is the itemized deduction for state and local income taxes. According to Internal Revenue Service (IRS) statistics in 2017 (before temporary provisions limited the itemized deduction), the average deduction on itemized returns for state and local income taxes was 5.9% of income for those with an adjusted gross income (AGI) of $200,000 or greater.[47] Because most state income tax rates are progressive, income taxes paid as a share of income would be even higher at the margin. Using an example of 6%, if the federal statutory income tax rate is 35%, and the state income tax is deductible, the total tax rate that applies to the last dollar of income is 35% plus 6% minus the value of the tax deduction (0.35 times 6%), or 38.9%. If the state and local income tax deduction is eliminated or capped, the effective marginal tax rate rises to 41% (35% plus 6%). On average then, disallowing the state income tax deduction is the equivalent of raising the marginal tax rate by 2.1 percentage points for taxpayers claiming itemized deductions.

Although state and local income taxes make this point clearly, any source or use of income that is tax favored and applies at the margin would have the same effect on supply response.[48] The scope of this marginal effect is also significantly broadened when considering that part of the labor supply response to changes in wages is a participation response, making the margin for this purpose the average tax on the participant's wage income. For example, the earned income credit has been estimated to increase the participation of lower-income unmarried women; a reduction in that credit, even though it does not apply to last dollar, would have a participation effect.[49] The tax benefit of excluding employer health insurance, for example, may not have an effect of marginal wage but could affect a participation response.

A Congressional Research Service report estimated that, for taxpayers at the top marginal income tax rate, a revenue neutral elimination of itemized deductions would leave effective marginal

[46] One study of the effects on savings that eliminated all taxes on capital income and replaced them with higher wage taxes found a savings response in the life-cycle model with variable labor that was almost five times as large as in a model with fixed labor. In the infinite horizon model, it was about 50% larger. See Eric Engen, Jane Gravelle, and Kent Smetters, "Dynamic Tax Models: Why They Do the Things They Do," *National Tax Journal*, vol. 50, September 1997, pp. 657-682.

[47] Internal Revenue Service, Statistics of Income 2017, Individual Income Tax Returns with Itemized Deductions, at https://www.irs.gov/statistics/soi-tax-stats-individual-statistical-tables-by-size-of-adjusted-gross-income.

[48] See Jane G. Gravelle and G. Thomas Woodward, "Clarifying the Relation Between Base-Broadening and Effective Marginal Tax Rates," presented at the National Tax Association Conference, November 2013, which showed marginal effects for several itemized deductions; and CRS Report R42435, *The Challenge of Individual Income Tax Reform: An Economic Analysis of Tax Base Broadening*, by Jane G. Gravelle and Thomas L. Hungerford, which showed these patterns are likely for many other tax benefits.

[49] Nada Eissa and Jeffrey B. Liebman, "Labor Supply Response to the Earned Income Tax Credit," *Quarterly Journal of Economics*, vol. 111, no. 2, May 1996, pp. 605-637.

rates largely unchanged.[50] The effect was largely due to the elimination of the itemized deduction for state and local taxes and charitable deductions, which tend to rise continually with income.

Some provisions may have marginal effects in the long run but may not induce much response within the budget horizon. For example, restricting the mortgage interest deduction or property tax deduction for those who already have mortgages or homes is not likely to change their choices for labor supply in the short run because the choices have already been made, although it might affect individuals who plan to become homeowners.

Some benefits are marginal in some income ranges but not in others. For example, contributions to employer pension plans and 401(k) plans are more likely to rise with earnings for all but very high-income individuals where caps are effective, and thus have marginal effects along with participation effects. An elimination of the child credit would reduce marginal taxes at some higher-income levels because of phaseouts, but increase them at certain low-income levels due to limits on refundability.

The effect of revenue-neutral base broadening depends not only on the type of provision but also on how the change is made. For example, proposals have been made for capping tax expenditures, which would leave the increased marginal tax effect intact for taxpayers above the cap but provide less revenue to permit statutory rate reductions. Thus, this change would be more likely to raise effective marginal tax rates for high-income households.

Some models, including those used by JCT, use microsimulation models that can take into account important base broadening features to estimate effective marginal tax rates based on the legislative proposal. Addressing the marginal effects of base broadening is much more complicated in individual income tax reforms and therefore adds to the general challenges of estimating macroeconomic effects. Nevertheless, the message is clear: dynamic scoring that does not take account of these offsetting effects and rests on statutory tax rate changes will overstate the effects of rate reductions financed with base broadening, and possibly project positive effects, when the effects are negative.

General Issues with Dynamic Scoring for Taxes

Tax reform may not be revenue neutral, so that stimulus and crowding out effects could be part of the macroeconomic analysis. Even a revenue neutral tax reform could affect marginal tax rates, which could generate supply side effects. This section discusses issues that arise when a tax revision decreases or increases revenue or alters effective marginal tax rates. The following discussion addresses whether stimulus or crowding out effects should be considered and whether the various supply side models are appropriate. It also reviews the empirical evidence on behavioral responses and how they compare with those in some of the current models.

Should Short-Run Stimulus Effects (Demand Side Effects) Be Considered?

As noted briefly in the overview, there are several reasons that short-run stimulus effects, which cause a tax cut to lose less revenue than a static score and a tax increase to raise less revenue, should not be considered in dynamic revenue scoring in general, even in models where these effects can be considered.

[50] See CRS Report R43079, *Restrictions on Itemized Tax Deductions: Policy Options and Analysis*, by Jane G. Gravelle and Sean Lowry.

The short-run stimulus effect affects aggregate demand through increased spending due to tax cuts. This increased spending increases output by re-employing unemployed resources (workers who have lost their jobs and idle capital). As some workers become employed and increase their own spending and profits rise, the additional income introduces new spending, which in turn leads to additional production. The successive rounds of output effects are called multipliers. These effects occur only in an underemployed economy (otherwise the stimulus increases the price level), and they are transitory because eventually the economy would have returned to full employment without the stimulus.[51]

Numerous reasons exist that this effect might be inappropriate to consider in dynamic estimation. The most basic argument is that changes in the tax code should not depend on the fiscal timing, as tax changes can be hard to reverse. A permanent tax cut should, arguably, not be viewed more favorably because it was enacted in a recession.

A second reason for not including these effects, is that they also occur with spending changes. Moreover, spending multipliers are typically more powerful than tax cut multipliers because a part of tax cuts is not spent. If the purpose of the change is to stimulate the economy, then that decision would be better informed by comparing tax cuts with spending increases, rather than considering the effects of tax cuts alone. In a sense, dynamic estimates are already accounted for when multipliers for different spending and tax cuts are estimated.

Third, the magnitude and even existence of a stimulus effect depends on assumptions about the behavior of the country's central bank, the Federal Reserve System. The Federal Reserve can take measures to offset a fiscal stimulus with a monetary contraction or a fiscal contraction with a monetary expansion to keep output constant. It can also fully accommodate the change by keeping interest rates constant and strengthening the stimulus or contraction, or it can do anything in between. If, however, the Federal Reserve has a fixed objective for output, fiscal policy would simply be one more factor to counteract in its policies and a tax cut or tax increase would not affect output. When the JCT does dynamic estimates, it generally includes a case where the Federal Reserve offsets the policy, which is helpful in interpreting the contribution of these transitory effects.

Should Debt Effects Be Considered?

There is a somewhat more compelling case that the effects of tax changes on debt should be considered in dynamic revenue scoring. For instance, taken in isolation, consider the tradeoff to be either financing spending through taxes or borrowing. In addition, if the claim is made that a tax cut will largely pay for itself, then analyzing it as a stand-alone policy including both supply side effects and the effects on crowding out from debt might be appropriate.

The counter-argument to this view is that spending cuts have the same types of effects on debt as revenue increases, so that it may not be appropriate to consider them only for taxes. If dynamic scoring is considered for both spending and tax changes, including crowding out might be more appropriate.

The main uncertainty about the effects of debt is the extent to which foreigners can finance debt. If foreigners financed all of the debt, there would be no crowding out and no effect on revenues at least within the budget horizon.

[51] See CRS Report R42700, *The "Fiscal Cliff": Macroeconomic Consequences of Tax Increases and Spending Cuts*, by Jane G. Gravelle, which reports the range of multipliers considered by CBO and discusses alternative models.

Note that the intertemporal models (Ramsey infinite horizon and OLG life-cycle) cannot be solved without some resolution of the debt although there can be effects in the interim. A temporary debt that is resolved eventually with transfers has no crowding out effect in the interim in the Ramsey model because private saving offsets it.

This issue of debt with intertemporal models means, however, that a tax change that affects the deficit can never be considered in isolation, but is accompanied by some other measure to address the deficit and whether it is a change in spending, transfers, or taxes makes a difference in the results.

Supply Side Effects

Although there is little disagreement that incorporating supply side responses when analyzing tax changes would contribute, in theory, to evaluating legislative proposals, the case is less clear when these projections provide an uncertain or unrealistic picture of expected effects. The Solow model is straightforward and can easily be used to calculate the expected magnitude of feedback effects. Intertemporal models, in particular, have results that are driven by assumptions embedded in the nature of the model, but which appear unrealistic and have no empirical support in some cases.

A Solow Model Estimate of an Illustrative Tax Cut

The Solow model uses labor, capital, and technology to explain economic growth, particularly to explain observable data such as the capital labor ratio.[52] That is, it began as a model that could explain observations, much as the Keynesian IS-LM model was developed to explain the Great Depression. The Solow growth model was easily adapted to examining tax changes by making the labor supply a function of after tax wages and the savings rate a function of the after tax rate of return.

A simple version of this model, presented in the **Appendix**, can be used to illustrate the magnitude of expected feedback effects. Although the model abstracts from specific features of the tax system, it roughly represents current taxes with a 25% income tax. The results suggest that a 20% reduction in marginal tax rates on labor taxes would increase output in the short run by around 0.5% to 1% and revenue feedback effects would be around 3% to 7% (assuming the capital stock is fixed, a fairly reasonable short-run assumption). This estimate uses a labor supply elasticity of 0.1 and 0.2, similar to the elasticities used by JCT and CBO (as discussed subsequently). These feedback effects are relatively minor.

The feedback effects for capital income are somewhat more complex, because it takes a period of time to achieve them. For example, if the capital stock is growing at 3% due to savings, even a 100% increase in investment (either from savings or from capital inflows) would increase the capital stock by only 3%. For growth in the capital stock arising from savings, one simulation showed that by the fifth year (the midpoint of the budget horizon) only 9.6% of the final adjustment in the capital stock had occurred.[53]

To illustrate the possible feedback effects, **Table 1** uses a 0.1 and 0.2 labor supply elasticity along various savings rate elasticities to derive the long-run steady state. The first two savings elasticities are 0.0 and 0.4. A zero savings elasticity is a central tendency from the literature that

[52] Robert M. Solow, (1956), "A Contribution to the Theory of Economic Growth," *Quarterly Journal of Economics*, vol. 70, iss. 1 (The MIT Press, 1956), pp. 65-94.

[53] See Eric Engen, Jane Gravelle, and Kent Smetters, "Dynamic Tax Models: Why They Do the Things They Do," *National Tax Journal*, vol. 50, September 1997, pp. 657-682.

used aggregate time series data to estimate the elasticity; 0.4 is toward the larger positive estimates in that literature.[54] An infinite elasticity is provided to show maximum potential long-run effects (that is, savings must eventually rise or fall to return to the initial after-tax return).

Table 1. Long-Run Revenue Offsets from Supply Side Effects in a Solow Model

(Assumes a 25% Tax Rate on Labor and Capital Income)

	Labor Income Tax	Capital Income Tax	Income Tax
Labor Supply Elasticity: 0.1			
Savings Elasticity			
0.0	4.4%	0.0%	3.3%
0.4	4.4%	14.5%	6.8%
Infinity	4.4%	48.9%	15.6%
Labor Supply Elasticity: 0.2			
Savings Elasticity			
0.0	8.9%	0.0%	4.8%
0.4	8.9%	15.2%	10.5%
Infinity	8.9%	53.3%	20%

Source: See **Appendix**.

Notes: In each case, the effect on total taxes in the economy is considered. Thus, a cut in the labor income tax alone will affect labor income tax revenue and capital income tax revenue.

These longer-run effects are not very different from the short-run effects when the savings supply elasticity is zero. For example, the feedback from a labor income tax cut is 4% to 9% rather than 3% to 7%. Larger savings elasticities can eventually lead to more significant feedback effects, although none is large enough to fully offset the revenue loss.

For budget horizon estimates, a Solow growth model takes a long time to reach the steady state. Effects from labor tax changes in the budget horizon are already close to the long-run steady state. When capital income tax cuts were involved, the effects in the budget horizon tend to be small relative to the long-run steady state (when an effect occurs). In a study of capital income tax cuts with a 0.4 elasticity, on average in the first five years (the mid-point of the budget horizon) only about 10% of the adjustment was complete, and by year 25 only about a third.[55] Strictly speaking, an infinite elasticity would imply immediate adjustment, but such a large change in the savings rate is not plausible, and this is one reason some economists found this type of model to account for savings responses unsatisfactory.

Table 2 shows the output effects for a 20% tax cut, so some idea of the magnitude of output effects might be gained.

[54] See Jane G. Gravelle, *The Economic Effects of Taxing Capital Income* (MIT Press: Cambridge, MA, 1994), p. 27.

[55] Eric Engen, Jane Gravelle, and Kent Smetters, "Dynamic Tax Models: Why They Do the Things They Do," *National Tax Journal*, vol. 50, September 1997, pp. 657-682.

Table 2. Long-Run Output Effects of a 20% Tax Cut in a Solow Model

(Assumes an Initial 25% Tax Rate on Capital and Labor Income)

	Labor Income Tax	Capital Income Tax	Income Tax
Labor Supply Elasticity: 0.1			
Savings Elasticity			
0.0	0.7%	0.0%	0.7%
0.4	0.7%	0.7%	1.4%
Infinity	0.7%	2.4%	3.1%
Labor Supply Elasticity: 0.2			
Savings Elasticity			
0.0	1.3%	0.0%	1.3%
0.4	1.3%	0.8%	2.1%
Infinity	1.3%	2.7%	4.0%

Source: See **Appendix**.

Notes: In each case, the effect on total output in the economy is considered. Thus, a cut in the labor income tax alone will affect both labor and capital inputs. The effects are derived for a small change and evaluated at the midpoint between the old and new rate, 22.5%.

The JCT has found slightly larger effects for rate cuts in its MEG model (controlling for deficit and stimulus effects) with an average feedback effect of 9% to 10% in the first five years.[56] The model is, however, not a pure Solow model, but incorporates an intertemporal substitution elasticity that reflects choices from an infinite horizon model where the representative agent is myopic (i.e., assumes relevant parameters like the interest rate will not change in response to a tax change).

Open Economy Considerations

The Solow model discussed above is a closed economy. The capital stock might change more quickly with an open economy where investment is not constrained by a savings response. The effects would depend on whether the capital income tax is residence based (where the foreign investor is not subject to tax, such as a tax on dividends or interest) or source based (the corporate income tax where the foreign investor is subject to tax). In the latter case, the maximum effect assuming perfectly mobile capital would be the same as the capital stock elasticity at infinity for a small country with perfect product substitution and a source-based tax. However, that extreme case is unlikely to occur, because estimates suggest the investment substitution elasticity is closer to 3.[57] Moreover, the United States is a large country, products are imperfect substitutes, and taxes are a combination of source based and residence based. All of these factors would reduce the effects. One study of a 10 percentage point decrease in the corporate tax rate (a partial cut in

[56] Joint Committee on Taxation, *Macroeconomic Analysis Of Various Proposals To Provide $500 Billion In Tax Relief*, JCX-4-05, March 1, 2005, https://www.jct.gov/publications/2005/jcx-4-05/.

[57] For a review, see Jennifer Gravelle, "Corporate Tax Incidence: Review of General Equilibrium Estimates and Analysis," *National Tax Journal*, vol. 66, March 2013, pp. 185-214. A working paper version is available at http://cbo.gov/sites/default/files/cbofiles/ftpdocs/115xx/doc11519/05-2010-working_paper-corp_tax_incidence-review_of_gen_eq_estimates.pdf.

capital income taxes) suggested an output increase of less than 0.2% for an elasticity of 3. This tax cut was a slightly larger percentage cut than the one in **Table 1** and **Table 2**.[58]

Intertemporal Models

Although the Solow model provided a labor supply response in a way that was consistent with standard theory about consumer choices between consumption and leisure within a time period, many economists were dissatisfied with the treatment of savings responses. A simple savings elasticity cannot be derived from underlying utility functions. Intertemporal models were developed to conform to fundamental economic theory about consumer choice by incorporating a utility function to generate labor and savings supply responses. In these models, consumers choose consumption and leisure over time. Some issues arise about intertemporal models of either type, and some are peculiar to either the Ramsey infinite horizon or life-cycle OLG models.

Some of the initial intertemporal models held labor constant and attempted to study saving in that way. However, modelers also wanted to incorporate labor supply. These models produce results that may be theoretically elegant but are difficult or impossible to support with empirical research, particularly when labor supply can be shifted intertemporally. Moreover, the theoretical requirements of these models require some very strong assumptions about individuals' information. In a typical intertemporal model of either type, individuals have perfect foresight and perfect information (they know how wages and rates of return will change over time for the economy as a whole for an infinite period of time or a very long time). Intertemporal models, however, can be constructed to include uncertainty, as is the case with the CBO or the PennWharton OLG model, which assumes wage shocks and uncertain lifetimes. In this type of model, individuals have precautionary savings, which is less responsive to changes in the rate of return.

It is difficult, if not impossible, to incorporate the various institutional rigidities in the labor and savings markets. Individuals in these models can generally enter and leave the work force without penalty, for example, even though in reality leaving the work force may make re-entry at the same wage more difficult. They can change hours even though for many jobs a fixed workweek, such as a 40-hour week, is the norm. They can borrow and lend without constraints and at the same rate (although some models have introduced borrowing constraints for some agents who cannot borrow). The new JCT model reflects this constraint by allowing only discrete choices of employment (no employment, part time, or full time).

In addition, intertemporal models cannot permit a permanent deficit that leads to unlimited growth in the debt-to-GDP ratio; a way to deal with the deficit must be incorporated in the modeling exercise. Thus, an intertemporal model cannot be used to examine a tax cut or tax increase; it must be a tax cut or increase and something else, such as a spending change or a future change in taxes, or a lump sum payment, each producing a different result. The JCT has, however, developed ways to make this issue relatively unimportant by delaying the fiscal adjustment.[59]

Intertemporal models also presume a certain type of behavior with respect to savings behavior that may not characterize actual behavior. Agents in these models look ahead and base their current savings on all of the future periods in their life (even up to infinity). However, many individuals either cannot or will not behave that way. For example, some individuals are young

[58] See CRS Report R41743, *International Corporate Tax Rate Comparisons and Policy Implications*, by Jane G. Gravelle.

[59] Rachel Moore and Brandon Pecoraro, "Dynamic Scoring: An Assessment of Fiscal Closing Assumptions," *Public Finance Review*, vol. 48, iss. 3 (2020), pp. 340-353.

and have no assets or cannot borrow, and if they would like to consume more than their income at this stage of their life, they cannot, so they save nothing and change consumption only when income goes up. Some individuals do not have enough information or knowledge to operate by some type of "rule-of-thumb," such as saving a fixed dollar amount or a fixed share of income. Others may be at a stage where they want to build a rainy day fund for precautionary purposes, or they may be saving for a target (such as enough to make a down payment on a house). Douglas Elmendorf discusses some of these alternative models of savings.[60] As noted above, the CBO OLG model includes risk and precautionary savings, along with age-related borrowing constraints. Models can also allow individuals to value wealth directly and save for the purpose of accumulating wealth, as is the case in the new JCT OLG model.

There are also issues specific to each type of model. Since individuals do not live an infinite period of time, the infinite horizon, or Ramsey, model version of the intertemporal model appears on its face to be unrealistic. It can be justified only as a depiction of actual individuals' choices rather than as the prescriptive planning model it was originally developed as,[61] if individuals are assumed to take into account the welfare of their descendants (who in turn consider the welfare of their descendants, who in turn consider their descendants, and so forth). In general, there is no marriage in these models, which could have implications for bequests; agents grow through an asexual reproduction process; in addition, there is no allowance for those without children. The long-run elasticity of savings is infinite, so that the after tax return always returns to its original value. It is for this reason that the model is inconsistent with an open economy.

The OLG life-cycle model seems more realistic, although lack of marriage and the presence of childless agents in some models currently used still have potential implications for the savings response (because these may affect intended bequests, which respond to the rate of return). Some models have uncertainty in lifespans that lead to accidental bequests.

The OLG model, at least in some forms, allows those who are retired to return to the labor force without accounting for the unlikelihood of returning to the work force after many years of retirement. This feature appeared in the original Auerbach-Kotlikoff model.[62] Some models, including those of John Diamond, however, have a fixed retirement age.[63] The importance of this

---

[60] Douglas W. Elmendorf, "The Effect of Interest-Rate Changes on Household Saving and Consumption," Federal Reserve Board, June 1996, http://www.federalreserve.gov/pubs/feds/1996/199627/199627pap.pdf.

[61] The Ramsey model was originally a social planning model: a prescriptive rather than descriptive model where treating society as a single infinitely-lived optimizer representing society was appropriate. See Frank P. Ramsey, "A Mathematical Theory of Saving," *Economic Journal*, vol. 3, 1928, pp. 543-559. In a history that is somewhat complicated, it came to be used as an alternative model of both growth and of business cycles. Economists who were dissatisfied with the ad hoc treatment of savings in the Solow model and economists who were dissatisfied with IS-LM type models of business cycles where problems arose through the lack of market clearing prices adapted the Ramsey model as both a descriptive model of growth and a model that could explain business cycles through normal market behavior. Basically, business cycles, in this view, occurred because a shock that caused wages to rise or fall temporarily caused workers to increase or decrease labor supply. In other words, unemployment during business cycles was voluntary rather than involuntary. This development, particularly for business cycles, has been was criticized by many economists. See, for example, Larry Summers "Some Skeptical Observations on the Real Business Cycle Theory," *Federal Reserve Bank of Minneapolis Quarterly Review*, vol. 10, 1986, pp. 23-27, and Robert Solow, "The State of Macroeconomics," *Journal of Economic Perspective*, vol. 22, Winter 2008, pp. 243-249. Short-term macroeconomic forecasting, both government and commercial, remains rooted in IS-LM models with sticky prices and wages, and usually multiple sectors. See CRS Report R42700, *The "Fiscal Cliff": Macroeconomic Consequences of Tax Increases and Spending Cuts*, by Jane G. Gravelle, for a discussion of mainstream estimation.

[62] Alan J. Auerbach and Laurence J. Kotlikoff, *Dynamic Fiscal Policy*, Cambridge University Press, New York, New York, 1987.

[63] See, for example, John Diamond, *The Economic Effects of the Romney Plan*, August 3, 2012, at http://bakerinstitute.org/files/474/; and John Diamond and George Zodrow, *The Dynamic Effects of Eliminating or*
(continued...)

feature varies with the type of tax revision, and the feature can be very important in a reform that replaces income taxes with consumption taxes because the loss in purchasing power of income from retired individuals causes them to return to the labor market to restore income through an income effect.

Some of these aspects can be altered. Researchers have had some success in incorporating uncertainty about earnings into models, which can account for some rainy day saving that responds differently from saving for retirement or bequests. CBO's OLG model and the Penn Wharton Budget Model is of this type, although the magnitude of the effect is not clear.

With consistent parameters that produce the same income and substitution elasticities for labor supply, the effect of a permanent tax cut on wages is similar in Solow and intertemporal models.[64] However, the effect of a change in the tax on capital income is different because it will elicit a labor supply response to a change in the tax rate on savings. The change in the timing and intergenerational distribution of taxes when income taxes are replaced by consumption taxes can also have important effects on labor supply, as noted above.

Are Explicit or Implicit Responses Used in Supply Side Models Consistent With Empirical Evidence?

Even in the same model, projections can differ depending on the parameters or elasticities of the model. Before examining the effects in models, a brief review of the empirical evidence is in order. This evidence includes standard labor supply elasticities (that relate labor supply and savings to permanent wage differences), savings elasticities, intertemporal substitution elasticities, and Frisch elasticities (intertemporal substitution of labor). The first two are relevant to the Solow model, and all enter into or can be derived in intertemporal models.

Standard Labor Supply Elasticities

The elasticities discussed in this subsection are estimates of the labor supply response to a permanent wage change (such as one that would arise from a permanent tax cut or increase). That type of supply response is incorporated in all of the dynamic models with supply side effects. The Frisch intertemporal elasticity discussed below is a different type of elasticity.

As noted earlier, the labor supply response to a change in wage is uncertain in direction because it is the result of a positive elasticity of substitution and a negative elasticity of income.

Curtailing the Home Mortgage Interest Deduction, December 7, 2012, http://bakerinstitute.org/media/files/Research/b93d8df4/TEPP-pub-DiamondZodrowHomeMortgageInterestDeduction-120712.pdf.

[64] The large increase in labor supply in the Joint Tax Committee's study of the Camp tax proposal, which did not indicate a change in effective tax rates on capital income, cannot be explained by the difference in labor substitution elasticities. Overall, the JCT estimated an increase in labor supply in the first five years of 0.3% in the MEG model, but of 1.4% in the OLG model. The substitution elasticities that should govern these effects were 0.2 and 0.24 respectively (as shown below in **Table 3** and **Table 4**). This elasticity difference suggests a 20% increase (0.24/0.2) in labor supply, which would support a supply response of 0.4% increase in labor supply in the MEG model, not 1.4%. A separate study of the Camp proposal co-authored by the model's developer found a labor supply response of 0.5% slightly higher elasticity, 0.28, consistent with the MEG results but not the JCT's OLG results. See John W. Diamond and George R. Zodrow, *Dynamic Macroeconomic Estimates of the Effects of Chairman Camp's 2014 Tax Reform Proposal*, Tax Policy Advisers LLC, prepared for the Business Roundtable, http://businessroundtable.org/sites/default/files/reports/Diamond-Zodrow%20Analysis%20for%20Business%20Roundtable_Final%20for%20Release.pdf. The difference in labor supply was responsible for close to half the difference between the GDP growth of 0.2% in the first five years under MEG and the growth of 1.8% under the OLG model. The remaining difference is from the shifting of intangibles discussed on p. 17.

A large body of evidence suggests the labor supply response to increases in wages is small, varies across workers, and can be negative for men. This small response appears to reflect both income and substitution elasticities that are small, so that even if a tax change substantially lowers marginal relative to average rates (the first affecting substitution and the second affecting income), the response would be small. This evidence includes historical observation, cross section econometric studies, and estimates from experiments.[65] Much of the interest and challenge is estimating responses related to the behavior of married women, where a large fraction of this group does not participate in the labor market. Studies of married women have produced larger, although varying responses. In recent decades, however, as the participation of married women in the labor market has increased, their responses have declined and have become more like those of men.[66]

A recent survey of labor supply responses of men indicated that labor supply was largely inelastic. The mean (average) of the studies was 0.06 and the median was 0.03. The studies indicated substitution elasticity with a mean of 0.31 and a median of 0.13. The income elasticity had a mean of -0.15 and a median of -0.12.[67] A CBO 2012 working paper reviewed research and indicated a substitution elasticity for men from 0.1 to 0.3, with an income elasticity of 0.0 to -0.1. Married women had substitution elasticities from 0.2 to 0.4, with the same income elasticity range. For the work force as a whole, it indicated a substitution elasticity of 0.1 to 0.3.[68]

A point to note about labor supply responses: if labor supply is very responsive in either direction, then it is difficult to explain why labor market participation rates and hours for men have been so constant over a long period of time when both real pre-tax wages and tax rates have been changing.[69] Moreover, it is even more difficult to expect a large positive response when historically the rise in real wages in the latter part of the 19th century and early part of the 20th century has been associated with a reduction in the workweek. (Women have increased their participation, largely during the 1970s and 1980s, but this change may reflect technological advances in household production, declining fertility, and changes in cultural attitudes.)[70]

---

[65] A study of labor supply used cross-country estimates, comparing labor supply in the United States with other countries. This study argued that cross-country differences reflected tax rates. See Edward C. Prescott, "Why Do Americans Work So Much More Than Europeans?," Federal Reserve Bank of Minneapolis, *Quarterly Review*, July 2004, pp. 2-13, http://www.minneapolisfed.org/research/qr/qr2811.pdf. Alberto F. Alesina, Edward L. Glaser, and Bruce Sacerdote, "Work and Leisure in the United States and Europe: Why So Different?" in *NBER Macroeconomics Annual* 2005, ed. Mark Gertler and Kenneth Rogoff, vol. 20 (Cambridge, MA: MIT Press, 2006), pp. 1-64, attribute the cross-national labor supply differences mainly to differences in unionization and labor market regulations.

[66] See CRS Report RL31949, *Issues in Dynamic Revenue Estimating*, by Jane G. Gravelle, for an extensive review of labor supply estimates. See also CRS Report R42111, *Tax Rates and Economic Growth*, by Jane G. Gravelle and Donald J. Marples, for historical charts and updated evidence.

[67] Michael P. Keane, "Labor Supply and Taxes: A Survey," *Journal of Economic Literature*," vol. 6, no. 4 (December 2011), Table 6, p. 1042. The author provided averages for the total labor supply elasticity (Marshallian) and the elasticity of substitution (Hicks); CRS calculated the remaining mean and the medians.

[68] Robert McClelland and Shannon Mok, *A Review of Recent Research on Labor Supply Elasticities*, Working Paper, CBO, October 12, 2012, http://www.cbo.gov/sites/default/files/cbofiles/attachments/10-25-2012-Recent_Research_on_Labor_Supply_Elasticities.pdf.

[69] A problem with an intertemporal model with an infinite horizon is that either a positive or negative labor supply elasticity is incompatible with a balanced growth economy; otherwise, labor would grow to fill all available time, or shrink to virtually nothing. The CBO OLG model, for example, assumes a zero labor supply elasticity (income and substitution effects offset each other), which is compatible with a model where wage rates grow indefinitely. Models that do not have a zero labor supply response have to assume some time dependent change in tastes for leisure versus consumption to be compatible with growth.

[70] See CRS Report R42111, *Tax Rates and Economic Growth*, by Jane G. Gravelle and Donald J. Marples, for data on participation and hours.

Note that while labor supply elasticities are entered directly into Solow type models, they have to be derived in some intertemporal models, given the standard form of the utility function (the mathematical expression that yields the tradeoff between consumption and leisure) and depend on the time endowment.

Savings Elasticities

A much more limited literature on savings elasticities developed during the late 1970s and 1980s. These studies used aggregate data in the economy on savings rates and rates of return to estimate the savings elasticity. The evidence generally showed small, possibly negative savings responses. Although elasticities as large as 0.4 and 0.6 were found, later studies showed these effects were sensitive to minor specification changes.[71] In general, the evidence suggests savings is not responsive to rates of return (a zero elasticity).

The savings response in a life-cycle model depends on the intertemporal substitution elasticity. It is also affected by income effects (i.e., it takes less saving to consume a given amount in the future), which produce a negative effect on savings, and wealth effects (including a reduction in the present value of labor income), as well as other parameters of the model as discussed by Elmendorf.[72] A Ramsey model has an infinite savings elasticity so that savings will increase or decrease to restore the after tax return.

Intertemporal Elasticity of Substitution

Partly because of the growing interest in intertemporal models, researchers began to study intertemporal substitution elasticities rather than the effect of rates of return on saving rates. The intertemporal elasticity of substitution (IES) measures the percentage change in the ratio of consumption in two periods divided by their relative prices. For comparing two adjacent periods, the price in the second period relative to the first is (1/(1+r)) (which is the discount factor for money in the second period, where r is the after tax rate of return). Thus, the percentage change in price is the change in r divided by (1+r). The IES is the primary driver of savings responses that arise from shifting consumption to the future, and contributes to the labor supply effect due to intertemporal shifting of leisure.

Empirical studies have looked at changes in macroeconomic consumption aggregates in some cases and have used individual consumption behavior in others to estimate the elasticity. The pioneering study of intertemporal substitution elasticities was by Robert Hall,[73] who found that the elasticity was extremely small, could be zero, was statistically insignificant and was no more than 0.2. Early surveys of the value led to the use of elasticities of 0.25 to 0.33.[74] Most subsequent studies produced elasticities below 0.5, although some very large ones were estimated.

[71] These studies are reviewed in Jane G. Gravelle, *The Economic Effects of Taxing Capital Income* (Cambridge, MA, MIT Press, 1994), p. 27. The most recent study was Jonathan Skinner and Daniel Feenberg, "The Impact of the 1986 Tax Reform on Personal Saving," in *Do Taxes Matter? The Impact of the Tax Reform Act of 1986*, Ed. Joel Slemrod (Cambridge MA: The MIT Press, 1990).

[72] See Douglas W. Elmendorf, *The Effect of Interest-Rate Changes on Household Saving and Consumption: A Survey*, Federal Reserve Board, July 1997, https://www.federalreserve.gov/econres/feds/the-effect-of-interest-rate-changes-on-household-saving-and-consumption-a-survey.htm.

[73] Robert E. Hall, R.E., "Intertemporal Substitution in Consumption," *Journal of Political Economy*, vol. 96, no. 2, April 1988, pp. 339-357.

[74] Auerbach and Kotlikoff report the results of nine different studies that ranged in value from less than 0.1 to more than 1. The median value was around 0.3 and a weighted average of eight of them using the mid-point of each range (continued...)

Professors at Prague's Charles University prepared a 2013 meta-analysis (i.e., a large analysis that combines data from many studies) of estimates of the IES across many countries found an overall elasticity of 0.5 for the world on average and 0.6 for the United States.[75] About half the 169 studies were based on U.S. data. The authors cautioned that the cross-country estimates were too large in value because of publication bias. Publication bias is a problem widely recognized in many fields. Basically, if theory indicates an elasticity should be positive, and the estimate is negative, peer reviewers are less likely to recommend publication, editors are less likely to publish, and researchers, expecting the unlikelihood of publishing, tend not to submit their articles (which often involve a fee) or even prepare a working paper. Yet, when a large number of estimates have been made, because of the fundamental theory of statistical estimation, some would be negative (particularly if the true value is low). Publication bias also suggests that estimates of the income and substitution elasticities are probably too large in absolute value.

Havraneka, one of the co-authors of this meta-analysis, subsequently published the basic (worldwide) results after correcting for estimated publication bias.[76] The correction indicates that the elasticity for macro aggregate studies is zero (as Hall originally found). In the basic case (without selecting across studies for other characteristics), the elasticity for micro studies (which were about a quarter of the studies) was 0.2. He also reported that the elasticity for micro studies of asset holders was 0.36. His preferred estimate with various other characteristics selected was 0.33 for asset holders. In general, an IES for asset holders would be appropriate only if the model identified a separate group of liquidity-constrained consumers. For a model without that feature, the elasticity for asset holders would be too high. If the macro elasticities were considered as well as micro, then an IES of zero to 0.2 might be in order.

In addition, note that publication bias may also affect other types of estimates discussed in this section, including the estimates of standard labor substitution elasticities already reviewed, because they included only estimates in the direction expected by theory.

There are two caveats about the empirical evidence on the IES for consumption. The first is that the estimates have considered periods that are close together, but the elasticity in models is applied over many periods of time and is determined by a utility function that assumes a constant elasticity of substitution. Most of the effect on savings from a change in the tax rate on capital income arises from reducing current consumption to shift it to these periods further into the future. Therefore, applying these effects in intertemporal models assumes that individuals make the same sort of calculations into the future. One reason, for example, that individuals may be reluctant to shift consumption farther in the future is that they may not be as certain to be alive. In addition, they may not have the information or cognitive skills to make choices about consumption far into the future, and there is evidence that most individuals have much shorter

---

(and excluding a study by Mankiw, Rotemberg and Summers in which it is clear the authors were not very satisfied with the model) yielded an estimate of 0.39. See Alan J. Auerbach and Laurence J. Kotlikoff, *Dynamic Fiscal Policy*, Cambridge University Press, New York, New York, 1987. They adopt a value of 0.25. Elmendorf undertakes a survey of the studies most commonly cited and obtains a weighted average of 0.37; he uses 0.33 in his work. See Douglas W. Elmendorf, "The Effect of Interest-Rate Changes on Household Saving and Consumption," Federal Reserve Board, June 1996, http://www.federalreserve.gov/pubs/feds/1996/199627/199627pap.pdf.

[75] C Tomas Havraneka, Roman Horvathb, Zuzana Irsovab, and Marek Rusnaka, "Cross-Country Heterogeneity in Intertemporal Substitution," Institute of Economic Studies, Faculty of Social Sciences, Charles University in Prague, http://ies.fsv.cuni.cz/sci/publication/show/id/4868/lang/cs. A meta-analysis does not simply average results of studies but weights them according to the number of observations and sometimes by confidence intervals.

[76] Tomas Havranek, "Intertemporal Substitution: The Importance of Method Choices and Selective Reporting," *Journal of the European Economic Association*, vol. 13(6), pp. 1180-1204.

planning horizons.[77] Uncertainty about life span may also lead to a buffer stock of savings, or target savings, which is not sensitive to the substitution effect. Some life-cycle models incorporate this type of savings.

The second, and perhaps more important, concern for effects in the budget horizon, is that due to the nature of the utility function, leisure also responds to changes in the rate of return, which then generates a significant short-run labor supply response. No empirical evidence supports this response, which can dominate the effects when taxes on capital income are cut deeply.[78] Ballard, a discussant of the JCT intertemporal model simulations, stated, "any simulation model that generates a large elasticity of labor supply with respect to the interest rate is shooting in the dark."[79] Ballard believes that the controlling of the response of labor supply to interest rates is crucial to modeling and that this can be achieved, in part, via the time endowment (limiting the available supply of leisure).

Frisch (Intertemporal Labor Substitution Elasticity with Respect to Wages)

The Frisch elasticity, which estimates the response of workers to changes in the wage rate over time, is not likely to be of importance in an analysis of a permanent tax change.[80] It is, however, an estimated parameter that can be compared with the implied elasticities in the intertemporal models. As is the case with standard labor supply estimates, it is calculated from other parameters in intertemporal models.

There are two types of estimates. Some are from micro data studies that examine individual behavior over time. These elasticities tend to be small, on the whole, at least for men. The other estimates are from aggregate micro data, which tend to be large, usually above 1 or 2. These macroeconomic estimates are largely based on variations in hours and wages over the business cycle. They rest on the assumption that unemployment during recessions is voluntary, whereas most models of business cycles consider workers who lose their jobs or have their hours reduced are largely involuntarily unemployed or underemployed.[81] Assuming some or most of unemployment is involuntary, these estimates overstate the Frisch elasticity.

The micro data studies largely concentrate on the response of hours of work and examine the response with profiles of wages and hours over time. Both show an inverted U shape, with fewer hours when young and when old, and lower wages when young and old, respectively, but the shapes are quite different, which leads to lower elasticities.[82]

---

[77] Fisher and Montalto also report that 34% of individuals had a planning horizon of a year or less and 85% less than 10 years. See Patti J. Fisher and Catherine P. Montalto, 2010, "Effect of Saving Motives and Horizon on Saving Behaviors," Journal of Economic Psychology, vol. 31, no. 1 (2010), pp. 92-105.

[78] In simulations of intertemporal models where a consumption tax was substituted for an income tax in a revenue neutral change and the wage tax actually increased, labor supply increased by significant amounts throughout the first 10 years and dominated the change in output. See Eric Engen, Jane Gravelle, and Kent Smetters, "Dynamic Tax Models: Why They Do the Things They Do," *National Tax Journal*, vol. 50, September 1997, pp. 657-682.

[79] Comment by Charles Ballard, Joint Committee On Taxation, *Tax Modeling Project And 1997 Tax Symposium Papers*, Joint Committee Print, November 20, 1997, posted on the JCT website at https://www.jct.gov/publications.html?func=startdown&id=2940.

[80] An exception would be where a tax cut today is offset by a tax cut in the future as a way of dealing with the requirement that deficits must be offset in intertemporal models.

[81] See CRS Report R42700, *The "Fiscal Cliff": Macroeconomic Consequences of Tax Increases and Spending Cuts*, by Jane G. Gravelle, for a further discussion of differences in macroeconomic models.

[82] Numerous studies have criticized either smaller or larger Frisch elasticities on various grounds. For example, Keane and Rogers argue that the low elasticities in micro studies for men could be higher if human capital formation were (continued...)

Turning to the microeconomic data, Keane also surveyed the Frisch elasticity studies for men for hours of work. He lists 13 studies with a mean elasticity of 0.85. The estimate, however, was greatly influenced by one outlier (of 6.25); with that study excluded, the mean was 0.4. The median value was 0.31, although six of the studies had values clustered between 0.03 and 0.17, whereas the others varied substantially. CBO researchers recently examined the Frisch estimates.[83] They relied on microeconomic evidence. As discussed in their paper, the few studies of Frisch elasticities for married women tend to be higher than those of married men. The elasticity estimates for women also appear to be declining, consistent with other work that shows married women's labor supply response is becoming more like that of married men. The paper also reviews labor force participation elasticities, where studies have been focused on those close to retirement. Overall, the authors suggest a range of the Frisch elasticity from 0.27 to 0.53, with a central estimate of 0.4. Neither of these studies reference Ball, who found a zero Frisch elasticity.[84] For Keane's summary, including this study would reduce the mean to 0.34 and the median to 0.17.

Elminegad, Havrenek and Horvath perform a meta-analysis of 36 studies, both macro and micro, and find an elasticity from all studies of 0.5. However, but when they correct for publication bias and identification issues, the elasticity is zero (with publication bias and identification each accounting for about half the reduction) [85] Identification bias occurs when there is not enough exogenous variation. Just accounting for publication bias, the value should be 0.25. A recent study of a Swiss tax holiday by Martinez, Saez, and Siegenthaler (2021) has a strong identifier, as the holiday years varied by canton.[86] The authors found no response for participation in the labor market or for hours of work for wage earners, and a small response (elasticity of 0.2) for self-employment earnings, which could be partially due to evasion. This quasi-experimental study provides evidence of a virtually nonexistent elasticity.

A Note on Time Endowments

One of the most important, and yet often largely overlooked, parameters that affect the labor supply response in intertemporal models used to analyze taxes is the time endowment.[87] Because

---

considered, although responses to transitory effects would be smaller than the response to permanent changes in the wage profile. See Michael Keane and Richard Rogerson, "Micro and Macro Labor Supply Elasticities: An Assessment of Conventional Wisdom," *Journal of Economic Literature*, vol. 50, no. 2 (June 2012), pp. 464-476. Card, however, questions even the small elasticities. He provides diagrams showing wage patterns of those with elementary, high school and college educations. They show very different patterns of wage growth (i.e., wages of college graduates tend to rise initially and for some extended period of time, whereas wages of those with elementary education change very little). These groups have very similar lifetime working profiles. This evidence suggests that there is little relationship between wages and work effort; rather men begin working when they finish schooling and reduce hours slightly when they get older. David Card, "Intertemporal Labor Supply: An Assessment," in Christopher Sims, (ed.), *Advances in Econometrics*, Sixth World Congress, New York, Cambridge University Press, 1994.

[83] Felix Reichling and Charles Whalen, Review of Estimates of the Frisch Elasticity of Labor Supply, Working Paper 2012-13. October 2012, http://www.cbo.gov/sites/default/files/cbofiles/attachments/10-25-2012-Frisch_Elasticity_of_Labor_Supply.pdf.

[84] Laurence Ball, "Intertemporal Substitution and Constraints on Labor Supply: Evidence from Panel Data," *Economic Inquiry*, vol. 8, no. 4 (October 1990), pp. 706-724.

[85] Ali Elminejad, Toms Havrenek, and Roman Horvath, *Publication and Identification Biases in Measuring the Intertemporal Subsitution of Labor Supply*, ZBW, Leibnix Information Centre for Economics, Kiel Hamburg, April 9, 2021, https://www.econstor.eu/bitstream/10419/232534/1/Frisch.pdf.

[86] Isabel Z. Martinez, Emmanuel Saez, and Michael Siegenthaler, "Intertemporal Labor Supply Substitution? Evidence from the Swiss Income Tax Holidays," *American Economic Review*, vol. 111, no. 2 (2021), pp. 506-546,

[87] This time endowment is effectively set by setting the shares of leisure and consumption in the utility function. Since consumption and labor are known, this parameter sets the amount of leisure and the total time endowment.

choices are made with a utility function where individuals choose leisure and consumption, leisure demand has to be translated into labor supply, and the correspondence between those two drives the relationship.[88] A larger time endowment, which allows a larger amount of leisure, causes all of the labor supply elasticities to be larger.

If this measure is set independently, there are no obvious guides to how big it should be. A 40-hour workweek is 24% of the total hours in a week, and the leisure share is 76%. There is, however, a biological need to sleep. If a 40-hour workweek is assumed, and 8 hours per day are assigned to sleep, the share of leisure would be 64%. However, workers may have an embedded lunch hour, and spend some necessary time commuting (which is like working, in that it provides benefits such as lower housing prices), household activities, and care of family members. The American Time Use Survey indicates that the ratio of leisure to the sum of leisure and work is 43% for men aged 35 to 44 and 47% for women in the same age range. These numbers tend to be relatively steady throughout the primary working age of 25 to 54 for both groups.[89] On average, men between the ages of 35 and 44 work 42 hours a week and women work 29 hours (reflecting some of those who are not in the work force). Women, however, spend much more time than men on housework and care of family members.

Another way of considering this issue is that if it were assumed that the ratio of a leisure to hours available for a full-time worker is 0.5, then that person would be effectively able to hold two jobs (work 80 hours a week), which would imply 10- to 12-hour work days every day. Assuming up to another half time job could be taken, then a ratio of 0.33 would be appropriate.

The first study by Auerbach and Kotlikoff set the time endowment at 5,000 hours a year, which would lead to a leisure share of time at 0.6, assuming working for 40 hours for 50 weeks (2,000 hours).[90] In a 1993 study, Fullerton and Rogers set the time endowment at 4,000 hours, which would suggest a share of 0.5.[91] According to current data, average hours are 42.5 for those who usually work full time and 38.5 for all workers.[92] Neither study had a discussion of the basis for its choice. Current or recently used models range from a 0.3 to a 0.6 ratio of leisure to hours available.

Comparing Empirical Estimates to Estimates in the Models

This section examines the estimates used in the models. To summarize the review, the evidence suggests that

- the labor income elasticity is between 0.0 and minus 0.1,
- the substitution elasticity between 0.0 and 0.3,
- total labor supply elasticity less than 0.3,
- the savings rate elasticity around zero but no more than 0.4 if positive,

[88] Some models enter labor as part of a negative additive utility and there is no time endowment issue, but that is not the case with the models in **Table 4**.

[89] U.S. Department of Labor, American Time Use Survey, Table 3, http://www.bls.gov/news.release/atus.t03.htm.

[90] Alan J. Auerbach and Laurence J. Kotlikoff, *Dynamic Fiscal Policy*, Cambridge University Press, New York, New York, 1987.

[91] Don Fullerton and Diane Lim Rogers, *Who Bears the Lifetime Tax Burden*, Washington, DC, The Brookings Institution, 1993.

[92] U.S. Department of Labor, Household Data, Annual Averages, Table 19. Persons at Work in Agriculture and Non-Agriculture Industries by Hours of Work, 2012.

- the intertemporal substitution elasticity should be 0.2 or less, and
- the Frisch elasticity close to zero.

Note that except for the intertemporal substitution elasticity, none of these estimates were adjusted for publication bias, and thus would probably be smaller in absolute value.

Table 3 shows the values in the Solow models. The labor income and substitution elasticities in all four of the models that report separate values are consistent with the empirical estimates noted above. The Treasury study is low on the elasticities for labor income and substitution effects; it is also toward the high end on the savings elasticity. All of these estimates are close to the ranges suggested above for labor supply, but the Tax Foundation has a large savings response (an infinite savings elasticity means that the after tax return to its prior value). Note, however, that even a limited difference can have an impact, so that a change that cut marginal and average rates, the same amount would have twice the effect in the CBO model as in the JCT model. Note also that the JCT model is not a pure Solow model, but rather has an intertemporal model of consumption over time.

Table 3. Supply Elasticities in Solow Models

Elasticity	Joint Committee on Taxation (JCT)	Congressional Budget Office (CBO)	Treasury	Urban Brookings Tax Policy Center	Tax Foundation
Labor Income	-0.10	-0.05	0.00	-0.05	NA
Labor Substitution	0.20	0.24	0.00	0.24	NA
Total Labor	0.10	0.19	0.00	0.19	0.3
Savings	NA	0.20	0.40	0.20	Infinity (Long Run)

Sources: Joint Committee on Taxation, "Overview of Joint Economic Committee Modeling, JCX 33-18," April 23, 2018, https://www.jct.gov/publications/2018/jcx-33-18/; Congressional Budget Office, "How CBO Analyzes the Effects of Changes in Federal Fiscal Policies on the Economy," November 2014, https://www.cbo.gov/sites/default/files/113th-congress-2013-2014/reports/49494-FiscalPolicies.pdf, and "The 2013 Long Term Budget Outlook," September 2013, p. 82, http://www.cbo.gov/sites/default/files/cbofiles/attachments/44521-LTBO2013_0.pdf; Robert Carroll, John Diamond, Craig Johnson, and James Makie III, "A Summary of the Dynamic Analysis of the Tax Reform Options Prepared for the President's Advisory Panel on Federal Tax Reform," U.S. Department of the Treasury, Office of Tax Analysis, May 25, 2006, prepared for the American Enterprise Institute Conference on Tax Reform and Dynamic Analysis, May 2006; Benjamin R. Page and Kent Smetters, "Tax Policy Center, Dynamic Analysis of Tax Plans," Tax Policy Center, April 5, 2017, https://www.urban.org/sites/default/files/publication/89456/2001217-dynamic-analysis-of-tax-plans-an-update.pdf; and Stephen J. Entin, Huaqun Li, and Kyle Pomerleau, "Overview of the Tax Foundation's General Equilibrium Model," April 2018, https://files.taxfoundation.org/20180419195810/TaxFoundaton_General-Equilibrium-Model-Overview1.pdf?_gl=1.

Notes: The JCT model uses a savings response consistent with that in a myopic Ramsey mode with an IES of 0.35; previously, it used an estimate of 0.25 and indicated that the long-run elasticity is 0.29. Presumably, the adjustment is more rapid than in a standard Solow model. JCT, previously, and CBO also provide sensitivity analysis with labor supply elasticities. Their life-cycle elasticity appears to be slightly higher than that suggested in the meta-analysis.

As the table shows, there is no savings elasticity as such in the JCT model because savings is generated from intertemporal consumption, which in that respect is similar to an intertemporal elasticity of substitution. JCT's value of 0.35 is slightly higher than the central tendency of the evidence.

Some elasticities in the intertemporal model must be derived. The parameters that are directly entered into a model that has a utility function composed of leisure and consumption are the intertemporal elasticity of substitution (over time), the intratemporal substitution between leisure and consumption, and leisure as a share of time (which is set by the value of coefficients on leisure and consumption in the utility function).

In three models referenced in this report—the JCT's DSGE, the new in-house JCT OLG model, and the OG-USA model—labor is entered separately in the utility function so that there is no intratemporal substitution elasticity. The JCT DSGE model is an infinite horizon model and the OG-USA model is an overlapping generations model. According to the last JCT study, the Frisch elasticity is 0.2, which means that the labor income and substitution elasticity is -0.2 and 0.2, and the intertemporal substitution elasticity with respect to wages is less than 0.2 because 48% of agents do not respond to the interest rate. The intertemporal substitution elasticity with respect to consumption is 0.47, but is smaller because of the share of workers that are non-savers.[93] The OG-USA model has an intertemporal substitution of elasticity for consumption of 0.33, and while leisure is an additive in the utility function, the Frisch elasticity depends on the share of the labor in the time endowment. They report a Frisch elasticity of 0.41, which is consistent with a labor share of about 60% of the time endowment.[94] The new OLG model has an intertemporal substitution elasticity of one for a combination of consumption and housing, which is considerably larger than estimates from the literature and larger than those in other models. However, it also includes wealth in the utility function, which lowers the savings response because an increase in the rate of return means a growth in wealth that reduces saving via an income effect. The labor supply elasticity cannot be defined numerically, as labor is provided in discrete choices (full time employment, part time employment, and no employment). However, the labor supply elasticity appears to be small.[95]

In the remaining models (including the prior JCT OLG model), to convert leisure demand into labor supply, the substitution elasticity and income elasticity for leisure (which is one because of the nature of the utility function) must be multiplied by the ratio of leisure to hours available (assuming there is no other nonlabor income).[96] The Frisch elasticity is the ratio of leisure to labor, multiplied by a weighted average of the intertemporal and the intratemporal substitution elasticities (with the weights the shares of leisure and consumption). The other intertemporal elasticity of labor supply (i.e., the change in labor as the relative price of future consumption changes through changes in the rate of return) is the ratio of leisure to labor, multiplied by the intertemporal substitution elasticity.

Table 4 reports both these direct and derived elasticities for the prior JCT, CBO, and Treasury models, along with assumptions in the EY Quest, the Diamond-Zodrow OLG model, and the Penn Wharton Budget Model. Note that only one model in **Table 4** is a Ramsey model (the

[93] JCT, *Macroeconomic Analysis Of H.R. 6760, The "Protecting Family And Small Business Tax Cuts Act Of 2018" As Reported By The Committee On Ways And Means*, JCX-79-18, September 26, 2018, https://www.jct.gov/publications/2018/jcx-79-18/.

[94] Jason DeBacker, Richard W. Evans, and Kerk L. Phillips, "Integrating Microsimulation Models of Tax Policy into a DGE Macroeconomic Model," *Public Finance Review*, vol. 47, no. 2 (2019), pp. 207-275.

[95] For a detailed description of the general model, see Rachel Moore and Brandon Pecoraro, "Macroeconomic Implications of Modeling the Internal Revenue Code in a Heterogeneous-Agent Framework," *Economic Modelling*, vol. 87 (May 2020), pp. 72-91. This version of the model is slightly different from the one in use by the JCT, as the JCT model has wealth in the utility function.

[96] The values change slightly with income used for consumption, which raises the substitution elasticity and lowers the income elasticity. For example, the JCT implied elasticity would be 0.17 if 25% of consumption came from other sources and the incomes elasticity would be 0.27 rather than 0.30. See CRS Report RL31949, *Issues in Dynamic Revenue Estimating*, by Jane G. Gravelle, for the conversion formulas.

Treasury model), although it has a utility function similar to the OLG models.[97] Also note that two of the models, CBO and Penn Wharton, have uncertainty, which tends to lead to precautionary savings and a smaller effect of the rate of return on savings. Penn Wharton also reports that the savings elasticity is 0.5 (although it allows users to set their own targets).

All of the intertemporal elasticities are large compared with the empirical evidence. As indicated in **Table 4**, in contrast to the Solow models, the implied labor substitution elasticities are higher than those empirically estimated in the CBO, the Treasury Ramsey model, and the Penn Wharton model. A part of the reason for this high elasticity is the large leisure share of time, although they also tend to have larger substitution elasticities. All of the income elasticities are too large in absolute value and all of the models, except CBO and the Penn Wharton model, have a backward bending labor supply (in contrast to the Solow models). The largest absolute values are in the Treasury Ramsey and Penn Wharton models, with the lowest in the prior JCT, EY, and Diamond models. Since the form of the utility function forces the income elasticity of demand for leisure to be one, these values are driven by the leisure share of time. Compared with empirical estimates, the Frisch elasticity is too high in almost all the models, but is particularly high in the Penn Wharton and Treasury Ramsey models. Finally, the last elasticity, the intertemporal labor supply, response to the interest rate should probably be close to zero because there is no evidence supporting any response. They are largest in the Penn-Wharton and Treasury models.

Table 4. Elasticities and Parameters in Intertemporal Models

Parameter or Elasticity	JCT, OLG (Prior Model)	CBO, OLG	Treasury Ramsey Model	Treasury OLG Model	EY Quest Study of The Tax Cuts and Jobs Act OLG	Diamond Study of Inflation Reduction Act OLG	Penn Wharton Budget Model OLG
Intertemporal Substitution Elasticity	0.40	0.33	0.25	0.35	0.40	0.50	0.625
Intratemporal Substitution Elasticity	0.60	1.00	0.80	0.60	0.60	0.80	1.00
Leisure Share	0.40	0.39	0.60	0.50	0.0	0.30	0.54
Implied Labor Substitution Elasticity	0.24	0.39	0.48	0.30	0.24	0.24	0.54
Implied Labor Income Elasticity	-0.40	-0.39	-0.60	-0.5	-0.40	-0.30	-0.54
Implied Frisch (Intertemporal Labor Supply With Respect to Wages Holding Interest Rates Constant)	0.35	0.50	0.71	0.48	0.35	0.30	0.97

[97] As discussed in the working paper, parameters of the CBO Ramsey model suggest its principal difference from the CBO OLG model was assuming a leisure share of hours of 0.5, rather than 0.4, which increases the elasticities. See Maria I. Marika Santoro, *The CBO Infinite-Horizon Model with Idiosyncratic Uncertainty and Borrowing Constraints*, Working Paper 2009-3, October 2009, http://www.cbo.gov/sites/default/files/cbofiles/ftpdocs/106xx/doc10683/2009-03.pdf.

Parameter or Elasticity	JCT, OLG (Prior Model)	CBO, OLG	Treasury Ramsey Model	Treasury OLG Model	EY Quest Study of The Tax Cuts and Jobs Act OLG	Diamond Study of Inflation Reduction Act OLG	Penn Wharton Budget Model OLG
Implied Intertemporal Labor Supply Elasticity With Respect to Prices Holding Wage Rate Constant	0.27	0.21	0.38	0.35	0.27	0.253	0.73

Sources: The JCT prior OLG model was used to estimate the effect of the Tax Cuts and Jobs Act of 2017. The Joint Committee reported increased elasticities for the OLG model in its analysis. Macroeconomic Analysis of the "Tax Reform Act of 2014," JCX-22-14, February 26, 2014, https://www.jct.gov/publications.html?func=startdown&id=4564. Formerly the elasticities (in order as listed in **Table 4**) were 0.25, 0.50, 0.30, 0.15, -0.30, 0.18, and 0.11. See Macroeconomic Analysis Of Various Proposals To Provide $500 Billion In Tax Relief, JCX-4-05, March 01, 2005, at https://www.jct.gov/publications.html?func=startdown&id=1189; Shinichi Nishiyama and Felix Reichling, "The Costs to Different Generations of Policies That Close the Fiscal Gap," Congressional Budget Office, Working Paper 2015-10, December 2015, at https://www.cbo.gov/publication/51097. For Treasury studies, see Robert Carroll, John Diamond, Craig Johnson, and James Mackie III, "A Summary of the Dynamic Analysis of the Tax Reform Options Prepared for the President's Advisory Panel on Federal Tax Reform," U.S. Department of the Treasury, Office of Tax Analysis, May 25, 2006, prepared for the American Enterprise Institute Conference on Tax Reform and Dynamic Analysis, May 2006. EY Quest model is from Brandon Pizzola, Robert Carroll, and James Mackie, "Analyzing the macroeconomic impacts of the Tax Cuts and Jobs Act on the US economy and key industries," https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/growth/growth-pdfs/ey-tax-reform-projected-to-grow-us-economy.pdf The academic studies are from John Diamond and the Penn Wharton Budget Model. The estimates are based on the latest application by John Diamond, "Macroeconomic Effects of the Inflation Reduction Act," August 4, 2022, https://www.bakerinstitute.org/research/macroeconomic-effects-inflation-reduction-act. Also reported are estimates for the Camp plan. The estimates for the Penn Wharton Model were provided to the author. Formulas for converting the first three parameters in supply elasticities are in CRS Report RL31949, *Issues in Dynamic Revenue Estimating*, by Jane Gravelle, 2007, Appendix C, https://www.everycrsreport.com/files/20070426_RL31949_788e1e67fd8aaa2e827bd090f203b1616d4eb84c.pdf. Note that some of the information used to obtain estimates was provided directly by the authors and does not appear in the publications. This table does not include the Global-Gaidar model (see Seth G. Benzell, Laurence J. Kotlikoff, Guillermo LaGarda & Victor Yifan Ye, "Simulating Business Cash Flow Taxation," NBER Working Paper 23675, August 2017, https://www.nber.org/papers/w236750), where economic effects are dominated by international capital flows, but the intertemporal and intratemporal substitution elasticity is 0.25 and 0.4, respectively. No leisure share is reported, but the original Auerbach Kotlikoff model had a leisure share of 0.6. If so, elasticities in rows 4-6 would be 0.24, 0.4, and 0.47.

Notes: Implied labor substitution and income elasticities are calculated assuming only wage income. If capital income exists, the substitution elasticity elasticities would be higher. The labor substitution elasticity is the share of leisure times the substitution elasticity; the labor income elasticity is the share of leisure times -1; The Frisch elasticity is the ratio of leisure to labor times a weighted average of the share of leisure times the intertemporal elasticity and the share of labor times the intratemporal elasticity; and the elasticity of labor with respect to the interest rate is leisure divided by labor times the intertemporal elasticity, assuming the interest rate and the savings rate are equal. The last measure would be multiplied by the interest rate over the saving rate if they are different.

Is it possible to make choices that would lead to better elasticities? It would require using the time endowment as a tool to fit the model to evidence, as suggested by Ballard. For example, set the intertemporal elasticity at 0.2, consistent with the evidence. Set the intratemporal substitution elasticity at 1.5 and the leisure share of hours at 0.15. Then the labor substitution elasticity would be 0.225, the income elasticity would be -0.15, and there would be a slight positive elasticity of total labor supply. The Frisch elasticity would be 0.23 (using labor and leisure shares as proxies for shares of consumption and leisure), at the low end, but reasonable considering publication bias, and the elasticity of labor with response to price change would be 0.026, small enough not to be very troubling.

Note that the CBO and Penn Wharton models are models with uncertainty. As noted above, generally, uncertainty should lead to precautionary savings that is not sensitive to the interest rate, and a lower savings response.[98]

Conclusion: Are Intertemporal Models Helpful or Harmful In Determining Feedback Effects?

Economists were attracted to intertemporal models because they were dissatisfied with the ad hoc treatment of savings in Solow models. However, intertemporal models are far less transparent, and modelers appear in some cases to make little attempt to connect the elasticities associated with labor supply to the ones found in empirical evidence. The JCT model used in the past has come close but,[99] as illustrated, it is possible to come even closer to matching the empirical evidence, while at the same time minimizing "shooting in the dark" with a labor supply response to the interest rate. JCT also incorporates life-cycle elements in its MEG model that do not involve labor supply responses to rates of return. Nevertheless, the assumption of equal substitution elasticities between consumption across far apart periods means that these models still rest on unproven, and probably unreasonable assumptions about the elasticity of substitution between consumption amounts that are 10 or 20 years apart. There is a question of whether intertemporal models do more harm than good, at least with respect to the feedback effects during the budget horizon, especially when parameter choices may induce a large labor supply response to the rate of return.

Intertemporal modelers presenting the background on their models sometimes report the first two values in **Table 4** but no measure of the leisure share of time, which makes it impossible to evaluate on the basis of their published work.[100] Sometimes even the minimal information on elasticities is not provided. (JCT and CBO report all their relevant assumptions.) Without the parameters to understand the models (and particularly without information on the time endowment), these models become impossible to evaluate or compare.

---

[98] Engen, Gravelle, and Smetters included a comparison of a myopic OLG model with fixed labor with and without uncertainty. Introducing uncertainty reduced the effects by more than half. However, that may not be similar with endogenous labor. See Eric Engen, Jane Gravelle, and Kent Smetters, "Dynamic Tax Models: Why They Do the Things They Do," *National Tax Journal*, vol. 50, September 1997, pp. 657-682.

[99] **Table 4**'s notes summarize these estimates.

[100] Even accomplished modelers Diamond and Zodrow do not always report this value. See John W. Diamond and George R. Zodrow "Promoting Growth, Maintaining Progressivity, and Dealing with the Fiscal Crisis: CGE Simulations of a Temporary VAT Used for Debt Reduction," *Public Finance Review*, vol. 41, no. 6, November 2013, pp. 852-884. They chose a value of 0.4 for the IES and 0.8 for the intratemporal substitution elasticity.

Appendix. A Simple Model of Feedback Effects

Consider a model that incorporates a labor supply based on an estimated elasticity of E. In that case, with L as labor, W as wages, and t as the tax rate on wages (denoting a "d" as a change, so that dL is a small change in L and dL/L is a percentage change in L), the labor supply can be defined as

(1) $dL/L = E(dW/W - dt/(1-t))$

This model assumes that E is positive, so labor rises with an increase in W and falls with an increase in t. Also note that the response is not to a percentage change in t, but to a percentage change in the after tax share, (1-t).

With this information, a simple revenue feedback effect can be estimated. Revenue from the tax is tWL and the change in revenue is

(2) $d(tWL) = dt(WL) + tW(dL)$

Holding wages constant (this assumption will subsequently be relaxed), and substituting from (1) into (2), the ratio of the second term in (2) to the first (the feedback effect) is

(3) $(tWdL)/((dt)WL) = -Et/(1-t)$

Assuming a tax rate of 25% and a labor supply elasticity of 0.1 to 0.2, the feedback effect ranges from 3.3% to 6.6%. The feedback effect is larger the larger the initial tax and the larger the elasticity.

A decrease in labor supply looking at only the labor market would be expected to raise wages, which would affect the wage base and also have a feedback effect on labor. The rise in wages and the contraction in labor would also increase the rate of return to capital. This in turn could cause an increase in the capital stock (either from savings or from capital flows from abroad). To address these effects in the short run, the model would also require a production function that shows how labor and capital can be combined.

Every model has a "numeraire" or a fixed value since economic effects depend on relative, rather than absolute, values. A sensible numeraire for this model is the overall price level, P. Changes in prices are a weighted average of the wage and rate of return depending on their share of income. Setting the share of capital income as a, and denoting the rate of return as R and the capital stock as K (to keep the model simple, depreciation is not included and income shares reflect net product):

(4) $dP/P = a(dR/R) + (1-a)\, dW/W = 0$

Finally consider a common production function (a Cobb Douglas) that has the characteristic that income shares are fixed, so that a is a constant and

(5) $RK/WL = a/(1-a)$

When this equation is differentiated to convert it into percentage changes;

(6) $dR/R + dK/K - dW/W - dL/L = 0$

If K is constant, substitute from (4) to eliminate dR/R. From equation (1)

(7) $(td(WL))/(dtWL) = [E(1-a)t]/[(1-t)(1+aE)]$

The feedback response from the labor tax, assuming a is 0.25, is smaller. Rather than 3.3% to 6.6%, it is 2.4% to 4.8%.

If capital income is also subject to tax, then the effects of the rise in R needs to also be calculated and taken into account. If taxed at the same rate, the result is [Eat]/[(1-t)(1+aE)], which is 0.8% to 1.6%. Adding both responses = [Et]/[(1-t)(1+aE)]. As this example indicates, with an across the board tax the feedback effects are not much different incorporating these general equilibrium effects (3.2% and 6.4% rather than 3.3% and 6.6%).

These results can also be used to show increases in output. In the case where the capital stock is fixed, the percentage change in labor for a given percentage change in the after tax share is the same as the feedback effect in (3) but since labor is only a part of output, it would be multiplied by the output share (0.75). The result is the same as the ratio in (7). Thus a 20% decrease in the tax rate would increase output, with an elasticity of 0.1, by 2.4% times 0.2, or 0.5%. For the 0.2 elasticity, the result would be 1%.

The previous short run model had a fixed capital stock and three variables, the rate of return R, the wage rate W and the labor supply, L. A Solow growth model allows (if it is a closed economy) growth over time in capital and feedback effects. In the long run, that permits a change in capital. Capital can grow not only because of a change in savings rate but also because increased labor income generates capital to go along with it even if the savings rate does not change.

In the long run steady state, additional variables, output (Q) and the savings rate (s) have to be added.

(8) dQ/Q = adK/K +(1-a)dL/L

which indicates that the percentage change in output is a weighted average of the percentage changes in capital and labor.

In addition, the savings rate is determined by the after tax return, where t_k is the tax rate on capital income.

(9) ds/s = Es (dR/R-dt_k/(1-t_k))

Finally, in the steady state savings equals investment,

(10) gK = sQ

where g is a constant exogenous growth rate of population and technology. Thus,

(11) dK/K = ds/s + dQ/Q

These results are shown in **Table 1** and **Table 2**, for various elasticities.

The feedback effects, which all have the same denominator: 1+aE+(1-a)Es, and are all multiplied by t/(1-t) have the following numerators:

(A) Labor tax change with general income tax in place: E(1+Es)

(B) Capital income tax change with general income tax in place: Es(1+E)

(C) Income tax change (on capital and labor): (1-a)E(1+Es) +aEs(1+E)

Output effects can also be calculated for the solutions to the change in labor and capital as (1-a) dL/L+adK/K.

Author Information

Jane G. Gravelle
Senior Specialist in Economic Policy

Disclaimer