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Welfare and Macroeconomic Effects of Deficit-Financed Tax Cuts: Lessons from CGE Models

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I. Introduction

Tax cuts are often adopted with no explicit provision for offsetting the resulting revenue loss. Examples of this include the tax-cut packages enacted on June 7, 2001 and May 28, 2003. The decrease in revenue from such tax cuts initially increases the deficit, leading to a larger stock of government debt. However, the government's infinite-horizon budget constraint requires that offsets ultimately be adopted to service or retire that debt. Deficit-financed tax cuts have been controversial, with supporters often pointing to beneficial economic effects from reductions in distortionary taxes and opponents pointing to the adverse economic effects of deficits.

In view of these conflicting economic effects, an ultimate assessment of deficit-financed tax cuts requires an estimate of the magnitudes of the various effects. Computable general equilibrium (CGE) models offer a natural way to obtain such estimates. In this paper, we survey prior work that has studied deficit-financed tax cuts in CGE models and present new results for a range of tax-cut experiments. Prior work has often emphasized the impact on macroeconomic variables, such as output, consumption, labor supply, and the capital stock. We report these impacts, but also emphasize the impact of deficit-financed tax cuts on the welfare of various generations in our overlapping generations (OLG) framework. We find that even when deficit-financed tax cuts increase long-run output, they often reduce the welfare of future generations while increasing the welfare of earlier generations.

The remainder of the paper is organized as follows. In section II, we provide the economic background for this topic, including the early results obtained by Auerbach and Kotlikoff (1987) in their CGE model of an OLG economy. In section III, we survey the lessons learned from similar studies in the 2000s. In section IV, we describe the structure and calibration of the model that we use. We present our results in section V. In section VI, we describe recent empirical work that investigates how actual deficit-financed tax cuts are ultimately paid for. In section VII, we briefly review the work that has been done in models of infinitely-lived agents. We conclude in section VIII.

II. Background

In this section, we discuss the basics of modeling OLG economies and the early work by Auerbach and Kotlikoff.

A. Basic Theory in OLG Models

In an OLG model, the economic impact of a deficit-financed tax cut generally reflects both intergenerational-redistribution and incentive effects.

In most cases, deficit-financed tax cuts lighten the fiscal burdens on early generations and increase those on later generations. The extent and distance of the shifting depend upon how rapidly the resulting debt is retired or serviced. It also depends, however, upon the ages of the affected taxpayers. A tax cut for the young financed by fiscal measures on the old may actually redistribute resources *toward* earlier generations, even if the financing measures are adopted later than the tax cut. Intergenerational redistribution from a deficit-financed tax cut is a zero-sum game; any steady-state loss reflects a gain to transitional generations (or vice versa).

The incentive effects depend upon how the initial tax cut and the financing measure affect distortions in the economy. For example, if a distortionary tax is reduced and the resulting debt is ultimately financed through a less distortionary fiscal instrument a net improvement in the efficiency of the fiscal structure occurs.

These effects have an impact on the welfare of the affected generations and also determine (through income and substitution effects) their labor supply, consumption, and other decisions. Those decisions determine the impact of the deficit-financed tax cut on the various macroeconomic variables.

B. Rationale for CGE Modeling

Some analyses have studied deficit-financed tax cuts in an ad hoc manner, in which the various effects of deficits are discussed heuristically. This approach can easily lead to problems. For example, labor supply may be assumed to depend only upon the explicit marginal tax rate on labor, ignoring the labor-supply impact of taxes on consumption and taxes on capital income. Dynamics may be handled in a very cursory manner, with little attention to the impact of incentives on the timing of work and other decisions. This approach cannot readily incorporate the simultaneity that is at the heart of general equilibrium analysis.

CGE models provide a more disciplined manner of proceeding. The models assume utility and profit maximization, with precise assumptions about the economic environment. The interaction of the effects is also taken into account. The direct income and substitution effects of the policy change, for example, cause changes in factor prices, which in turn have income and substitution effects. CGE modeling therefore yields a coherent and self-consistent set of results. Of course, the ultimate validity of the results depends upon the extent to which the model accurately describes the actual economy.

C. Auerbach-Kolikoff Results

The pioneering CGE modeling of deficit-financed tax cuts (among other policies) in an OLG framework was done by Auerbach and Kotlikoff (1987). We draw on their findings as background for the work that has been done in the 2000s.

Auerbach and Kotlikoff reported (pp. 91-96) the effects of broad-based income tax cuts that last one, five, and twenty years, followed by income-tax increases that keep the debt-to-output ratio stabilized at its new, higher level.

Their model featured a (rather low) initial income tax rate of 15 percent. One experiment reduces the tax rate to 10 percent for 20 years, after which it is increased to maintain the debt-to-GDP ratio at its year-20 value. The required income-tax rate rises steadily over time, reaching a steady-state value of 30.4 percent. In the steady state, the capital stock is reduced 49 percent and labor supply is reduced 5 percent, causing output to fall by 19 percent and the wage rate to fall by 14 percent.

The dynamics are also interesting. As Auerbach and Kotlikoff emphasized, the crowding out of capital proceeds in a very gradual manner, with much of it occurring after the tax cut has expired. After 10 years, the capital stock has fallen only 2 percent. Even at the 30-year mark, a decade after the tax cut has expired, the capital stock has fallen 20 percent, only two-fifths of the steady-state decline.

Auerbach and Kotlikoff identified two reasons for the slow pace. First, the income effect inducing additional consumption by the early generations is spread over their entire lifetimes, not just the period that the tax cut is in effect. Second, the substitution effect of the tax cut induces additional saving while it is in effect, because after-tax returns are higher during that period.

These policy experiments reduce steady-state welfare, but improve the welfare of earlier cohorts. Steady-state utility is reduced by more than 14 percent (measured by the fraction of lifetime resources that would have to be taken to compensate for the required utility decline). A large part of the utility effects are redistributive, however, with utility gains for all generations that are already in the economy at the time the tax cut begins.

The duration of the deficit-financed tax cut has a sharply non-linear effect. Compared to the 5-year tax cut, the 20-year tax cut causes 10 times the increase in the steady-state income tax rate, 7 times the steady-state crowding out of capital, 9 times the steady-state labor supply reduction, and 11 times the steady-state welfare loss.

Auerbach and Kotlikoff noted that, in some respects, a longer tax cut is qualitatively different from a shorter one. During the period that the tax cut is in place, the substitution effects are equally large regardless of duration, but the income effects are larger for the longer tax cut. For example, they found that crowding out of capital begins immediately with the 20-year tax cut because the income effect always outweighs the substitution effect. With the 5-year tax cut, in contrast, there is initial crowding in of capital because the substitution effect outweighs the income effect within the 5-year period.

Their results paint a dismal picture of the steady-state effect of deficit-financed tax cuts, as the short-run improvement in incentives from the initial tax cut is followed by a long-term deterioration due to the subsequent tax increase. In their words (p. 93):

> "Although temporary tax cuts may initially crowd in capital formation, there is no way to escape the long-run costs of short-run deficit finance … Although one might think that, having crowded in capital through short-term tax cuts, one could adopt a painless policy for eliminating the accumulated debt (or simply meeting repayment commitments), such is not the case *when income taxes must be relied on*. One cannot postpone indefinitely raising tax rates, and once these rates are raised, the stimulus to saving through substitution effects is reversed; in addition, the cross-generational income effects that are at the heart of the crowding-out process ultimately play a decisive role in reducing national saving." (emphasis added)

Negative results are inevitable when the income-tax cut must ultimately be financed by income-tax increases.

Auerbach and Kotlikoff did not, however, consider deficit-financed tax cuts in which a reduction in one type of tax is ultimately financed by increasing a different type of tax or fiscal instrument that is potentially less distortionary. In that case, some, but not all, of the conclusions are modified. Such work has been developed in the 2000s and will be the focus of our discussion below.

III. Lessons Learned in the 2000s

As CGE modeling has become more widespread, the number of studies examining deficit-financed tax cuts has increased. Although today's OLG models are broadly similar to Auerbach and Kotlikoff's early model, they are more likely to feature multiple production sectors and possibly a rudimentary international sector. In the remainder of this section, we describe some of the results that have been obtained.

Using the model described in section IV, below, Diamond (2005) considers a permanent extension of the 2001 and 2003 tax cuts. Financing begins after 10 years and stabilizes the debt-output ratio at its new higher level. If the extension is financed by reductions in transfer payment, GDP is 0.8 percent higher in 2045-2054. If the extension is financed by a reduction in government consumption, GDP is 0.1 percent higher; if the extension is financed by an increase in tax rates, GDP is 0.2 percent lower. The differing impacts on GDP are largely due to differing impacts on capital accumulation; the corresponding changes in the 2045-2054 capital stock are 0.7 percent, 0.3 percent, and negative 1.2 percent.

A 2006 Treasury Department study[1] employs a similar model to examine the permanent extension of the 2001 and 2003 tax cuts. This study finds that extending the 2001 and 2003 tax cuts would raise long-run GNP and consumption by 0.7 percent if the extension was financed by a reduction in government consumption, but would reduce long-run real GNP by 0.9 percent if financed by an across-the-board increase in income tax rates. (In each case, the financing measure starts after 2017 and stabilizes the debt-to-output ratio at its new, higher level). The difference again largely reflects a differing impact on capital accumulation, with the long-run capital stock rising 2.3 percent in the first case and falling 1.8 percent in the second case. The output impact in 2011 through 2016 is positive for both cases.

The study decomposes the effects of the tax-cut extension into three components. Lowering the dividend and capital gains tax rate has long-run benefits under either financing mechanism, as do the reductions in the top four ordinary income tax rates. The gains are, however, larger under the government-consumption financing mechanism. Extending the remainder of the tax cuts generates long-run losses under either mechanism, although the losses are smaller when government consumption is reduced.

The Congressional Budget Office produces annual dynamic analyses of the President's budget proposals. In recent years, these proposals have featured a net tax reduction, primarily reflecting a permanent extension of the 2001 and 2003 tax cuts. The most recent analysis considers two financing assumptions, a gradual reduction in government spending (both government purchases and transfer payments) and a gradual increase in marginal tax rates.[2] In each case, the financing measures are phased in from 2019 through 2028. Using a closed-economy OLG model, CBO finds (pp. 39-40) that the President's tax and spending proposals would increase 2009-2013 GNP by 0.4 percent and 2014-2018 GNP by 0.6 percent with the government-purchases adjustment. With the tax-rate adjustment, CBO finds the corresponding increases to be 0.4 and 0.8 percent. Using an open-economy OLG model, CBO finds that the proposals would increase GNP by even larger amounts. With the government-spending adjustment, the increases for the two time periods are 0.8 percent and 1.2 percent; with the tax-rate adjustment, they are 0.7 and 1.0 percent. CBO does not, however, examine the long-run effects.

Dennis, et al. (2004), another study by CBO economists, examines a 10 percent reduction in marginal tax rates, financed either by cuts in government spending or by increases in tax rates. The financing mechanisms start 10 years after the tax cut is adopted and become fully effective after 20 years. In the OLG closed-economy model, steady-state GDP falls by 0.1 percent with the spending cut and by 1.5 percent with the tax-rate increase. In the open-economy model, long-run GDP rises by 0.5 and 0.2 percent, respectively, but the more welfare-relevant GNP falls by 0.4 and 2.1 percent, respectively. Output always rises in the short run (Table 3, p. 13).

A study by the Joint Tax Committee considers a rate reduction in individual income taxes accompanied by base-broadening measures.[3] In an OLG model, two

[1] Office of Tax Analysis, U.S. Department of the Treasury (2006).
[2] U.S. Congressional Budget Office (2008).
[3] U.S. Congress, Joint Committee on Taxation (2006).

different offsets to changes in government debt are used, one involving changes in transfer payments and one involving changes in individual income tax rates. Under either offset, the policy increases real GDP by 1.2 percent in 2006-2011. The 2007-2012 GDP increase is 1.9 percent with the transfer offset and 1.1 percent with the tax offset. The long-run increase in GDP is 2.6 percent with the transfer offset and 1.2 percent with the tax offset (Table 2, p. 10). The higher output growth is largely due to higher growth of the capital stock with the tax offset (Table 3, p. 11); long-run capital growth is 4.5 percent with the transfer offset and 1.8 percent with the tax offset. The long-run growth in consumption is 1.6 percent with the transfer offset and 1.0 percent with the tax offset (Table 8, p. 15).

Auerbach (2002) examines extension of the 2001 and 2003 tax cuts. He examines a somewhat different policy experiment than most of the other studies. The other recent studies generally make those tax cuts permanent and then layer a financing mechanism on top of the tax cuts. (Of course, when the financing mechanism is a tax-rate increase, layering on the tax increase effectively undoes the tax cuts in whole or in part.) Following the approach of Auerbach and Kotlikoff (1987), Auerbach instead considers experiments in which the 2001 and 2003 tax cuts last 10, 15 or 20 years before expiring, after which the debt-to-output ratio is stabilized using either increases in wage taxes or capital income taxes. Output increases while the tax cuts are in effect, but falls after the tax cuts expire. The long-run output decline is greater when the tax cut lasts longer, causing more debt to be accumulated, and when the financing is done through higher taxes on capital income. The negative effects are diminished if part of the revenue loss is offset by reducing government purchases during the time that the tax cuts are in effect.

In summary, the studies generally find that both the form of the initial tax cut and the financing method matter. An increase in steady-state output is most likely if the initial tax cut is targeted toward marginal-rate reduction, if the financing method does not raise marginal rates and has income effects that encourage work (transfer-payment reductions are ideal for those purposes), and if the financing is implemented quickly. The impact on steady-state output is generally driven by the impact on the steady-state capital stock rather than steady-state labor supply.

Despite the valuable insights that have been gleaned from previous work, the results are generally limited in both the range of policy experiments and the extent of the welfare analysis. The papers have drawn from a somewhat limited set of initial tax cuts, generally across-the-board income tax cuts or extension of the 2001 and 2003 tax laws. Also, despite the early example set by Auerbach and Kotlikoff (1987), the more recent studies generally do not report the welfare impacts on the various generations.

To explore these issues, we report some new results for a range of deficit-financed tax cuts.

IV. Model Structure and Calibration

We use a dynamic overlapping-generations life-cycle computable general equilibrium model that explicitly calculates reform-induced changes in all asset values that would accompany a debt-financed tax cut. As noted previously, the model has three production sectors – owner-occupied housing, rental housing, and a composite good sector that includes all non-housing goods and services. The time path of investment demands in all three sectors is modeled explicitly, taking into account capital stock adjustment costs. On the consumption side, the current tax advantage of owner-occupied housing relative to other assets is taken into account in modeling the demands for the three goods.

The model allows for a fairly detailed description of the transitional and long–run macroeconomic effects of debt-financed tax cuts and an examination of the intergenerational welfare effects. The model does not allow for multiple income groups within each generation.

This section outlines the basic structure of the model, which combines various features from Auerbach and Kotlikoff (1987) and other similar and well-known models constructed by Goulder and Summers (1989), Goulder (1989), Keuschnigg (1990), Fullerton and Rogers (1993) and Hayashi (1982). A detailed description of the model is provided in the appendix, and an even more complete description is provided in Diamond and Zodrow (2005).

A. Production

Firms in the composite good production sector produce output using a CES (constant elasticity of substitution) production function with capital and labor as inputs. Firms choose the time path of investment to maximize the present value of firm profits or, equivalently, to maximize firm value, net of all taxes and subject to quadratic costs of adjusting the capital stock. Total taxes in the composite good production sector include the corporate income tax and state and local property taxes. Each firm maintains a fixed debt/asset ratio and pays out as dividends a constant fraction of earnings after taxes and depreciation in each period, which is consistent with the "old view" of dividend taxation.

The model assumes individual-level arbitrage, which implies that the after-tax return to bonds must equal the after-tax return received by the shareholders of the firm. The value of the firm in the composite good sector equals the present value of all future net distributions to the owners of the firm.

Housing is produced in the owner-occupied and rental housing production sectors. Following Goulder and Summers (1989) and Goulder (1989), rental housing is produced by non-corporate landlords and owner-occupied housing is produced by the owners. The technology used in the production of rental housing and owner-occupied housing is assumed to be identical, with capital and labor combined in the same CES production function. Landlords and owner-occupiers are also assumed to choose time paths of investment to maximize the equivalent of firm value, net of total taxes.

In the rental housing sector, the firm is modeled as a non-corporate firm, which implies that landlords are simply taxed at the individual level. In the owner-occupied housing sector, the measurement of the tax burden takes into account the fact that imputed rents are untaxed and that maintenance expenditures are not deductible, while mortgage interest and property taxes are deductible. The optimal investment path is calculated as above.

B. Individual Behavior

On the individual side, the model has a dynamic overlapping generations framework with fifty-five generations alive at each point in time. There is a representative individual for each generation, who has an economic life span (which begins upon entry into the work force) of fifty-five years, with the first forty-five of those years spent working and the last ten years spent in retirement. Individual tastes are identical so that differences in behavior across generations are due solely to differences in lifetime budget constraints. An individual accumulates assets from the time of "economic birth" that are used to finance both consumption over the life cycle, especially during the retirement period, and the making of bequests. The model includes a joy-of-giving bequest motive so that the real values of bequests change with changes in income and other economic variables.

The consumer is assumed to choose the time paths of consumption and leisure to maximize rest-of-life utility, which is a discounted sum of annual utilities, subject to a lifetime budget constraint that requires the present value of lifetime wealth including inheritances to equal the present value of lifetime consumption including bequests. Annual utility is assumed to be a CES function of consumption of an aggregate consumption good and leisure. The aggregate consumption good is modeled as a CES function of the composite good and aggregate housing services (including a minimum purchase requirement for both goods), with aggregate housing services in turn modeled as a CES function of owner-occupied and rental housing services.

In addition, the model includes a simple social security system, government purchases of the composite good, transfer payments, a hump-backed wage profile over the life cycle, a progressive tax on wage income, and constant average marginal tax rates applied to interest income, dividends, and capital gains. Transfer payments excluding those funded by the payroll tax are modeled as going disproportionately to younger generations with the youngest 25 percent of the population receiving 31 percent of benefits. The progressive wage tax is modeled using a quadratic wage tax function similar to Auerbach and Kotlikoff (1987). The model assumes a closed economy, no uncertainty, and perfect competition in every sector of the economy.

C. Calibration

The model is calibrated by choosing a number of parameter values and economic variables so that the initial income tax steady state in the base year, which is the year of reform, closely resembles the prevailing features of the U.S. economy in 2007. Parameter values are chosen to be consistent with empirical estimates and parameter values used in other CGE studies, especially Altig, et al. (2001), Auerbach and Kotlikoff (1987), Auerbach (1996), and Fullerton and Rogers (1993). The values for economic variables are generally chosen to be consistent with estimates from the National Income and Product Accounts.

Table 1 shows the values of the model parameters that are the most important in terms of determining individual and firm behavioral responses.

The rate of time preference, ρ, is set equal to 0.005. In CGE models, the rate of time preference (or discount rate) is typically chosen in tandem with the intertemporal and intratemporal elasticities of substitution to generate reasonable levels of saving and investment and labor supply in the initial steady-state. Using the Euler equation approach, Ziliak and Kneisner (1999) estimate that the rate of time preference under two specifications that yield values of 0.001 and 0.013. Jorgensen and Yun (2001) estimate a higher value of 0.02. The value we choose is at the low end of these estimates but is consistent with other CGE studies such as Altig, et al. (2001).

The elasticity of intertemporal substitution σ determines the willingness of consumers to substitute consumption across periods in response to changes in the relative prices of consumption and therefore plays a critical role in establishing the responsiveness of saving to tax changes. Empirical studies using aggregate consumption data typically find that the EIS is between zero and one.[4] The range of assumed values for the EIS used in CGE models is quite small, primarily because the chosen value must generate a steady-state capital stock that is consistent with the data and the assumed value of the pure rate of time preference. Auerbach and Kotlifoff (1987), Fullerton and Rogers (1993), Jorgenson and Yun (2001), Altig, et al. (2001), and Diamond and Zodrow (2007) all assume a value of the EIS between 0.25 and 0.50, depending partly on the interaction of the EIS with the choice of the pure-rate-of-time-preference parameter. We assume that the EIS is equal to 0.33.

The intratemporal elasticity of substitution ε and the percentage of the endowment devoted to leisure are key parameters that determine the compensated and uncompensated wage elasticities. For a given intratemporal elasticity of substitution, there is a larger percentage increase in labor supply associated with an increase in the wage rate if the share of the initial time endowment devoted to leisure is greater. The intratemporal elasticity of substitution determines consumer willingness to substitute between labor supply and leisure in response to changes in their relative prices and therefore is critical in determining the labor supply response to a change in the after-tax wage. We assume that the intratemporal elasticity of substitution is equal to 0.8 and that the share of the time endowment devoted to leisure is 0.3.[5]

The elasticities of substitution between the composite good and aggregate housing consumption σ_{CH} and between rental and owner housing σ_{RO} are chosen so that the values of the compensated own-price elasticities of owner and rental housing are both roughly -0.8 as reported in Rosen (1985).[6] The various weighting parameters in the production functions and utility function are set to replicate as closely as possible the actual pattern of aggregate production and consumption for the three goods in the model.

Table 2 shows the values for technological parameter values. The rate of population growth is equal to 0.01 and the rate of technological growth is equal to 0.01, so that the economy grows at a 2 percent annual rate in steady state.

The size of adjustment costs is also important in determining the effects of debt-financed tax cuts. We assume that the adjustment cost parameter (β_X) in the non-housing production sector is equal to 5, meaning that an increase of 1 percentage point in the ratio of investment to the capital stock is associated with an increase of 5 percentage points in q. This value is a compromise between the estimates presented in Cummins, Hassett and Hubbard (1994), Shapiro (1986) and the earlier and considerably larger estimates presented in Summers (1981). In the absence of data on the values of the adjustment cost parameters in the owner-occupied and rental housing sectors, these values are assumed to equal the value of the adjustment cost parameter in the composite

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[4] See Gunning, Diamond and Zodrow (2007).

[5] This implies that the aggregate uncompensated labor supply elasticity is approximately 0.24, which is within the range of empirical estimates. This value is significantly lower than the value assumed in Altig, et al. (2001) and Auerbach and Kotlikoff (1987), but yields an aggregate labor supply elasticity that is consistent with most of the empirical literature. It is, however, inconsistent with the relatively large labor supply elasticities found in the work of Prescott (2005) and Davis and Henreckson (2005).

[6] Estimates of housing demand elasticities span a wide range. DiPasquale and Wheaton (1994) report an estimated housing demand elasticity equal to -0.15 while Riddel (2004) reports an estimated elasticity equal to -1.5.

good sector, although there is no economic reason why these values would need to be the same.

Table 3 shows the initial steady state values for output, the capital stock, firm value, investment and earnings in each sector, which are calibrated to data from the U.S. Bureau of Economic Analysis (2008).

Table 4 shows the initial steady state values for federal taxes in the base year. The federal tax system raises $2609 billion in total tax revenue in the base year; federal income taxes raise $1,660 billion and social security payroll taxes raise $949 billion, which is assumed to equal the amount of social security benefits. Total federal income taxes are 18.9 percent of GDP. Federal government expenditures are 19.5 percent of GDP. Government debt is assumed to be 30 percent of annual GDP. This ratio is constant in the steady state.

Table 5 shows the federal tax rates in the initial steady state. Under the progressive wage tax, the income-weighted average marginal wage tax rate is equal to 26 percent and the average wage tax rate is 21.4 percent.[7] The tax rate on individual interest income is 15.2 percent and the tax rate on dividends is 16.3 percent. Capital gains in the composite good and rental housing sectors are taxed at an effective annual accrual rate of 5 percent and capital gains in the owner-occupied housing sector are untaxed.[8] The payroll tax is 10.7 percent; this is lower than the actual 15.3 percent rate because all wage income is subject to the payroll tax in the model. Social Security benefits are taxed at 5.2 percent. The effective tax rate on investment in the composite good sector is 28.8 percent[9] and the effective tax rate in the rental housing sector is 21 percent.[10] The model also includes deductions and credits in the calculation of taxable wage income. Deductions and credits are only allowed in the working period (the first 45 years) of an individual's life; retired individuals do not receive deductions or credits.

V. Simulation Results

In this section we examine the macroeconomic and welfare effects of several alternative tax cuts under a number of different financing options. The magnitude of the tax reduction is determined so that the decrease in revenue over the ten-year period following enactment is $500 billion with no behavioral responses. The decrease in revenues is unanticipated and enacted immediately. For concreteness, we refer to the year of enactment as 2007, the year to which, as noted above, the initial steady state is calibrated. The tax cuts are permanent. The three main financing methods are: (1) government transfers (other than social security benefits) are reduced immediately to finance the tax cut; (2) government debt is used to finance the tax cut for ten years and then government

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[7] The value of marginal and average tax rates is based on data from the Office of Tax Analysis Department of the Treasury.

[8] The effective annual accrual tax rate on capital gains in the owner-occupied housing sector is assumed to equal zero, since the Taxpayer Relief Act of 1997 exempted gains up to $250,000 on the sale of a house for single taxpayers and up to $500,000 for married taxpayers filing a joint return.

[9] The corporate tax rate is assumed to be 35 percent, with accelerated depreciation allowances for allowed for the purpose of calculating taxable income. The amount of remaining basis for tax purposes is explicitly calculated in each period and used in the calculations of depreciation allowances. The corporate share of the composite-goods sector is 62 percent. This is use to calculate a weighted-average tax rate in each production sector. Note that the non-housing production sector is treated as a corporate firm in the model.

[10] For the purpose of calculating the weighted average tax rate in the rental housing sector the corporate share of the rental-housing sector is assumed to be 10 percent. Note the rental housing firm is treated as a non-corporate firm in the model.

transfers (other than social security benefits) are reduced so that government debt grows at the steady state rate of growth; and (3) government debt is used to finance the tax cut for ten years and then all personal income tax rates (wage, interest, dividends, and capital gains) are increased proportionately so that government debt grows at the steady state growth rate. The financing measures become known to agents when the tax cut is introduced.

Numerous other tax cuts and financing arrangements could be evaluated, but are omitted due to space and other considerations. For two reasons, we do not consider a reduction in government purchases as a financing mechanism. First, we cannot model the intergenerational welfare effects, a key part of the analysis, without making arbitrary assumptions about the utility derived from the government purchases. Second, as an institutional matter, it is unclear whether government purchases, which are set in annual appropriation bills and which often respond to military developments and other volatile factors, could be reduced permanently as part of a fiscal reform.

The following discussion begins with a summary of the macroeconomic effects of enacting each of the tax cuts on prices, consumption, labor supply, investment, and output as well as the associated intergenerational welfare redistributions. We examine the macroeconomic effects of cutting the tax rate on wage, interest, dividend and corporate income and the macroeconomic effect of increasing tax credits. We also discuss the intergenerational welfare effects and macroeconomic revenue feedback effects of each of the tax cuts.

A. Immediate Spending Offset

Table 6 shows the macroeconomic effects of a 3.9 percent reduction in the average and marginal wage tax rates, a 22.1 percent reduction in the effective tax rate on interest income, a 50.6 percent reduction in the effective tax rate on dividend income, a 12.3 percent reduction in the effective tax rate on corporate income, and a 41 percent increase in personal tax credits. In this set of simulations, transfer payments are immediately reduced to hold the amount of government debt constant.

Under the wage tax cut, the before-tax interest rate increases in the year of enactment by 23 basis points and then immediately returns to its approximate level in the initial steady state. Labor supply increases by 0.4 percent in every year after reform. The before-tax wage rate declines initially by 0.1 percent as labor supply increases immediately by 0.4 percent (note that the capital stock is initially fixed). Labor supply increases because the income weighted after-tax wage rate increases by 1.6 percent in the year of reform (1.8 percent in the long-run). Investment increases in all three production sectors, with investment in the housing sector increasing by twice as much as in the non-housing sector in the years immediately following the reform. In the long run, investment in the non-housing and housing sectors increases by 0.5 percent. Consumption increases by 0.2 percent in the year of enactment and by 0.4 percent in the long run. GDP increases by 0.3 percent in the year of reform and by 0.4 percent in the long run.

Under the interest income tax cut, the before-tax interest rate decreases in the year of enactment by 5 basis points and by 30 basis points in the long run. Labor supply increases by 0.1 percent in the year of enactment but then returns to its initial steady state level. The before-tax wage rate is initially unchanged and increases by 0.1 percent in the long run as the capital stock increases by 0.4 percent. Investment increases in all three production sectors, with investment in the owner (rental) housing sector increasing by 1.1

(0.6) percent in the year of reform. Non-housing investment initially increases by 0.3 percent in the years immediately following the tax cut. In the long run, investment in the non-housing and rental housing sectors increases by 0.4 percent, and investment in the owner housing sector increases by 0.6 percent. Consumption decreases by 0.1 percent in the year of enactment and then returns to its initial steady-state level after 10 years. GDP increases by 0.1 percent in the long run.

The macroeconomic effects of reducing the dividend (recall that we are assuming the “old view” of dividend taxes) and corporate tax rates are similar to each other. The before-tax interest rate increases by 24 (48) basis points in the year the dividend (corporate) tax rate is cut and then gradually declines to a level that is 4 (5) basis points higher than in the initial steady-state. Under the dividend and corporate rate cuts, labor supply increases by 0.1 percent in every year after enactment. Under the dividend (corporate) rate cut, the before-tax wage rate is initially unchanged and increases by 0.7 (0.5) percent in the long run as the capital stock increases by 2.7 (2.1) percent. Investment in the owner and rental housing sectors decreases 2.3 to 3.2 percent in the year of enactment. Non-housing investment increases by 2.6 (1.9) percent in the year of enactment under the dividend (corporate) tax cut. In the long run, investment in the non-housing sector increases by 2.7 (2.1) percent under the dividend (corporate) rate cut. Consumption decreases by 0.1 to 0.2 percent in the year of enactment and increases by 0.3 to 0.4 percent in the long run. Under the dividend (corporate) tax cut, GDP increases by 0.7 (0.5) percent in the long run.

One might think that corporate and dividend tax cuts of the same size should have identical quantitative effects, as well as similar qualitative effects, since they both reduce the effective tax rate on corporate investment. The two taxes differ, though, in a subtle, but crucial, respect. Due to accelerated depreciation, a corporate tax cut includes a windfall gain for existing capital, as some deferred tax liabilities are forgiven. In this old-view world, there is no similar windfall from the dividend tax cut. The dividend tax cut is therefore more powerful in promoting long-run growth because none of it is “wasted” on a lump-sum transfer to holders of existing assets. This is analytically similar, but quantitatively smaller, than the difference between adopting a wage tax and a consumption tax. We return to this key difference in our discussion of welfare effects.

An increase in personal tax credits offset by a reduction in transfers does not significantly affect the before-tax wage rate, labor supply, or GDP. The before-tax interest rate increases by 4 basis points in the year of enactment and then declines to a level 2 basis points lower than in the initial steady-state. In the long run, investment in the owner and rental housing sectors increases by 0.1 percent and non-housing investment increases by 0.2 percent. Consumption decreases by 0.1 percent in the year of enactment and then returns to its initial steady state level after 10 years. Both the tax credits and the transfer payments are lump-sum, but the substitution of the former for the latter provides a slight boost to investment because the tax credits are distributed to younger cohorts.

B. Government Transfer Offset after 10 Years

Table 7 shows the macroeconomic effects of the various tax cuts if government debt is used to finance the tax cuts for 10 years and transfer payments are then decreased to hold the growth rate of government debt constant at the steady-state rate of growth in the economy.

Under the wage tax cut with a reduction in government transfer payments after 10 years, the before-tax interest rate increases by 16 basis points in the year of enactment and by 8 basis points in the long run. The before-tax wage rate declines by 0.1 percent as labor supply increases immediately by 0.4 percent (note that the capital stock is initially fixed). Labor supply increases because the income weighted after-tax wage rate increases by 1.6 percent in the year of reform (1.8 percent in the long-run). In the years immediately following the tax cut investment increases in all three production sectors, with investment in the housing sector increasing by twice as much as in the non-housing sector in the years immediately following the reform. In the long run, investment in the non-housing and housing sectors decreases by 0.1 to 0.2 percent. Consumption increases by 0.3 percent in the year of enactment and by 0.4 percent in the long run. GDP increases by 0.3 percent in the long run. The debt-to-GDP ratio increases from 29.7 percent in the initial steady state to 33.3 percent in the long run. In this case, the increase in government debt relative to GDP increases interest rates and crowds out private investment.

A reduction in the tax rate on interest income accompanied by a reduction in government transfers after 10 years has very modest effects in the long run on the macroeconomic aggregates. The before-tax interest rate decreases in the year of enactment by 11 basis points and by 22 basis points in the long run. Labor supply, consumption and GDP are essentially unchanged from the initial steady-state. In the years immediately after the tax cut, investment increases in all three production sectors, with investment in the owner (rental) housing sector increasing by 0.8 (0.4) percent in the year of reform. Non-housing investment increases by 0.1 percent in the year of the tax cut. In the long run, investment in the non-housing and rental housing sectors decreases by 0.1 to 0.2 percent as an increased debt-to-GDP ratio crowds out private investment. The debt-to-GDP ratio increases from 29.8 percent in the initial steady state to 32.7 percent in the long run. The debt-to-GDP ratio in this scenario increases by less than that caused by the wage tax cut with the same financing assumption as a result of the lower interest rate which reduces government spending.

In this case, as under the immediate financing offset, the macroeconomic effects of reducing the dividend and corporate tax rates are similar to each other. Cutting the dividend tax rate causes the before-tax interest rate to increase by 17 basis points in the year of enactment and in the long run. Cutting the corporate tax rate causes the before-tax interest rate to increase by 41 basis points in the year of enactment and then gradually decline to a level that is 17 basis points higher than in the initial steady-state. Under the dividend and corporate rate cuts, labor supply increases by 0.1 percent in every year after enactment. Under the dividend (corporate) rate cut, the before-tax wage rate is initially unchanged and increases by 0.4 (0.3) percent in the long run as the capital stock increases by 2.7 (2.1) percent. Investment in the owner and rental housing sectors decreases 2.7 to 3.5 percent in the year of enactment. Non-housing investment increases by 2.3 (1.7) percent in the year of enactment under the dividend (corporate) tax cut. In the long run, investment in the non-housing sector increases by 1.8 (1.2) percent under the dividend (corporate) rate cut. Consumption decreases by 0.1 to 0.2 percent in the year of enactment and increases by 0.3 to 0.4 percent in the long run. Under the dividend (corporate) tax cut, GDP increases by 0.5 (0.4) percent in the long run.

An increase in personal tax credits offset by a reduction in transfers after 10 years does not significantly affect the before-tax wage rate, labor supply, or consumption. The before-tax interest rate decreases by 3 basis points in the year of enactment and then increases to a level 10 basis points higher than in the initial steady state. In the long run, investment in all three production sectors decreases by 0.7 percent. GDP decreases by 0.1 percent in the long run.

C. Across-the-Board Tax Increase after 10 Years

Table 8 shows the macroeconomic effects of the various tax cuts if government debt is used to finance the tax cuts for 10 years and then an across-the-board tax increase is implemented to hold the growth rate of government debt constant at the steady state rate of growth in the economy.

In the case of a wage tax cut with an across-the-board increase in tax rates after 10 years, the before-tax interest rate increases by 13 basis points in the year of enactment and by 15 basis points in the long run. The before-tax wage rate declines by 0.1 percent as labor supply increases immediately by 0.4 percent (note that the capital stock is initially fixed). Labor supply increases because the income-weighted after-tax wage rate increases by 1.6 percent in the 10 years following enactment. After 10 years, tax rates are increased to hold the growth of government debt constant. As a result, the increase in the after-tax wage rate declines from 1.6 percent to 0.6 percent in year 2017. In the long run, the after-tax wage rate increases by 0.04 percent as the net wage tax rate is reduced by one percent. Labor supply increases by 0.1 percent in the long run. In the year immediately following the tax cut, investment in the housing sector increases by 0.3 to 0.6 percent while investment in the non-housing sector is unchanged. In the long run, investment in the non-housing sector decreases by 1.6 percent and investment in housing decreases by 0.7 to 1.3 percent. Consumption increases by 0.3 percent in the year of enactment and decreases by 0.1 percent in the long run. GDP increases by 0.3 percent in the year of enactment and decreases by 0.3 percent in the long run. The debt-to-GDP ratio increases from 29.7 percent in the initial steady-state to 33.6 percent in the long run. In this case, debt financed tax cuts increase government debt relative to GDP and thus increase interest rates and crowd out private investment. Tax burdens on investment are also higher in the steady state, due to the tax increases.

Decreasing the tax rate on interest income with an across-the-board tax increase after 10 years has very modest effects on the fundamental macroeconomic aggregates in the long run. The before-tax interest rate decreases in the year of enactment by 13 basis points and by 18 basis points in the long run. In the 10 years after enactment, the after-tax wage rate and labor supply are unchanged. After 10 years, the increase in the marginal wage tax rate and a decline in the before-tax wage rate, which is related to slower growth in investment, leads to a 0.2 percent decrease in labor supply in the long run. In the year immediately after the tax cut, investment in owner housing increases by 0.9 percent and investment in rental housing increases by 0.2 percent. Non-housing investment is unchanged in the first few years following the tax cut. The across-the-board tax increase reduces investment beginning in 2017. In the long run, investment in the non-housing sector decreases 1.3 percent, and investment in the owner and rental housing sectors decreases by 0.5 and 1.1 percent. In this case, the debt-to-GDP ratio increases from 29.8 percent in the initial steady state to 32.9 percent in the long run. The debt-to-GDP ratio increases by less than under the wage tax cut, with the same financing assumption, because the decrease in the interest rate reduces government spending on interest payments.

The macroeconomic effects of reducing the dividend and corporate tax rates are similar to each other in this case, an across-the-board tax increase, as they were under the other financing assumptions. Cutting the dividend tax rate causes the before-tax interest rate to increase by 14 basis points in the year of enactment. After 2017, the before-tax interest rate increases steadily until it is 25 basis points higher in the long run. Cutting the corporate tax rate causes the before-tax interest rate to increase by 37 basis points in the year of enactment and then declines to a level that is 15 basis points higher than in the initial steady state in the following year. After 2017, the before-tax interest rate gradually increases until it is 25 basis points higher than in the initial equilibrium. Under the dividend and corporate rate cuts, labor supply decreases by 0.3 percent in the long run. Under the dividend (corporate) rate cut, the before-tax wage rate is initially unchanged and increases by 0.2 (0.0) percent. Under the dividend rate cut, investment in the owner and rental housing sectors decreases by 3.0 to 3.8 percent in the year of enactment. Non-housing investment increases by 2.2 percent in the year of enactment. Under the corporate rate cut, investment in the owner and rental housing sectors decreases by 2.6 to 3.3 percent in the year of enactment. Non-housing investment increases by 1.5 percent in the year of enactment. In the long run, investment in the non-housing sector increases by 0.4 percent under the dividend rate cut and decreases by 0.2 percent under the corporate rate cut. Consumption changes by 0.0 to -0.1 percent in the year of enactment and by 0.0 to -0.2 percent in the long run. In the long run, a dividend tax cut does not change the level of GDP, while the corporate tax cut causes GDP to decrease by 0.2 percent.

An increase in personal tax credits with an across-the-board tax increase after 10 years increases the before-tax interest rate by 20 basis points in the long run. The before-tax wage rate gradually decreases as government debt crowds out private capital and the tax increases depress investment. In the long run, the before-tax wage rate decreases by 0.5 percent and labor supply decreases by 0.4 percent. Investment decreases in all three production sectors. In the long run, non-housing investment decreases by 2.5 percent, and owner and rental housing investment decreases by 1.5 and 2.2 percent. Consumption decreases by 0.6 percent and GDP decreases by 0.8 percent in the long run. The debt-to-GDP ratio increases to 34.5 percent.

D. Summary of Macroeconomic Effects

As one would expect, all four of the reductions in distortionary taxes increase long-run GDP when they are offset by an immediate reduction in transfer payments. The GDP boost is largest for reductions in dividend and corporate taxes, because those taxes are more distortionary. There is no GDP boost from the increase in personal tax credits.

When the reduction in transfer payments is delayed by 10 years, however, the long-run effects are less beneficial. In each case, the GDP boost is diminished by 0.1 or 0.2 percentage points. This dimunition brings the boost in the interest-tax-cut case to essentially zero, but a noticeable GDP gain still appears in the other three reductions of distortionary taxes. The long-run gains are smaller because the increase in debt crowds out private investment (there is virtually no change in labor supply). Notably, long-run non-housing investment is increased by cuts in wage taxes and interest taxes when the transfer payment cut is immediate, but such investment is reduced in the presence of the 10-year lag. The dividend and corporate cuts, which are more directly targeted to investment, still boost long-run non-housing investment even with the 10-year lag, but by significantly less than with an immediate transfer cut.

The macroeconomic effects are much worse when tax rates are increased to finance the deficit. Long-run GDP falls in every case, except for the dividend-tax cut under which GDP is virtually unchanged. Non-housing investment falls in every case, except the dividend-tax cut. Long-run labor supply falls in every case, except for the wage-tax reduction. With tax-increase financing, crowding out is reinforced by the distortionary effects of the tax increases.

E. Intergenerational Welfare Effects

As discussed in section III, examining the macroeconomic effects of tax policy changes has become an important tool for tax policy analysts in the 2000s. None of the analyses to date, however, have provided policy makers with anything more than simple macroeconomic aggregates as presented in the discussion above. This omission is unfortunate, since macroeconomic aggregates are not always reliable indicators of whether certain policies make individuals better off, are not sufficient to compare alternative policies, and do not allow policy makers to examine the effects of policies across groups. In this section, we present estimates of the intergenerational welfare effects of the various policies.

Figure 1 shows the intergenerational welfare effects of the five policies assuming that government transfers are cut immediately so that government debt grows at the steady state rate of the economy. For generations alive at the time of reform (generations with a year of birth between negative 54 and 0) the largest welfare gains occur under the corporate rate cut, the dividend rate cut, and the interest income tax cut.

The difference between the dividend and the corporate tax cuts again reflect the windfall gain to existing assets built into the latter, but not the former. The corporate tax cut is more beneficial to the early generations who hold those assets and is therefore less beneficial to later generations.

In the case of an increase in personal tax credits all existing generations are worse off while future generations are better off. This reflects the fact that the tax credits are distributed to younger cohorts, on average, than the transfer payments. As the generational accounting literature has long taught, a balanced-budget lump-sum redistribution from old to young harms current generations and helps future generations.

The deficit-financed tax cuts, shown in **Figures 2 and 3**, uniformly reduce the well-being of future generations. This welfare loss occurs even when those generations are bequeathed a more efficient tax system (as is true in all of the cases in which reductions in distortionary taxes are financed by delayed cuts in transfer payments). The reason for their welfare loss is the shift in net fiscal burdens; deficit financing moves such burdens away from current generations and onto future generations. As one would expect, the deficit-financed tax cuts almost uniformly benefit the generations alive at the time of the reform.

Two of the cases feature an interesting set of effects. When wage taxes or dividend taxes are reduced and the revenue loss is offset by a reduction in transfer payments after 10 years, steady-state utility declines although steady-state consumption increases. In the wage-tax case, the utility decline reflects an increase in labor supply. In the dividend-tax case, the explanation for the apparent paradox is more subtle. For a given value of aggregate steady-state consumption (holding labor supply fixed), steady-state utility is higher when the marginal rate of substitution between consumption at different ages, which is given by the after-tax interest rate, is closer to the growth rate of the economy. The dividend tax cut increases the after-tax interest rate further above the growth rate of the economy, thereby lowering steady-state utility as a function of aggregate steady-state consumption.[11]

Figure 4 shows the intergenerational welfare effects of the reducing the wage and dividend tax rates assuming that government transfers are reduced 20 rather than 10 years after the reform. In this case, the welfare losses are much larger for future generations. For the wage tax cut the long run welfare loss is 2 percent of lifetime resources instead of 0.08 percent in the case of a 10 year deficit finance rule. For the dividend tax cut the long run welfare loss is 2.4 percent of lifetime resources instead of 0.32 percent. Similar to the findings of Auerbach and Kotlikoff (1987), the welfare losses increase non-linearly with the period of deficit finance.

A social planner concerned solely with the well-being of future generations would therefore want to pursue "fiscal responsibility" rather than "tax reform" if a choice must be made. Recall, however, that the gains to future generations from fiscal restraint are accompanied by losses to earlier generations. A normative evaluation requires a social welfare function that specifies the weights to be given to the various generations.

VI. How are Deficit-Financed Tax Cuts Typically Paid For?

All of the above results highlight the critical importance of the manner in which the deficit-financed tax cut is ultimately paid for. When a deficit-financed tax cut is passed, there is generally no consensus on how the resulting debt will ultimately be serviced. Yet, that question should play a prominent role in an evaluation of the tax cut.

It is generally impossible to conclusively determine how any tax cut was actually financed, because there is no way to determine how actual taxes and spending compare to those that would have occurred in an alternative world without the tax cut. Econometric evidence can, however, shed light on the question if identifying assumptions are made. Some early work by Bohn (1991) found that increases in debt are typically financed with a combination of revenue increases and spending cuts.

Some work on this question has been done in the 2000s. Auerbach (2006), updating Auerbach (2003, pp. 88-98), implements a similar approach, regressing tax and

[11] Despite its adverse effect on *steady-state* utility for a given level of aggregate steady-state consumption, increasing the after-tax interest rate above the economy's growth rate may be desirable once the impact on transitional generations is considered. A planner who cares about both transitional and steady-state generations and has unrestricted access to lump-sum taxes should adopt intergenerational transfers that drive the capital stock to the *modified* golden rule level, with a before-tax interest rate greater than the growth rate of the economy, and should eschew capital taxation so that the after-tax interest rate also exceeds the growth rate.

spending "policy changes," as defined by CBO, on the lagged budget surplus and the GDP gap for 1984:Q2 through 2004:Q1. He finds that both revenue and expenditures respond to budgetary conditions, as measured by either the lagged surplus or projected future surpluses. Revenue and spending are about equally responsive. Most of the spending response comes from nondefense discretionary spending.

Chung and Leeper (2007) find that VARs for taxes and spending are noninvertible when government debt is not included, i.e., that estimated innovations in the no-debt VARs are predictable from past values of debt and are therefore not true innovations. They therefore construct a VAR that includes government debt and interest rates, on which they impose the transversality condition requiring that a change in debt be offset by changes in the present value of future surpluses, discounted at the interest rate on government debt. They emphasize that the change in the present value of future surpluses reflects a combination of changes in future surpluses and changes in the interest rate on government debt. They estimate this VAR using NIPA data on taxes, government purchases, and transfer payments (for the federal government only) from 1947:2 through 2006:2. They find (pp. 18-19, 27, 34) that tax cuts tend to be followed by large tax increases, partly offset by *increases* in transfer payments (and possibly government purchases), with relatively little change in real interest rates. The confidence intervals on the estimates are, however, quite wide, making most of their estimates statistically insignificant.

Romer and Romer (2007) use a narrative approach to distinguish between various types of tax cuts. They discard tax changes that are motivated by countercyclical considerations, those that are enacted to finance contemporaneous changes in government spending, and tax increases that are adopted to finance inherited deficits. They instead focus their analysis on "long-run tax changes," those that are adopted to promote economic growth or efficiency or to reduce the size of government. The largest such changes were the tax cuts enacted in 1948, 1964, 1981, 2001, and 2003.

They regress the growth of real (non-interest) government expenditures on current and lagged values of the revenue impacts from these long-run tax changes. Somewhat surprisingly, they find that expenditures actually *rise* in response to these tax cuts, beginning about one year after the revenue loss occurs. The point estimates indicate that spending eventually (three to five years out) rises by roughly the same amount as the tax cut, although the estimates have sizable standard errors.[12]

The Romer and Romer estimates are not completely robust. A variety of estimation changes tends to weaken or eliminate the evidence that tax cuts increase spending, although they do not generate evidence that tax cuts reduce spending. Deleting the Korean War period, for example, renders the estimated spending increases statistically insignificant. Similarly, the cumulative impact on spending at a ten-year horizon is statistically insignificant. Looking only at nondefense spending yields point estimates that imply a spending-reduction effect, but the estimates are statistically insignificant.

[12] The estimated spending impacts from the other types of tax cuts generally accorded with *a priori* expectations, although the estimates were usually statistically insignificant. Tax increases to reduce the deficit were associated with reduced spending (although only for a short time), countercyclical tax cuts were associated with increased spending, and tax increases adopted to finance contemporaneous new spending were indeed associated with increased spending.

Romer and Romer suggest that studies which find evidence that tax cuts drive spending down may be biased by the inclusion of tax changes that are adopted to finance contemporaneous spending. They find that, after two years, the revenue impact of a long-run tax cut is not statistically different from zero, implying that the initial tax cut was reversed by subsequent increases in receipts. Further analysis reveals that the increase in receipts is largely due to the subsequent enactment of deficit-driven tax increases and spending-driven tax increases. For example, the 1964 tax cut was partially reversed by the tax surcharge adopted in 1968 and the 1981 tax cut was partially reversed by tax increases adopted in 1982 and later years.

Davig and Leeper (2006) estimate a regime-switching model in which fiscal policy alternates between an active regime and a passive regime. The active policy increases annual taxes net of transfer payments by about five cents in response to an additional dollar of outstanding government debt while the passive policy lowers annual net taxes by more than three cents for each additional dollar of debt. In the period from 1948 through 2004, Davig and Leeper estimate that 12 fiscal regime changes occurred, with fiscal policy being active 55 percent of the time. The authors do not break down the fiscal-policy response between taxes and transfer payments. Their results suggest that a single policy rule cannot accurately describe government responses under all circumstances.

VII. Models of Infinite-Lived Agents

Another strand of the literature has examined models of infinite-lived agents, which generally are variants of the original Ramsey (1928) model.

Early work was done by Judd (1985). In an economy with inelastic labor supply, he examined a policy that cuts labor and capital income taxes today and later reduces government spending. If the spending cuts are in the form of transfer payments (or government purchases that are perfectly substitutable for private consumption), then the capital stock and output grow steadily from the beginning. With an infinite horizon and Ricardian equivalence, the timing of the transfer-payment cuts is irrelevant. If the spending cuts are in the form of government purchases that are separable from private consumption, then capital is likely to decline in the short run, as consumption rises.

The work done in the 2000s has largely elaborated on the earlier findings without any profound changes. Yang (2007) studies an economy with infinite-horizon agents, some of whom intertemporally optimize and some of whom simply consume current disposable income. The government provides a consumption good, each unit of which is perfectly substitutable for 0.2 units of private consumption, investment in government capital that is complementary to private capital, and transfer payments to the non-savers. Yang considers a deficit-financed permanent reduction in the capital tax rate from 39 to 35.1 percent. She considers three fiscal reaction functions, each of which features a different fiscal instrument responding to the debt level; government consumption (-0.64 elasticity with respect to debt), government investment (-2.83 elasticity), or transfer payments (-5.32 elasticity). In each case, the capital income tax cut causes the debt-output ratio to rise from .43 to .46 in the new steady state.

When the debt is financed by reductions in government consumption, the tax cut has the expected effect on savers; they reduce current consumption and current leisure and enjoy greater future consumption and future leisure. Non-savers also enjoy higher consumption due to higher wages; the substitution effect of the higher wages also prompts higher labor supply. Output rises at all dates. Both groups experience a lifetime welfare gain from the tax cut, which is unsurprising given the limited utility from government consumption in the model.

When transfers to non-savers are reduced to finance debt, savers are affected by the tax cut in roughly the same manner as when government consumption is the financing tool. But, the capital tax cut then has adverse effects for non-savers, whose loss of transfers outweighs the increase in their wages. As a result, non-savers consume less and work harder. Output rises at all dates. Savers experience a welfare gain and non-savers a welfare loss.

Quite different results arise when debt is financed by reductions in government investment. Savers face lower consumption at most dates as the smaller government capital stock drives down rates of return on private capital. Non-savers also experience lower consumption at most dates due to declining wage rates. Output falls at all dates, except the first few years. Both groups experience a welfare loss from the tax cut.

Yang notes that, if the government responds less aggressively to debt, it must ultimately make a larger response because more debt accumulates. When it is government investment that responds, the less aggressive policy therefore magnifies the harmful effects.

Leeper and Yang (2008) study a similar economy, except that government consumption is separable (or, alternatively, worthless) and there is no government investment. They consider reductions in both labor and capital tax rates. When tax cuts of either type are financed by reductions in transfer payments, capital and labor both expand. When a capital tax cut is financed by labor tax increases, however, steady-state output falls, an initially surprising outcome. Although investment rises, labor supply falls in the steady state, which could be intertemporal substitution. When a labor tax cut is financed by reducing government consumption, private output falls in the steady state due to wealth effects. There is also a fall in the tax base when capital taxes finance the labor tax cut.

CBO (2008) also uses an infinite-horizon model to study the President's tax and budget proposals. When the revenue losses are offset by reductions in government spending, CBO finds that the proposals increase 2009-2013 GNP by 0.2 percent and 2014-2018 GNP by 0.3 percent. With the tax-rate adjustment, the increases are 0.2 percent in both periods. Long-run results are not presented.

VIII. Extensions and Conclusion

A variety of extensions that are not reflected in our results could usefully be undertaken.

One possible improvement would be to alter the baseline path. Due to the long-term fiscal imbalance, future tax rates are likely to be higher than current ones, increasing the marginal deadweight loss from boosting future tax rates. This alteration would reinforce the harmful effects of deficit-financed tax cuts, except when the debt is fully serviced on the spending side, because the marginal deadweight loss from the future tax increases would then exceed the marginal deadweight loss avoided by the current tax cut.

The model assumes that government debt carries an interest rate equal to the marginal product of capital. In reality, the interest rate on safe government debt is lower than the expected value of the stochastic marginal product of capital. If the difference is solely due to risk aversion, treating the interest rate as equal to the marginal product is probably the best approach. (Of course, it would be desirable to explicitly incorporate uncertainty, but that is a very difficult undertaking.) If the rate is lower due to other advantages of government debt, such as liquidity services, then it is appropriate to model the interest rate as lower than the marginal product. It might be useful to present results under that alternative assumption; it would ameliorate the harmful consequences of deficit-financed tax cuts.

An extension to an open-economy framework would be desirable, but poses challenging issues. The extension could make the greatest difference for analysis of changes in the corporate income tax because a change in the corporate income tax rate could trigger significant international capital flows in an open economy. The impact on capital flows would be muted, however, if a change in the U.S. corporate tax rate caused other countries to change their tax rates in the same direction.

The modeling of bequests poses difficult issues. Alternatives to the joy-of-giving framework that we adopted could be considered. For example, bequests could be modeled as accidental, resulting from individual lifespan uncertainty and the lack of perfect annuity markets. Of course, that approach would add complexity. Also, while some bequests clearly arise through this channel, it seems clear that the large bequests left by wealthy households must reflect other factors.

It must be acknowledged, however, that the joy-of-giving framework has some problematic features. When one generation leaves a private bequest to its children, the transfer is assumed to yield utility to both generations. If the same transfer is implemented through government fiscal policy, however, only the children's utility is assumed to be affected. Arguably, the different treatment accurately reflects the different attitudes that people have toward the two types of transactions. Still, it results in different utility effects from otherwise identical transactions, which is a departure from standard economic assumptions.

The proper modeling of bequests is a difficult question on which further work is necessary. It should be noted, though, that the joy-of-giving framework that we use produces a best-case scenario for future generations affected by deficit-financed tax cuts, since current generations offset part of future generations' losses through increased bequests. In any case, changing the modeling of bequests would probably have little impact on macroeconomic effects, such as the effect on saving, for the policies that we consider in this paper.

Our results and those of the other studies indicate that deficit-financed tax cuts can increase long-run output if the financing mechanism is less distortionary than the tax that is initially reduced and if the financing begins relatively soon after the tax cut is adopted. Even then, however, the shift in fiscal burdens generally reduces the well-being of future generations while increasing that of earlier generations.

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Table 1

Utility Function Parameter Values

Symbol	Description	Value	Source
	Consumers		
ρ	Rate of time preference	0.005	AAKSW
σ	Intertemporal elasticity of substitution	0.33	AAKSW, FR
ε	Intratemporal elasticity of substitution	0.8	FR
σ_{CH}	Elasticity of substitution for composite good and housing	0.8	-
σ_{TN}	Elasticity of substitution for taxed and non-taxed goods	0.5	-
σ_{RO}	Elasticity of substitution for rental and owner housing	2.0	-
α_E	Utility weight on leisure	0.23	-
α_C	Utility weight on composite consumption	0.77	-
α_G	Utility weight on composite non-housing consumption	0.78	-
α_H	Utility weight on composite housing consumption	0.22	-
α_{GT}	Utility weight on taxed non-housing consumption	0.56	-
α_{GN}	Utility weight on non-taxed non-housing consumption	0.44	-
α_O	Utility weight on owner-occupied housing	0.75	-
α_R	Utility weight on rental housing	0.25	-

NOTES: FR=Fullerton and Rogers (1993), AAKSW = Altig, et al. (2001).

Table 2

Technological Parameter Values

Symbol	Description	Value	Source
	Technology		
N	Population growth rate	0.01	AK, FR
G	Technological growth rate	0.01	AK, FR
α_1	Capital share in composite good production	0.25	-
α_2	Capital share in housing production	0.98	-
β_X	Composite good adjustment cost parameter	5	-
β_{rh}	Rental housing adjustment cost parameter	5	-
β_{oh}	Owner housing adjustment cost parameter	5	-
μ_X	Composite good adjustment cost parameter	0.1001	$\delta + 0.0201$
μ_h	Housing adjustment cost parameter	0.0386	$\delta_h + 0.0201$
ζ	Dividend payout ratio in the composite good sector	0.68	NIPA
b_X	Debt-to-capital ratio in composite good sector	0.35	FR
b_{rh}	Debt-to-capital ratio in the rental sector	0.35	FR
b_{oh}	Debt-to-capital ratio in the owner occupied sector	0.35	NIPA
δ	Economic depreciation in the composite good sector	0.1	-
δ_h	Economic depreciation in the housing sector	0.04	-

NOTES: AK = Auerbach and Kotlikoff (1987), FR = Fullerton and Rogers (1993), NIPA = National Income and Product Accounts.

Table 3

Initial Steady State Base Year Values ($ billions)

	Non-Housing	Rental Housing	Owner Housing	Total
Output	11760	536	1547	13844
Capital	14799	3734	12956	31489
Wages	8820	10	417	9490
Firm Value	9209	2420	8421	15640
Investment	1481	144	500	2126
Earnings	2368	-	-	2368
Services	-	138	472	610

Table 4

Initial Steady State Base Year Taxes and Targets ($ billions)

	Base Year Values	Target	Source
Federal Taxes	2609		NIPA
Income	1660		NIPA
Payroll	949		NIPA

Table 5

Initial Steady State Federal Tax Rates

Symbol	Description	Value
τ_{wmarg}	Income Weighted Marginal Wage Tax Rate	0.26
τ_{wave}	Average Wage Tax Rate	0.214
τ_d	Dividend Tax Rate	0.163
τ_i	Interest Income Tax Rate	0.152
τ_g	Composite good Capital Gains Tax Rate	0.05
τ_{gr}	Rental Housing Capital Gains Tax Rate	0.05
τ_{go}	Owner Housing Capital Gains Tax Rate	0
τ_s	Social Security Tax Rate	0.107
τ_{sb}	Social Security Benefit Tax Rate	0.052
τ_b	Effective Composite good Business Tax Rate	0.288
τ_{rs}	Effective Rental Housing Tax Rate	0.21

Table 6: Immediate Transfer Offset

	Year	2007	2008	2009	2012	2017	2027	2057	2107
Wage Tax Cut									
Δ	Before-Tax Interest Rate	0.23	0.02	0.01	0.01	-0.01	-0.02	-0.02	-0.02
Δ%	Before-Tax Wage Rate	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0
Δ%	Labor Supply	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Δ%	Investment NH	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5
Δ%	Investment RH	0.8	0.8	0.8	0.8	0.8	0.6	0.5	0.5
Δ%	Investment OH	0.8	0.9	0.8	0.8	0.8	0.6	0.5	0.5
Δ%	Consumption	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4
Δ%	GDP	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4
%	Debt to GDP	29.7	29.7	29.7	29.7	29.7	29.7	29.7	29.7
Interest Tax Cut									
Δ	Before-Tax Interest Rate	-0.05	-0.27	-0.27	-0.28	-0.28	-0.29	-0.30	-0.30
Δ%	Before-Tax Wage Rate	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Δ%	Labor Supply	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Δ%	Investment NH	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4
Δ%	Investment RH	0.6	0.6	0.6	0.6	0.6	0.5	0.4	0.4
Δ%	Investment OH	1.1	1.0	1.0	0.9	0.8	0.6	0.6	0.6
Δ%	Consumption	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0
Δ%	GDP	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
%	Debt to GDP	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8
Dividend Tax Cut									
Δ	Before-Tax Interest Rate	0.24	0.17	0.15	0.14	0.11	0.08	0.05	0.04
Δ%	Before-Tax Wage Rate	0.0	0.0	0.1	0.2	0.4	0.5	0.6	0.7
Δ%	Labor Supply	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Δ%	Investment NH	2.6	2.6	2.6	2.5	2.5	2.6	2.7	2.7
Δ%	Investment RH	-3.2	-2.6	-2.1	-1.4	-0.3	0.2	0.2	0.1
Δ%	Investment OH	-2.7	-2.2	-1.8	-1.2	-0.2	0.2	0.2	0.2
Δ%	Consumption	-0.2	-0.1	-0.1	0.0	0.2	0.3	0.4	0.4
Δ%	GDP	0.0	0.1	0.1	0.2	0.4	0.6	0.7	0.7
%	Debt to GDP	29.8	29.8	29.8	29.7	29.7	29.6	29.6	29.6
Corporate Tax Cut									
Δ	Before-Tax Interest Rate	0.48	0.15	0.12	0.12	0.10	0.08	0.05	0.05
Δ%	Before-Tax Wage Rate	0.0	0.0	0.1	0.1	0.3	0.4	0.5	0.5
Δ%	Labor Supply	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Δ%	Investment NH	1.9	1.9	1.9	1.9	1.9	1.9	2.1	2.1
Δ%	Investment RH	-2.8	-2.2	-1.9	-1.3	-0.4	0.0	0.0	0.0
Δ%	Investment OH	-2.3	-1.9	-1.6	-1.1	-0.3	0.0	0.1	0.0
Δ%	Consumption	-0.1	-0.1	-0.1	0.0	0.1	0.2	0.3	0.3
Δ%	GDP	0.0	0.1	0.1	0.2	0.3	0.5	0.5	0.5
%	Debt to GDP	29.8	29.8	29.8	29.7	29.7	29.7	29.6	29.6
Tax Credit Increase									
Δ	Before-Tax Interest Rate	0.04	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02
Δ%	Before-Tax Wage Rate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Δ%	Labor Supply	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Δ%	Investment NH	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2
Δ%	Investment RH	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.1
Δ%	Investment OH	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1
Δ%	Consumption	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0
Δ%	GDP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%	Debt to GDP	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8

Table 7: Transfer Offset After 10 Years

	Year	2007	2008	2009	2012	2017	2027	2057	2107
Wage Tax Cut									
Δ	Before-Tax Interest Rate	0.16	0.03	0.03	0.02	0.03	0.04	0.08	0.08
Δ%	Before-Tax Wage Rate	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2
Δ%	Labor Supply	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Δ%	Investment NH	0.2	0.2	0.2	0.2	0.1	0.0	-0.2	-0.2
Δ%	Investment RH	0.5	0.5	0.5	0.4	0.2	0.0	-0.2	-0.2
Δ%	Investment OH	0.6	0.5	0.5	0.4	0.2	0.0	-0.2	-0.1
Δ%	Consumption	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4
Δ%	GDP	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
%	Debt to GDP	29.7	30.0	30.3	30.9	32.8	33.3	33.3	33.3
Interest Tax Cut									
Δ	Before-Tax Interest Rate	-0.11	-0.25	-0.26	-0.26	-0.26	-0.25	-0.22	-0.22
Δ%	Before-Tax Wage Rate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
Δ%	Labor Supply	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Δ%	Investment NH	0.1	0.1	0.1	0.1	0.1	0.0	-0.2	-0.2
Δ%	Investment RH	0.4	0.4	0.4	0.3	0.1	0.0	-0.2	-0.1
Δ%	Investment OH	0.8	0.8	0.7	0.6	0.4	0.2	0.0	0.0
Δ%	Consumption	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Δ%	GDP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%	Debt to GDP	29.8	30.1	30.3	30.8	32.3	32.7	32.7	32.7
Dividend Tax Cut									
Δ	Before-Tax Interest Rate	0.17	0.17	0.17	0.16	0.16	0.15	0.17	0.17
Δ%	Before-Tax Wage Rate	0.0	0.0	0.1	0.2	0.3	0.4	0.4	0.4
Δ%	Labor Supply	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Δ%	Investment NH	2.3	2.3	2.3	2.2	2.1	2.0	1.8	1.8
Δ%	Investment RH	-3.5	-3.0	-2.6	-2.0	-1.1	-0.6	-0.8	-0.7
Δ%	Investment OH	-3.1	-2.6	-2.3	-1.7	-1.0	-0.5	-0.7	-0.6
Δ%	Consumption	-0.1	-0.1	0.0	0.1	0.2	0.4	0.5	0.4
Δ%	GDP	0.0	0.1	0.1	0.2	0.4	0.5	0.5	0.5
%	Debt to GDP	29.8	30.1	30.5	31.3	33.6	34.1	34.1	34.1
Corporate Tax Cut									
Δ	Before-Tax Interest Rate	0.41	0.15	0.14	0.14	0.14	0.14	0.17	0.17
Δ%	Before-Tax Wage Rate	0.0	0.0	0.1	0.1	0.2	0.3	0.3	0.3
Δ%	Labor Supply	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Δ%	Investment NH	1.7	1.7	1.6	1.6	1.5	1.4	1.2	1.2
Δ%	Investment RH	-3.1	-2.6	-2.3	-1.8	-1.1	-0.7	-0.9	-0.8
Δ%	Investment OH	-2.7	-2.3	-2.0	-1.6	-1.0	-0.7	-0.8	-0.7
Δ%	Consumption	-0.1	0.0	0.0	0.1	0.2	0.3	0.4	0.3
Δ%	GDP	0.0	0.1	0.1	0.2	0.3	0.4	0.4	0.4
%	Debt to GDP	29.8	30.2	30.5	31.3	33.9	33.9	33.9	33.9
Tax Credit Increase									
Δ	Before-Tax Interest Rate	-0.03	0.00	0.00	0.01	0.02	0.05	0.10	0.10
Δ%	Before-Tax Wage Rate	0.0	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.2
Δ%	Labor Supply	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Δ%	Investment NH	-0.1	-0.1	-0.1	-0.2	-0.3	-0.4	-0.7	-0.7
Δ%	Investment RH	-0.2	-0.2	-0.3	-0.3	-0.5	-0.6	-0.8	-0.7
Δ%	Investment OH	-0.2	-0.2	-0.3	-0.3	-0.5	-0.6	-0.7	-0.7
Δ%	Consumption	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Δ%	GDP	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
%	Debt to GDP	29.8	30.1	30.5	31.2	34.1	34.1	34.1	34.1

Table 8: Tax Offset After 10 Years

	Year	2007	2008	2009	2012	2017	2027	2057	2107
Wage Tax Cut									
Δ	Before-Tax Interest Rate	0.13	0.03	0.03	0.03	0.04	0.06	0.13	0.15
Δ%	Before-Tax Wage Rate	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.4	-0.4
Δ%	Labor Supply	0.4	0.4	0.4	0.4	0.4	0.1	0.1	0.1
Δ%	Investment NH	0.0	0.0	-0.1	-0.2	-0.7	-1.1	-1.5	-1.6
Δ%	Investment RH	0.3	0.3	0.2	0.1	-0.3	-1.3	-1.4	-1.3
Δ%	Investment OH	0.6	0.6	0.6	0.5	0.6	-0.6	-0.8	-0.7
Δ%	Consumption	0.3	0.3	0.3	0.4	0.4	0.1	0.0	-0.1
Δ%	GDP	0.3	0.3	0.3	0.3	0.3	-0.1	-0.2	-0.3
%	Debt to GDP	29.7	30.0	30.3	30.9	32.9	33.5	33.5	33.6
Interest Tax Cut									
Δ	Before-Tax Interest Rate	-0.13	-0.25	-0.26	-0.26	-0.27	-0.24	-0.19	-0.18
Δ%	Before-Tax Wage Rate	0.0	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.3
Δ%	Labor Supply	0.0	0.0	0.0	0.0	0.0	-0.2	-0.2	-0.2
Δ%	Investment NH	0.0	0.0	0.0	-0.1	-0.5	-0.9	-1.2	-1.3
Δ%	Investment RH	0.2	0.2	0.2	0.0	-0.3	-1.1	-1.2	-1.1
Δ%	Investment OH	0.9	0.9	0.8	0.7	0.8	-0.4	-0.5	-0.5
Δ%	Consumption	0.0	0.0	0.0	0.0	0.0	-0.2	-0.3	-0.4
Δ%	GDP	0.0	0.0	0.0	0.0	0.0	-0.3	-0.4	-0.5
%	Debt to GDP	29.8	30.1	30.3	30.8	32.4	32.9	32.9	32.9
Dividend Tax Cut									
Δ	Before-Tax Interest Rate	0.14	0.17	0.17	0.17	0.16	0.19	0.24	0.25
Δ%	Before-Tax Wage Rate	0.0	0.0	0.1	0.2	0.3	0.3	0.2	0.2
Δ%	Labor Supply	0.1	0.1	0.1	0.1	0.0	-0.3	-0.3	-0.3
Δ%	Investment NH	2.2	2.1	2.0	1.9	1.2	0.8	0.5	0.4
Δ%	Investment RH	-3.8	-3.3	-2.9	-2.4	-1.8	-2.0	-2.0	-1.9
Δ%	Investment OH	-3.0	-2.6	-2.2	-1.6	-0.6	-1.3	-1.4	-1.3
Δ%	Consumption	-0.1	0.0	0.0	0.1	0.3	0.1	0.0	0.0
Δ%	GDP	0.0	0.1	0.1	0.2	0.3	0.1	0.0	0.0
%	Debt to GDP	29.8	30.1	30.5	31.3	33.7	34.4	34.4	34.4
Corporate Tax Cut									
Δ	Before-Tax Interest Rate	0.37	0.15	0.14	0.15	0.15	0.18	0.24	0.25
Δ%	Before-Tax Wage Rate	0.0	0.0	0.1	0.1	0.2	0.2	0.1	0.0
Δ%	Labor Supply	0.0	0.0	0.0	0.0	0.0	-0.3	-0.3	-0.3
Δ%	Investment NH	1.5	1.5	1.4	1.3	0.7	0.2	-0.1	-0.2
Δ%	Investment RH	-3.3	-2.9	-2.6	-2.2	-1.7	-2.1	-2.1	-2.0
Δ%	Investment OH	-2.6	-2.2	-2.0	-1.5	-0.6	-1.4	-1.4	-1.4
Δ%	Consumption	0.0	0.0	0.0	0.1	0.2	0.0	-0.1	-0.1
Δ%	GDP	0.0	0.1	0.1	0.2	0.2	0.0	-0.1	-0.2
%	Debt to GDP	29.8	30.2	30.5	31.3	33.5	34.1	34.2	34.2
Tax Credit Increase									
Δ	Before-Tax Interest Rate	-0.06	0.00	0.01	0.01	0.03	0.08	0.18	0.20
Δ%	Before-Tax Wage Rate	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.5	-0.5
Δ%	Labor Supply	0.0	0.0	0.0	0.0	0.0	-0.4	-0.4	-0.4
Δ%	Investment NH	-0.3	-0.3	-0.4	-0.5	-1.1	-1.8	-2.4	-2.5
Δ%	Investment RH	-0.4	-0.5	-0.6	-0.7	-1.0	-2.4	-2.4	-2.2
Δ%	Investment OH	-0.1	-0.1	-0.1	-0.1	0.1	-1.5	-1.6	-1.5
Δ%	Consumption	0.0	0.0	0.0	0.0	0.0	-0.4	-0.6	-0.6
Δ%	GDP	0.0	0.0	0.0	0.0	-0.1	-0.5	-0.8	-0.8
%	Debt to GDP	29.8	30.1	30.5	31.2	33.6	34.4	34.4	34.5

Figure 1: Equivalent Variation - No Debt Finance

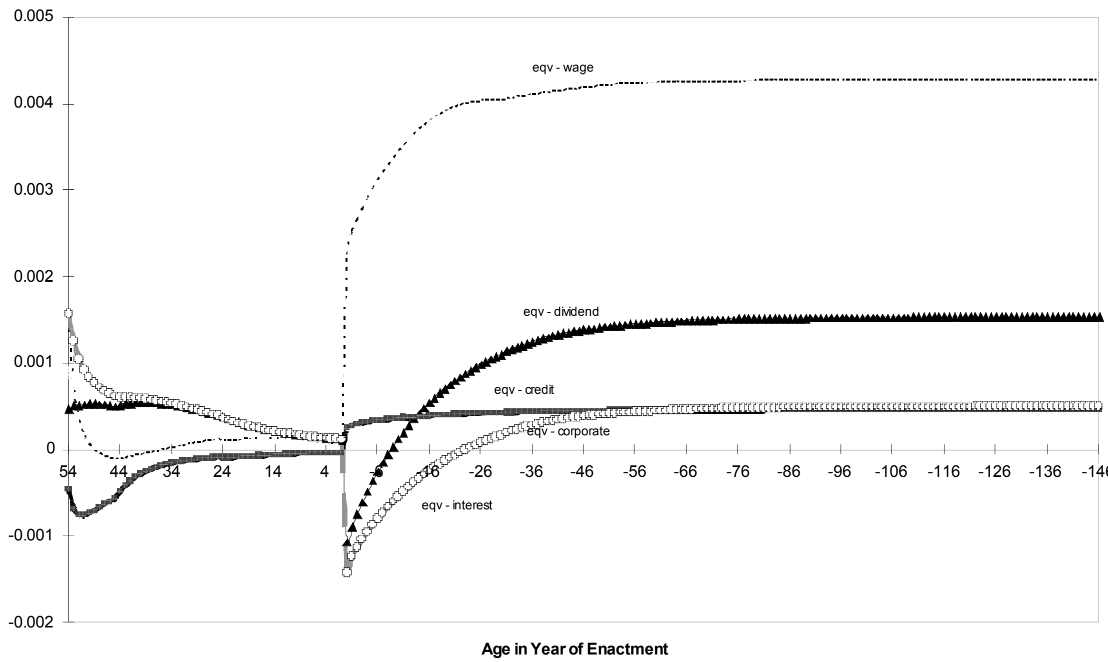


Figure 2: Equivalent Variation - Transfer Offset After 10 years

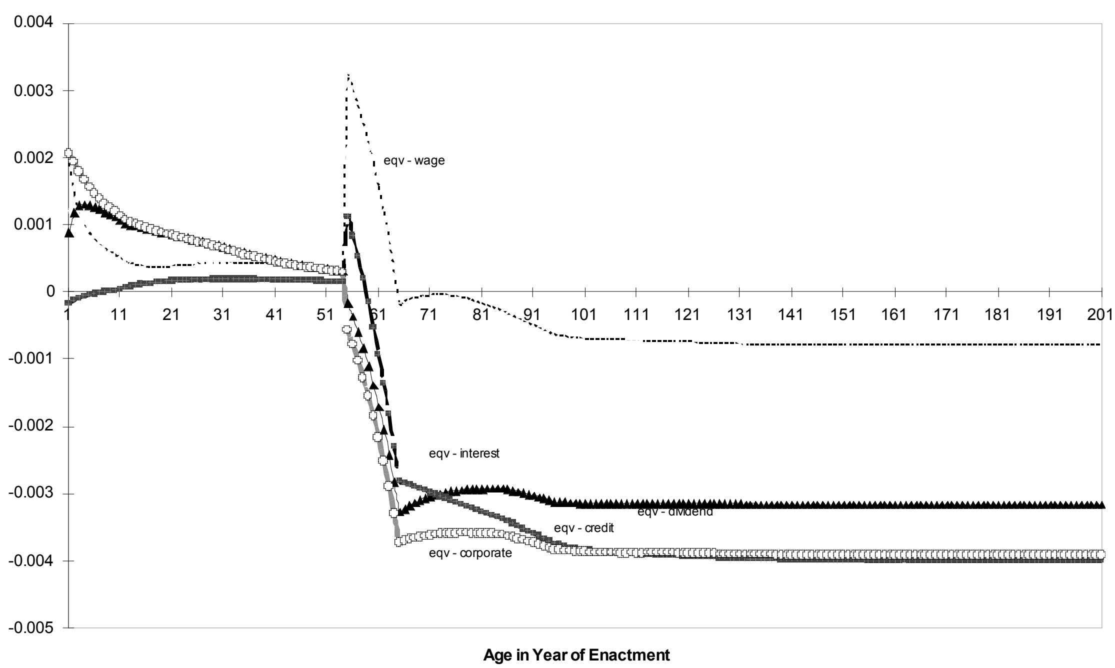


Figure 3: Equivalent Variation - Tax Offset after 10 Years

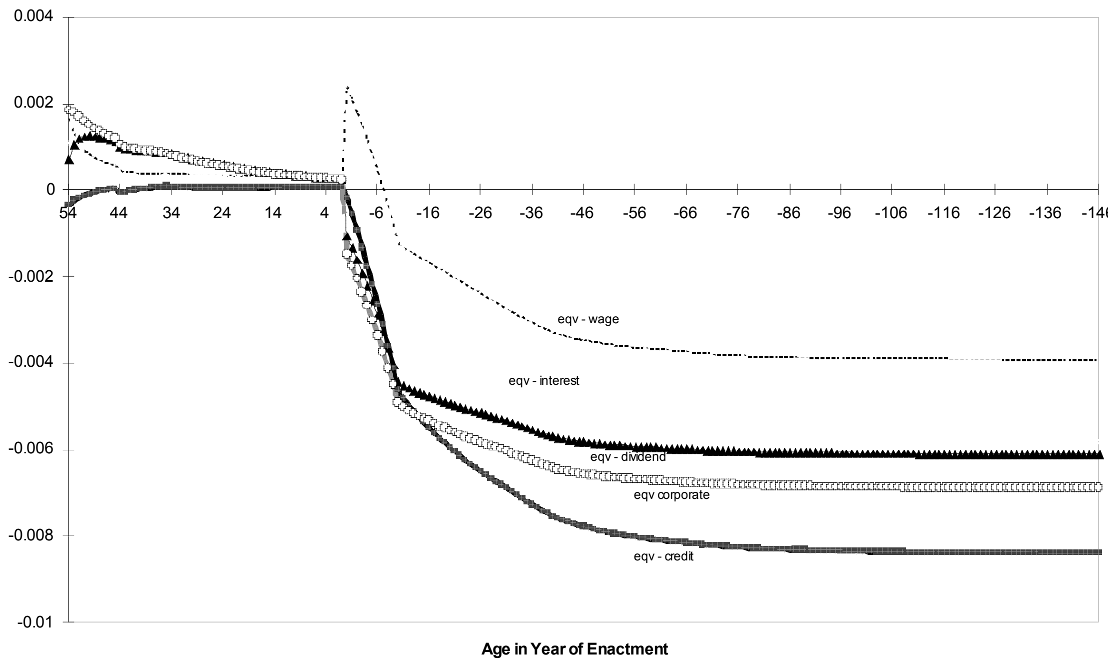
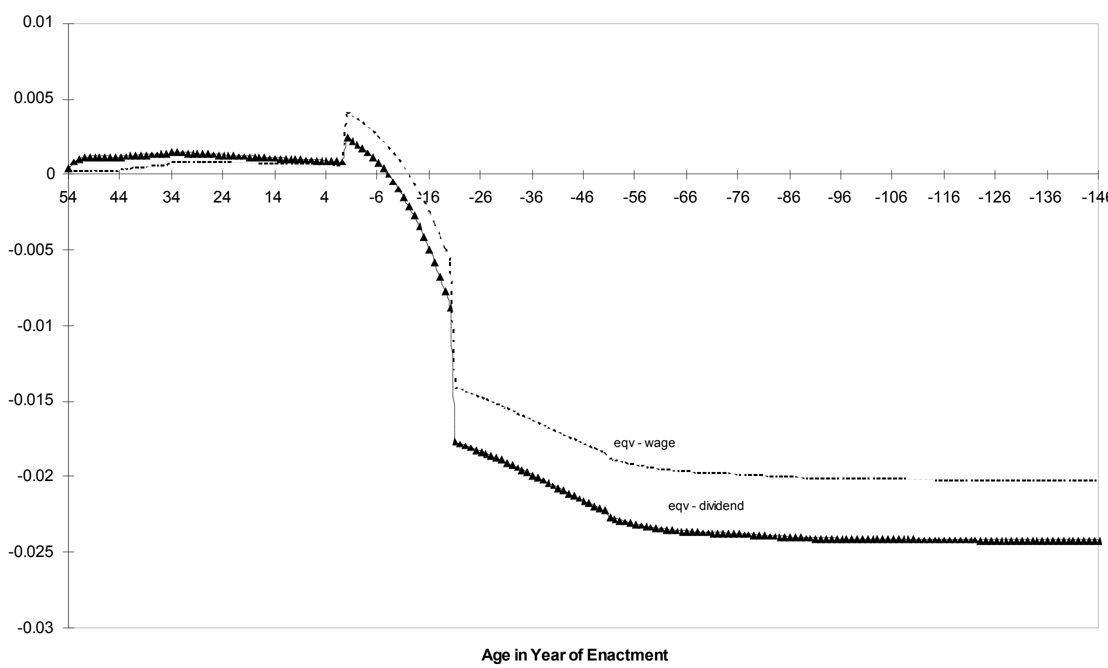


Figure 4: Equivalent Variation - Tax Offset after 20 Years



APPENDIX

This appendix provides a more detailed description of the model utilized in sections IV and V of this paper. A complete description is provided in Diamond and Zodrow (2005).

A. The Non-Residential Production Sector

In each period *s*, firms in the composite good production sector produce output (X_s) using capital K_s^X and labor L_s^X using a CES production function with an elasticity of substitution in production σ_X and a capital share parameter a_X. Firms are assumed to choose the time path of investment to maximize the present value of firm profits or, equivalently, maximize firm value V_X, net of all taxes. Total taxes in the composite good production sector in period *s*, are

$$T_s^X = \tau_{bs}^X \left[p_s^X X_s - w_s L_s^X - f_{FT} I_s^X - \Phi_s^X I_s^X - f_{IT} i_s B_s^X - f_{IT} \delta_\tau^X K_{\tau s}^X \right] + (1-\tau_{bs}^X)\tau_{ps}^X K_s^X ,$$

where τ_{bs} is the tax rate on business income in the composite good sector, p_s^X is the price of the composite good, w_s is the wage rate, I_s^X is gross investment, Φ_s^X are (deductible) adjustment costs per unit of investment, i_s is the before-tax interest rate, B_s^X is total indebtedness, $\delta_{\tau s}^X$ is depreciation for tax purposes, $K_{\tau s}^X$ is the remaining tax basis of the capital stock, τ_{ps}^X is the property tax rate on both composite good sector and non-residential capital, with property taxes assumed to be fully deductible against the business income tax, and f_{IT} (f_{FT}) is one under the income tax (flat tax) and zero otherwise.[13]

Following Goulder and Summers (1989) and Cummins, Hassett and Hubbard (1994), the adjustment cost function per unit of investment is assumed to be a quadratic function of gross investment per unit of capital

$$\Phi_s\left(\frac{I_s^X}{K_s^X}\right) = \frac{p_s^X(\beta^X/2)(I_s^X/K_s^X - \mu^X)^2}{I_s^X/K_s^X}$$

where β^X is the parameter that determines the level of adjustment costs and μ^X is set so that adjustment costs are zero in the steady state.

Assuming firms do not make any financial investments, total net cash receipts, including net new bonds issued B_s^X and net new shares issued VN_s^X, must either be used to finance new investments (including adjustment costs) or distributed to shareholders

$$[p_s^X X_s - w_s L_s^X - i_s B_s^X] - T_s^X + BN_s^X + VN_s^X = I_s^X\left(1+\Phi_s^X\right) + DIV_s^X ,$$

where DIV_s^X is the dividend payout in the composite good sector. Each firm is assumed to maintain a fixed debt/asset ratio b^X and pay out a constant fraction of earnings after taxes and depreciation in each period. This implies that new investments are financed with debt and new share issues if retained earnings do not supply enough equity to finance the desired level of investment.

The model assumes individual-level arbitrage, which implies that the after-tax return to bonds must equal the after-tax return received by the shareholders of the firm, or

[13] The property tax on businesses is treated as a tax on capital rather than a benefit tax (Muthitacharoen and Zodrow, forthcoming).

$$\left(1-\tau_{bs}^{X}\right)i_{s}=\frac{\left(1-\tau_{ds}\right)DIV_{s}^{X}+\left(1-\tau_{gs}\right)\left(V_{s+1}^{X}-V_{s}^{X}-VN_{s}^{X}\right)}{V_{s}^{X}},$$

where τ_{is} is the average marginal personal income tax rate on interest income, τ_{ds} is the average marginal tax rate on dividends, τ_{gs} is the average effective annual accrual tax rate on capital gains $\left(V_{s+1}^{X}-V_{s}^{X}-VN_{s}^{X}\right)$. Solving this expression for V_{s}^{X}, subject to the transversality condition requiring a finite value of the firm, yields

$$V_{s}^{X}=\sum_{u=s}^{\infty}\frac{\left[\left(1-\tau_{du}\right)/\left(1-\tau_{gu}\right)\right]DIV_{u}^{X}-VN_{u}^{X}}{\prod_{v=s}^{u}\left[1+(1-\tau_{iu})i_{u}/(1-\tau_{gu})\right]},$$

That is, the value of the firm in the composite good sector equals the present value of all future net distributions to the owners of the firm. The time path of investment that maximizes this expression in the presence of adjustment costs is

$$\frac{I_{s}^{X}}{K_{s}^{X}}=\frac{q_{s+1}^{X}-1+b^{X}+f_{FT}\Omega_{s}^{X}\tau_{bs}+f_{IT}Z_{s+1}^{X}}{p_{s}^{X}\beta^{X}\left(1-\tau_{bs}\Omega_{s}^{X}\right)},$$

where q_{s+1}^{X} is shadow price of additional capital (commonly referred to as ‘marginal q’ which equals the ratio of the market value of a marginal unit of capital to its replacement cost), Ω_{s}^{X} is a weighted average of the dividend and capital gains tax rates divided by one minus the capital gains tax rate, and Z_{s+1}^{X} is the tax savings from accelerated depreciation allowances on future investments.

The relationship between ‘marginal q’ and ‘average q’ (denoted as Q_{s}^{X}) is

$$q_{s}^{X}=\frac{V_{s}^{X}-X_{s}^{X}}{K_{s}^{X}}=Q_{s}^{X}-\frac{X_{s}^{X}}{K_{s}^{X}}$$

where X_{s}^{X} is the value of future accelerated depreciation deductions on the existing stock of capital used in the production of the composite good.

B. The Owner-Occupied and Rental Housing Production Sectors

Housing is produced in the owner-occupied and rental housing production sectors. Following Goulder and Summers (1989) and Goulder (1989), rental housing is produced by non-corporate landlords and owner-occupied housing is produced by the owners. The technology used in the production of rental housing (R_{s}) and owner-occupied housing (O_{s}) is assumed to be identical – capital and labor combined in a CES production function with an elasticity of substitution in production of σ_{H} and a capital share parameter of a_{H}.[14] Landlords and owner-occupiers are also are assumed to choose time paths of investment to maximize the equivalent of firm value, net of total taxes.

[14] Thus, the producer prices of rental and owner-occupied housing services are identical. However, rental and owner-occupied housing services are not perfect substitutes, so that the mix of rental and owner-occupied housing services changes along the transition path to a new equilibrium.

In the case of the rental housing sector, the firm is modeled as a non-corporate firm. This implies that landlords are taxed at the individual level, so total taxes paid are

$$T_s^R = \tau_{bs}^R \left[p_s^R R_s - w_s L_s^R - f_{FT} I_s^R - \Phi_s^R I_s^R - f_{IT} i_s B_s^R - mK_s^R - f_{IT} \delta_\tau^R K_{\tau s}^R \right] + (1-\tau_{bs}^R)\tau_{ps}^R K_s^R,$$

where τ_{bs}^R is the average marginal tax rate applied to rental housing income,[15] m is annual maintenance expenditures per unit of rental housing capital, and the definitions of all other variables are analogous to those in the composite good production sector. Solving the cash flow equation in the rental housing sector for after-tax rents received by landlords S_s^R yields

$$S_s^R = p_s^R F_s^R(\cdot) - w_s L_s^R - i_s B_s^R - mK_s^R - T_s^R + BN_s^R + E_s^R - I_s^R(1+\Phi_s^R),$$

where E_s^R is net new equity invested by landlords in the rental housing sector. Individual arbitrage in this case implies

$$\left(1-\tau_{is}\right) i_s = \frac{S_s^R + \left(1-\tau_{gs}\right)\left(V_{s+1}^R - V_s^R - E_s^R\right)}{V_s^R}$$

which can be solved for the value of the rental housing firm

$$V_s^R = \sum_{u=s}^{\infty} \frac{\left[1\big/\left(1-\tau_{gu}\right)\right] S_s^R - E_s^R}{\prod_{v=s}^{u}\left[1+(1-\tau_{iu}) i_s \big/ (1-\tau_{gu})\right]}.$$

The time path of investment that maximizes this expression in the presence of adjustment costs is

$$\frac{I_s^R}{K_s^R} = \frac{q_{s+1}^R - \Omega_s^R + b^R \Omega_s^R + f_{FT}\Omega_s^R \tau_{bs}^R + f_{IT} Z_{s+1}^R}{\mathrm{p_s} \Omega_s^R \beta^R \left(1-\tau_{bs}^R\right)}.$$

The expression for relationship between 'marginal *q*' and 'average *q*' in the rental housing sector is analogous to that in the composite good sector.

By comparison, in the owner-occupied housing sector, since imputed rents are untaxed and maintenance expenditures are not deductible while mortgage interest and property taxes are deductible, total taxes are

$$T_s^O = -z_s \tau_{is} i_s B_s^O + (1 - z_s \tau_{is}) \tau_{ps}^O K_s^O,$$

where z_s is the fraction of individuals who are itemizers. The flow of (untaxed) imputed rents to owner-occupiers is

$$S_s^O = p_s^O F_s^O - w_s L_s^O - i_s B_s^O - T_s^O - mK_s^O + BN_s^O + E_s^O - I_s^O(1+\Phi_s^O)$$

The expressions for individual level arbitrage and firm value are analogous to those in the rental housing sector, and investment in the owner-occupied sector is

$$\frac{I_s^O}{K_s^O} = \frac{q_{s+1}^O - \Omega_s^O + b^O \Omega_s^O}{\mathrm{p_s} \Omega_s^O \beta^O}.$$

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[15] The tax rate on rental housing income is a weighted average of the non-corporate tax rate on landlord profits and the corporate tax rate. The weight is determined by the share of rental housing produced in the corporate sector, which is equal to 10 percent.

The expression for relationship between 'marginal *q*' and 'average *q*' in the owner-occupied housing sector is analogous to that in the composite good sector.

C. Individual Behavior

On the individual side, the model has a dynamic overlapping generations framework with fifty-five generations alive at each point in time. There is a representative individual for each generation, who has an economic life span (which begins upon entry into the work force) of fifty-five years, with the first forty-five of those years spent working, and the last ten spent in retirement. Individual tastes are identical so that differences in behavior across generations are due solely to differences in lifetime budget constraints. An individual accumulates assets from the time of "economic birth" that are used to finance both consumption over the life cycle, especially during the retirement period, and the making of bequests. The model includes a joy-of-giving bequest motive. Inheritances are assumed to be received at the economic age of 25.

At any point in time *s*, the consumer maximizes rest-of-life utility LU_s subject to a lifetime budget constraint that requires the present value of lifetime wealth including inheritances to equal the present value of lifetime consumption including bequests. In particular, an individual of age *a* at time *s*=*t* chooses the time path of consumption of an aggregate consumption good and leisure in each period *s* to maximize rest-of-life utility

$$LU_s = \frac{\sigma}{\sigma - 1} \sum_{s=t}^{t+54-a} \frac{U_s(a)^{\left(1-\frac{1}{\sigma}\right)}}{\left(1+\rho\right)^{s-t}},$$

where σ is the intertemporal elasticity of substitution, ρ is the pure rate of time preference, and $U_s(a)$ is assumed to be a CES function of consumption of the aggregate consumption good and leisure in period *s* with an intratemporal elasticity of ε and a leisure share parameter of a_E. The aggregate consumption good is modeled as a CES function of the composite good and aggregate housing services (including a minimum purchase requirement for both goods), with aggregate housing services in turn modeled as CES function of owner-occupied and rental housing services. In addition, as described in detail in Diamond and Zodrow (2005), the model includes exogenous population and technology growth rates, a simple social security system, government purchases of the composite good, transfer payments, a hump-backed wage profile over the life cycle, a progressive tax on wage income, and constant effective marginal tax rates applied to interest income, dividends, and capital gains.