PROMOTING GROWTH, MAINTAINING PROGRESSIVITY, AND DEALING WITH THE FISCAL CRISIS: CGE SIMULATIONS OF A TEMPORARY VAT USED FOR DEBT REDUCTION

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ABSTRACT

Tradeoffs between economic efficiency, growth, and distributional equity permeate economics, including discussions of tax policy and tax reform. Computable general equilibrium (CGE) modeling is one tool that is often used to estimate the magnitudes of the variables that determine the efficiency, growth, and equity properties of alternative tax reforms. In this paper, we report the results of simulations of a CGE model that examines the economic and distributional effects of the enactment in the United States of a temporary value-added tax used to reduce the level of the national debt. The results suggest that such a reform is generally moderately progressive both for cohorts alive at the time of reform and for future generations, at least within the context of lifetime measures of tax burden, and that current middle-aged and elderly generations must bear a burden to confer a gain, relative to the status quo, on young and future generations.

Keywords: economic growth, progressivity, debt reduction, computable general equilibrium modeling, value-added taxation

JEL Codes: H21, H23, H63

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1. INTRODUCTION

Tradeoffs between economic efficiency and growth on the one hand and distributional equity on the other permeate economics, and the design of tax policy is no exception. Moreover, tax policy prescriptions depend heavily not only on the relative importance attached to efficiency and equity concerns but also on the magnitudes of the many behavioral responses to taxation. For example, the often contentious debate about the optimal progressivity of the income tax depends not only on the degree of social concern about income inequality and the extent of such inequality but also on the incentive effects of high marginal tax rates on labor supply.[1] Similarly, efficiency/growth and equity tradeoffs abound in debates regarding the optimal tax base. The traditional analysis supports a comprehensive annual income tax base as an equitable measure of ability to pay tax and an efficient tax base that does not distort choices regarding the sources and uses of income. This conclusion, however, has been strongly challenged in recent years, as proponents of a consumption tax base argue that it is both more equitable, in that it does not discriminate against those who save more over their life cycles, and more efficient, as the taxation of saving is highly distortionary.[2] Consumption-based taxation, however, is widely believed to be less progressive—although this concern can be addressed to some extent with progressive tax rates under direct consumption taxes and is mitigated by evaluating tax burdens relative to ability to pay over a relatively long time horizon. A middle ground has been suggested

by various recent papers (as well as actual reforms such as the dual income taxes enacted in the Nordic countries and elsewhere) which argue for a variety of reasons that some taxation of capital income is desirable on efficiency grounds, although likely at rates lower than those applied to labor income.[3] In addition, some capital income taxation may be desirable to reduce incentives for tax avoidance and evasion.

A common and critical element of all of these arguments is the need for quantitative economic models that analyze how various tax systems affect the economy and thus can estimate the magnitudes of the changes in the variables that determine the efficiency, growth, and equity properties of alternative tax systems, especially since the models that underlie the theoretical results described above are by necessity fairly simple representations of reality. This paper focuses on one approach that has been commonly used to address these issues — the construction of much more complex (although nevertheless still highly stylized) dynamic computable general equilibrium (CGE) models that can be used to estimate the macroeconomic and intragenerational and intergenerational distributional effects of tax reforms.[4]

In addition, as has been widely documented, the United States faces serious debt and deficit problems over the next decade (Congressional Budget Office (CBO) 2013), and in the long run is on an unsustainable fiscal path (Auerbach and Gale 2011). Realistic solutions will almost assuredly involve both spending reductions, especially in the Medicare, Medicaid, and Social Security programs, as well as tax increases; such an approach characterizes the two most prominent recent deficit reduction plans, the Simpson-Bowles report (National Commission of Fiscal Responsibility and Reform 2010) and the Rivlin-Domenici report (Bipartisan Policy Center 2010). The two reports, however, raise revenues in different ways, as Simpson-Bowles

uses revenues from corporate and individual income tax reform for deficit reduction, while Rivlin-Domenici raises revenue with a new value-added tax (VAT).[5]

The introduction of such a VAT targeted for debt reduction provides an excellent example of the efficiency/growth and equity tradeoff associated with raising additional tax revenues to address our fiscal problems. The exact nature of this tradeoff depends on the specifics of the VAT. Efficiency and administrative considerations (and horizontal equity concerns with respect to households with different consumption patterns) argue for a broad-based VAT that includes most forms of consumption; moreover, such a broad-based VAT would obviously have the largest impact in terms of debt reduction at any given tax rate. Vertical equity concerns for households at the bottom of the income distribution argue for a rebate that would offset the effects of the new VAT on such households, typically those in the neighborhood of the poverty level of consumption, with the rebate phased out at higher income levels to limit its revenue cost and impact on debt reduction. Moreover, as a consumption-based tax that would not further distort savings decisions, a broad-based VAT is generally believed to be one of the most efficient ways to raise revenues and reduce the deficit.[6] On the other hand, as noted above, the VAT is also generally believed to be a regressive tax, or at best a roughly proportional tax with respect to lifetime income (for those above the poverty level of income if the VAT includes a means-tested rebate).[7] [8]

To investigate these issues, this paper presents the results of some simulations of a CGE model that examine the macroeconomic and distributional effects of a broad-based, temporary VAT used for deficit reduction, in order to estimate the efficiency and growth effects as well as the equity implications of such a reform.[9] Specifically, the paper considers a temporary ten-year VAT, with all of the resulting net revenues used to achieve debt reduction.

The use of a dynamic, overlapping generations CGE model is especially useful in this context, as the introduction of a temporary VAT would have many complex economic and intra- and inter-generational distributional effects on the economy, both in the short run and the long run, that would not be captured with static or partial equilibrium analyses. These include the short and long run effects of VAT-financed reductions in the national debt (and the associated reductions in interest payments on the debt) on private savings and investment, the capital stock, asset prices, labor supply, interest rates, and wages. At the same time, however, the benefits of such a VAT would occur in the long run, while declines in consumption and labor supply would occur immediately, as would declines in real asset values due to the one-time price increase associated with the VAT (Diamond and Zodrow 2007, 2008). Enactment of a temporary VAT for debt reduction would thus have very different effects across generations as well as within generations, with current generations, especially the late-middle-aged and elderly households, in general experiencing welfare losses that would be offset by long run gains to younger and future generations. All of these effects on economic efficiency and growth, and on intergenerational and intragenerational redistributions are captured in our CGE simulation analysis.

At the same time, however, our CGE model has its limitations in analyzing the macroeconomic and distributional effects of a temporary VAT, beyond the standard concerns regarding the validity of the structural assumptions of the model, the choices of functional forms and parameter values and the sensitivity of the results to those choices, the compromises that must be made in imposing steady-state equilibrium conditions on the model, and the difficulties of modeling complex tax systems in model-equivalent forms (Gravelle 2006; Diamond and Zodrow 2006). Most importantly, the model assumes that the economy begins and ultimately ends in a steady state equilibrium. Thus, the model assumes that the economy is currently at a

high—but not an ever-increasing and thus unsustainable—debt/GDP ratio, and does not capture the potentially large benefits that a debt-reducing VAT might have in terms of reducing the likelihood of a catastrophic financial meltdown (Burman et al. 2010. In addition, although the model captures changes in labor supply associated with implementing a VAT, these changes are in the context of a full employment model, and thus do not directly capture any employment benefits of a successful debt reduction policy (although the model does so indirectly to the extent that the parameter values utilized implicitly reflect changes in labor force participation as well as changes in hours worked). Similarly, interest rates in the model are initially assumed to be at a full employment equilibrium level, given a relatively high national debt/GDP ratio, and thus are able to fall when the debt is reduced; by comparison, in the current high unemployment environment, interest rates are exceedingly low by historical standards and have little room to decline further. The simulation results presented in this paper should thus be interpreted as reflecting the effects of a debt-reducing VAT that moves the economy from a steady state full employment equilibrium characterized by a high national debt/GDP ratio, through an extended transition period, to another steady state full employment equilibrium with a much lower debt/GDP ratio[10], without capturing any of the benefits associated with moving the economy away from its current unsustainable fiscal path. At the same time, however, it should also be noted that it is not clear that these effects have yet been reflected in current economic conditions, as financial markets arguably appear to be assuming that the nation's debt and deficit problems will be addressed before a fiscal calamity occurs.

The paper proceeds as follows. The following section provides some context by briefly reviewing three key previous CGE simulation studies that examined the efficiency/growth and equity tradeoffs discussed above in the context of reforms different from the one we are

studying; this discussion focuses on lessons that are applicable to our analysis. Section III describes the details of the temporary debt-reducing VAT that we model, and provides a brief overview of the model that we use for the simulations. Section IV presents the simulation results for a benchmark case, as well as some results that examine the effects of expanding the VAT base and the effects of eliminating the rebate. The final section summarizes the results and their implications, and offers some caveats to the analysis and directions for future research. An appendix provides details on the parameters used in the simulations; see Gunning, Diamond, and Zodrow (2008) for a discussion of parameter choices in CGE models.

2. OVERVIEW OF EARLIER CGE STUDIES

Numerous studies have examined the efficiency/growth and equity tradeoffs in designing tax policy with the context of dynamic overlapping generations CGE models. In this section, we briefly review the results presented in three of the most prominent studies.

The seminal model constructed by Auerbach and Kotlikoff (1987) is limited in its capacity to analyze equity issues because it has only a single representative individual in each of its overlapping generations; nevertheless, it can still be used to examine the effects of different tax rates and tax bases, as the tax rates faced by households vary over their life cycles. In particular, Auerbach and Kotlikoff compare the relative effects of equal-yield progressive and proportional income, wage, and consumption taxes. They estimate that the long run efficiency cost of adding progressivity under both the wage and income taxes is reflected in a long run reduction of about 1 percent of national income, while replacing a proportional income tax with a progressive consumption tax is about half as costly; in the case of a progressive consumption tax, the distortion of labor supply decisions due to higher marginal tax rates during high-earning

years later in the life cycle is largely offset by more neutral tax treatment of savings decisions and a larger one-time windfall loss for the owners of old capital, who must pay the new higher marginal tax rate on consumption financed with savings already taxed under the income tax. On the other hand, moving to a wage tax confers a windfall gain to the elderly, who no longer pay income tax on the returns to their accumulated capital, an effect that is accentuated if the tax is progressive. Auerbach and Kotlikoff suggest that the introduction of population heterogeneity within generations could temper these effects of progressivity, since lower-income individuals benefit from reduced average and marginal tax rates under the progressive tax.

These intragenerational effects are captured in the influential work of Fullerton and Rogers (1993, 1996), who included 12 income groups within each generation in their dynamic overlapping generations CGE model, which also includes multiple production and consumption goods. Fullerton and Rogers (1996) focus on the economic and distributional effects of replacing the progressive income tax with a proportional wage tax, a proportional income tax, and a proportional consumption tax in the form of a value-added tax (VAT). They further explore efficiency-equity tradeoffs by allowing exemptions under each option.

Fullerton and Rogers show that all of the proportional tax reforms improve economic efficiency, with total efficiency gains somewhat under 1 percent of the total present value of lifetime incomes. At the same time, all of the proportional reforms are regressive. For example, in the steady state long run equilibrium, the lowest lifetime income group experiences reductions in lifetime income on the order of 5-6 percent, while the sixth decile experiences gains of 1.5-3 percent, and the highest lifetime income group has gains of nearly 10 percent. The proportional VAT is the least regressive option, due to the revenue gain obtained from the implicit capital levy on existing capital at the time of enactment, which allows lower future tax rates. Adding an

exemption reduces the efficiency gains by no more than 25 percent, with the smallest (virtually zero) decline for the VAT, reflecting the fact that only relatively modest increases in rates are necessary, as the tax base includes the one-time levy on owners of existing capital, which is taxed at a higher rate. These efficiency losses are accompanied by increases in progressivity but only for the lowest income groups, as the burdens of the proportional reforms become U-shaped, with the poor protected with the exemption, while the middle lifetime income groups benefit less than the highest groups.

Finally, Altig et al. (2001) extend the Auerbach-Kotlikoff model to include twelve income groups in each generation and analyze the efficiency/growth and equity tradeoffs associated with several tax reforms. We focus on their simulations of the effects of replacing the progressive income tax with either a "flat tax" (a wage tax with an exemption plus a cash flow business tax) or the "X-tax," a flat tax with progressive individual marginal tax rates and a business rate equal to the top individual rate (Bradford 1986, 2005); both reforms feature a consumption base that increases economic efficiency but potentially raises equity issues.

Enactment of the flat tax in the model increases national income by 4.5 percent in the long run (roughly half of the gain obtained with a proportional consumption tax) and results in U-shaped long run welfare gains, as the largest proportional gains accrue to the lowest lifetime income group, which benefits from the exemption and higher wages, and the highest income group, which benefits from the flatter rate schedule. Many groups, especially middle income groups in their early earning years who face relatively high tax rates and enjoy wage increases only with a significant delay, suffer losses during the transition. By comparison, the X-tax, despite its progressive rate structure, produces a larger increase in national income (6.4 percent), as a higher business tax rate implies a larger one-time capital levy on the owners of existing

capital, which allows relatively low future tax rates. Moreover, the long run welfare effects of the X-tax are uniformly progressive across all lifetime income groups, with the largest gains (about 2 percent of full lifetime resources) for the lowest income group and the smallest gains (slightly above 1 percent of full lifetime resources) for the highest income group. In the short run, however, the middle and upper income groups suffer losses (ranging from 0 to 2 percent of remaining lifetime resources) due to the imposition of the relatively high capital levy associated with the progressive X-Tax.

This brief overview of a few selected studies, suggests that CGE modeling results generally support the conventional wisdom that adding progressivity to a tax system tends to impose efficiency costs. However, it also demonstrates that the efficiency/growth and equity tradeoffs involved in implementing tax reforms can be subtle. In particular, the transitional effects associated with enacting progressive consumption tax reforms are complex, as progressivity not only increases annual tax burdens on higher income groups but also increases the capital levy imposed on elderly capital owners at the time of enactment; this implies both that the short run effects of the reform are likely to be progressive and that the long run effects of choosing a progressive approach may be less costly in efficiency terms.[11] In addition, the progressivity added to a proportional tax system with an exemption is important in equity terms but only at the low end of the income distribution, and also has relatively low efficiency costs. These considerations apply to the implementation of a VAT that includes a phased-out, means-tested exemption designed to eliminate or reduce its burden on lower income households. We turn next to the examination of the efficiency/growth and equity tradeoffs associated with the implementation of such a VAT, with the additional complication that the VAT is not a revenue

neutral replacement tax for the income tax such as those analyzed in the studies cited above, but a temporary tax designed to reduce the deficit and thus over time the national debt.

3. AN OVERVIEW OF THE MODELING APPROACH

3.1 A Temporary VAT for Debt Reduction

In this paper, we simulate the effects of using a temporary VAT to achieve a specified reduction in the national debt, focusing on the efficiency/growth and equity tradeoffs under such a policy. In order to focus exclusively on the effects of the VAT, our analysis abstracts from the effects of the other changes in expenditure policy, especially in the structure of entitlement programs such as Medicare, Medicaid and Social Security, that would assuredly also have to be part of any serious effort to reduce the deficit and the debt and put the United States on a sustainable fiscal path. Instead, we assume that government expenditures simply grow at the exogenously specified steady state growth rate of the economy.[12]

In order to analyze such a debt-reducing VAT, its details, especially with respect to its base, rate structure and phase-out, and the amount of the VAT rebate, must be specified. The VAT we simulate has the following properties.

3.1.1 The VAT Base

In principle, the base of a consumption-based VAT should include all consumption expenditures and exclude all investment purchases. Most observers argue that distributional concerns regarding the effects of the taxation of necessities under such a comprehensive VAT should be addressed with means-tested rebates that offset the VAT paid on consumption purchases by the poor; such an approach is far better targeted and administratively less cumbersome than the alternative of exempting certain goods from tax (Gillis, Mieszkowski and

Zodrow 1996). A separate issue is whether the VAT is applied to goods that might be excluded from the base for social reasons, such as education or health care, or perhaps food consumed at home, or for administrative reasons, such as the imputed value of financial services.[13]

We assume—perhaps optimistically—that a US VAT would follow the examples of several "modern" VATs, such as those in New Zealand and Australia, and have a relatively broad consumption base, similar to the "broad based" options constructed by Toder and Rosenberg (2010). Specifically, we assume the base includes all of personal consumption that might reasonably be expected to be subject to tax under a fairly comprehensive but still far from pure VAT. Accordingly, our base includes all personal consumption expenditures except educational expenses, government-financed medical expenses (primarily Medicare and Medicaid), services provided by charitable, religious, and other non-profit organizations, both the paid and the imputed values of various financial services, services provided by state and local governments, and state and local sales taxes. Taxation of housing services is not included in our benchmark simulations, but we also simulate the effects of expanding the VAT base to include housing. However, on the grounds that directly taxing imputed rents on owner-occupied housing is both politically infeasible and administratively cumbersome, we instead assume that housing is taxed by taxing rental housing and the construction value of new housing (which approximates the value of all future housing services); this somewhat indirect and approximate approach to taxing housing services is used by the "model" New Zealand VAT (Benge, Pallot, and Slack 2013). In particular, the VAT base is assumed to include food consumed at home, and private medical expenses, including both out-of-pocket expenses and insurance premiums. Using data for 2009, such a relatively broad-based VAT would include 65.7 percent of total net personal consumption expenditures. We assume further that the VAT includes a means-tested rebate

(described below) and that Social Security benefits, but not other transfer payments, are indexed for VAT-induced price inflation.

3.1.2 Rate Structure

We assume that the goal of the temporary VAT is to reduce the national debt from an initial equilibrium in which debt is 75 percent of GDP (roughly corresponding to the level of debt held by the public predicted by CBO (2012) to occur by 2013 under its alternative fiscal scenario) to a final equilibrium in which it is roughly 50 percent of GDP, and that this reduction is achieved over a period of 10 years with a temporary flat rate VAT, which is then eliminated from the tax system. Given these constraints, as well as the rebate and the indexing of Social Security benefits, the nominal VAT rate is roughly 6.1 percent.[14] This VAT rate is associated with gross revenues of roughly 2.9 percent of GDP and, after subtracting the rebate and the cost of indexing Social Security benefits, net revenues of roughly 2.4 percent of GDP.

3.1.3 VAT Rebate

We assume that the broad-based VAT includes a means-tested rebate designed to eliminate the burden of the tax on individuals below or at the poverty level, and reduce its burden on those whose incomes are only somewhat above the poverty level. In our benchmark year of 2007, the weighted average poverty level income is $17,570. We set the rebate to approximate the situation under which the VAT that would be paid on consumption at the average poverty level under the broad-based VAT would be rebated to all households with incomes less than $30,000, with the rebate phased out proportionately over incomes between $30,000-$60,000. This results in a total rebate of roughly $40 billion in 2007, or 0.28 percent of GDP. This rebate is modeled as a government transfer that is distributed to the lower lifetime income groups in each generation.

A separate issue is whether, given the existence of the rebate, government transfer payments are indexed for inflation (the VAT results in a one-time increase in nominal prices in the model). Many outcomes are of course possible. We assume that indexed Social Security payments are not adjusted to reflect the benefit of the rebate, which implies that low-income, retired households will effectively be "double-indexed" while higher-income households will simply be protected against the VAT-induced price increase.[15] By comparison, we assume that other transfers, which accrue primarily to the same households that receive the rebate, are not indexed.

3.2 An Overview of the Diamond-Zodrow Model

3.2.1 Model Structure

We simulate the effects of such a debt-reducing VAT using the Diamond-Zodrow (DZ) model, which is a large-scale dynamic OLG-CGE model that can be used to analyze both the short run and long run macroeconomic and distributional effects of tax reforms. In this section we provide an overview of the model; a detailed description is provided in the Zodrow and Diamond (2013).

The basic features of the model are as follows. Consumers are assumed to have perfect foresight and to maximize utility over a 55-year adult life, which begins at age 23 and consists of 45 working years followed by a 10-year retirement.[16] The model is constructed in discrete time, with each period corresponding to one year. Individual lifetime utility is the discounted sum of annual utility in each of the 55 periods. Annual utility is a function of leisure and an aggregate consumption good, which is in turn a composite of four goods — a non-housing composite consumption good produced by the corporate sector, a non-housing composite consumption good produced by the non-corporate sector, owner-occupied housing, and rental housing. The model

also includes relatively simple representations of bequests and inheritances,[17] and tax-deferred saving under the current income tax. There are 12 lifetime income groups within each generation, each characterized by its own profiles for lifetime earnings and lifetime transfers received.[18]

Firm managers are also characterized by perfect foresight. Firms are assumed to maximize firm value and thus the discounted value of future profits. Following the well-known *q*-theory of investment behavior formulated by Tobin (1969), firm managers calculate the optimal time path of investment in response to any changes in the tax structure, taking into account convex costs of adjusting investment from its initial steady state level.[19] Firm behavior is modeled separately for each of the four production sectors, with individuals who own their own homes treated as the owners of private "firms" that produce housing and then rent it to their owners (themselves), taking into account the income tax advantages of home ownership. The debt-capital ratio is assumed to be fixed in each industry.

The government must finance an exogenously specified time path of public services, which are assumed to be separable from the individual lifetime utility function, as well as income transfers, which are included in individual income. This fairly standard "differential incidence" approach significantly simplifies the model while still allowing us to analyze a wide range of tax reforms, as well as changes in government spending that take the form of changes in transfers payments (e.g., the per capital transfer offset described below), which are fully accounted for in the individual budget constraint.

The basic version of the DZ model follows Auerbach and Kotlikoff (AK) in assuming a closed economy, and we adopt that assumption for the simulations in this paper. This simplifying assumption is acceptable for some reforms that are unlikely to have large effects on rates of

return to capital and thus on international capital flows, or if one believes that international capital mobility, especially with respect to capital flows in and out of the United States, is less than often asserted.[20] Nevertheless, because international capital flows are of great importance in the modern economy, an important extension for future research is to add an international sector and model reform-induced international capital and trade flows.

In the initial steady state equilibrium, the government's tax instruments include a corporate income tax and an income tax with a progressive wage income tax structure and constant rate capital income taxes. The model can be used to analyze the short and long run effects of both reforms of the existing income tax system, such as base-broadening, rate-reducing reforms (BBRR) or various approaches to business-personal income tax integration, as well as various types of consumption tax reforms, including the Hall-Rabushka Flat Tax and its variants such as the Bradford X-Tax, cash flow expenditure taxes, national retail sales taxes, and the VAT analyzed in this paper. In general, the government must satisfy an annual budget constraint. However, as described above, the model can also accommodate a constant level of federal government debt relative to GDP, as well as changes in the level of debt for a finite period.

All markets are assumed to be perfectly competitive. Market equilibrium in the model requires that total consumer demand, obtained by aggregating the demands of each of the 12 types of individuals within each of the 55 generations alive at any single point in time, must equal aggregate supply in each of the four production sectors. In addition, factor demands must equal factor supplies in the labor and capital markets, the total amounts of debt and equity held as individual wealth must equal firm stocks of debt and equity, and both individual and firm expectations regarding the time paths of future prices must be satisfied. In all applications including those with government debt, the model must begin, and eventually arrive, at a steady

state equilibrium in which all key macroeconomic variables, including GDP and output in the various sectors, the capital stock, the effective labor force, any government debt held by the public, etc., grow at the steady state growth rate, which is defined as the sum of the long run population growth rate and the rate of labor-augmenting technological progress, both of which are specified exogenously and assumed to remain constant. Note that because we assume a constant rate of population growth in our model, we cannot analyze the effects of demographic changes, including the fiscal imbalances that currently plague the United States and many other countries due to an aging population. The model can, however, be extended to allow varying rates of population growth for a finite time period, as long as population growth eventually returns to a constant steady state growth rate; for example, Auerbach and Kotlikoff make such a modification in their analysis of reform of the Social Security system in the United States, and Fehr et al. (2013) construct a multi-regional model that analyzes demographic changes in great detail.

The model calculates asset values in all four markets explicitly for each period after the enactment of a reform, taking into account both the effects of all changes in the tax treatment of existing capital assets, as well as their previous tax treatment under the existing tax system. The model is thus especially well suited to analyzing reform-induced factor reallocations (e.g., as capital is reallocated to equalize after-tax rates of returns across the four production sectors), as well as the transitional effects of reform, including reform-induced changes in asset prices in all four sectors and the associated redistributions within and across all generations alive at the time of reform. The model can also be used to calculate the long run economic effects of reform, including the welfare effects of reform on future generations.

3.2.2 Calibration and Parameter Values

The initial equilibrium is calibrated to approximate data from 2007, which is chosen as the benchmark year because it is more likely to approximate a long-run equilibrium than the more recent "great recession" years, which have been characterized by relatively low levels of investment, especially in housing, and relatively high government deficits. The debt/GDP ratio is assumed to be 75 percent in the initial steady state.

All of the parameter values used in the simulations are provided in the Appendix. These are chosen to be consistent with the initial equilibrium and with empirical estimates and parameters used in other CGE studies, especially Altig et al. (2001), Auerbach and Kotlikoff (1987), Fullerton and Rogers (1993, 1996), and Fehr et al. (2013). Our choices regarding several of the most critical parameters can be summarized as follows.

Of particular concern in the context of this paper is the steady state growth rate in the model, which is defined as the sum of the long run population growth rate and the rate of labor-augmenting technological progress, both of which are specified exogenously and assumed to remain constant. The model assumes a fixed population growth rate of 1.1 percent and a fixed productivity growth rate of 2.3 percent, which equal the average population and productivity growth rates in the United States over both the past 50 and the past 20 years (Council of Economic Advisers 2010).[21] Thus, any steady state equilibrium in the model must be characterized by a constant growth rate of 3.4 percent in the key macroeconomic variables, including GDP and output in the various sectors, the capital stock, the effective labor force, etc., as well as the national debt. This in turn implies that the government's annual budget deficit in the steady state—which equals the increment in the debt—must equal the product of the growth rate and the steady state level of debt.

The choice of the intertemporal elasticity of substitution determines the willingness of consumers to substitute consumption across periods in response to changes in the relative prices of consumption and thus plays a critical role in establishing the responsiveness of saving to the enactment of the VAT. This parameter is set equal to 0.4, which is in the range between the value of 0.25 used by Altig et al. and the value of 0.5 used by Fullerton and Rogers. Given this value of the intertemporal elasticity of substitution, the rate of time preference, which is set equal to 0.005, is chosen to generate a capital stock roughly consistent with that observed in the initial equilibrium.

The intratemporal elasticity of substitution determines consumer willingness to substitute between labor supply and leisure in response to changes in their relative prices and is thus critical in determining the labor supply response to a change in the after-tax real wage which falls in response to the enactment of the VAT. This parameter is set equal to 0.8, following Altig et al.

The individual estimated lifetime wage profiles for the twelve income groups are taken from Altig et al. The model also requires data on the distribution of transfer payments other than Social Security, VAT rebates, bequests, Social Security benefits, average and marginal tax rates, and annual income. Using data from the Congressional Research Service (2012), total transfer payments, other than Social Security, are distributed so that 70 percent are paid to households in the bottom 40 percent of the income distribution, with the remaining 30 percent distributed among the top 60 percent in a declining fashion. The means-tested rebate is allocated as described in Section III. Social Security benefits are relatively larger for lower income households reflecting the progressive nature of Social Security benefits. Average tax rates range from –4.5 percent to 22.5 percent, while marginal tax rates range from 4.0 percent to 35.8 percent (marginal rates are assumed to be constant within each lifetime income group).

The production functions in the model are all Cobb-Douglas. This assumption follows Fehr et al. (2013) and simplifies the analysis; however, it may imply too much substitutability between labor and capital in production, as Chirinko, Fazzari, and Meyer (2004) suggest that the elasticity of substitution in production is instead on the order of 0.4 (rather than the value of 1.0 implied by the Cobb-Douglas production functions). The various weighting parameters in the production functions and utility function are set to replicate as closely as possible the actual patterns of aggregate production and consumption.

The adjustment cost factor in the nonhousing and housing production sectors is set at 2, a value generally consistent with Hall (2004) – although lower than that used by Altig et al.[22] A higher value for the adjustment cost parameter would slow down the adjustment process but have minimal effects on the long run outcomes.

3.3 Including a Debt-Reducing VAT in the DZ Model

As noted above, the DZ model is a standard dynamic growth model, which must both begin and end in a steady state equilibrium in which all macroeconomic variables, including the debt, grow at the steady state growth rate of the economy, which is determined by the exogenously specified population and productivity growth rates. Accordingly, we model a debt-reducing VAT as changing the growth path of the economy from an initial equilibrium in which the steady state debt/GDP ratio is 75 percent to a final equilibrium in which the steady state debt/GDP ratio is roughly 50 percent. That is, prior to the enactment of the VAT, the economy is in an initial steady state equilibrium with an annual deficit that is consistent with keeping the debt/GDP ratio constant at 75 percent. The temporary, debt-reducing VAT is then introduced and remains in effect as described above, that is, with a constant tax rate for 10 years. The adjustment of the economy to the imposition of the VAT continues after it is phased out, and the economy

eventually arrives at a new steady state equilibrium in which the debt/GDP ratio is constant at roughly 50 percent. The reduction in required tax revenues due to the decline in interest payments is assumed to be rebated uniformly to all households (a "per capita transfer offset"), and the economy is assumed to be closed.[23] The macroeconomic and distributional effects of the temporary VAT are then calculated as the percentage changes in the various variables under the VAT, relative to the initial equilibrium under which the debt/GDP ratio remains at 75 percent.

4. Simulation Results

This section describes the macroeconomic and distributional effects of a enacting a temporary, deficit-reducing VAT that would be in effect for 10 years. The temporary VAT raises net revenues, after paying for a means-tested rebate and indexing of Social Security benefits, equal to 2.4 percent of GDP, which is used to reduce the size of the deficit and thus over time the ratio of the national debt to GDP. We present and compare simulation results for several different assumptions about the structure of the VAT. Welfare results by age and by lifetime income cohort are calculated for each simulation.

4.1 The Benchmark VAT with Rebate

Table 1 shows the macroeconomic effects of reducing the deficit by enacting a temporary VAT with a low-income rebate, and indexed Social Security payments. As described above, the benchmark simulation assumes a closed economy and a per capita transfer offset. The debt/GDP ratio falls from 75 percent in the initial equilibrium to 45.5 percent in the long run as the deficit is reduced by roughly 2.4 percent percentage points in each of the 10 years that the VAT is collected; 2.9 percent of GDP is collected as VAT revenue, but revenue of 0.5 percent of GDP is used to increase Social Security payments and pay the means-tested rebate). The deficit/GDP ratio also falls as the debt/GDP ratio and thus interest payments decline gradually[24]; this effect is

reinforced by the decline in interest rates and because GDP increases gradually. For example, GDP initially increases by 0.1 percent 2 years after reform, and by 0.2 percent after five years, by 0.8 percent after 10 years, and by 1.6 percent in the long run. Deficit reduction implies that private saving formerly used to purchase government bonds to finance government spending can now be used to finance increases in private investment, as the classic "crowding out" effect of government debt is reversed. In this benchmark simulation, investment increases by 5.0 percent after two years, by 6.3 percent after five years, by 9.7 percent after 10 years, and by 7.2 percent in the long run.[25]

Several other macroeconomic effects are noteworthy. First, interest rates decline by 1.1 percentage points in the long run because the government's demand for debt is reduced, which in turn reduces the cost of capital and stimulates investment.[26] This also lowers government revenue requirements as the cost of servicing the debt declines. Second, the consumption-based VAT increases consumer prices so that consumption falls initially,[27] although this effect is mitigated because adjustment costs slow the increases in investment. The reduction in consumption is reinforced in the short run to the extent that elderly owners of capital, who have a relatively high propensity to consume in their retirement years, suffer unanticipated losses due to the implementation of the VAT as the real value of their capital assets declines, although this effect is mitigated by the fact that existing housing is not subject to the VAT. The net effect is that consumption falls by 0.7 to 1.2 percent during the years that the VAT is in effect, and then increases gradually to a long run increase of 1.5 percent.

Since the VAT is shifted forward to consumers through higher consumer prices, its implementation reduces real wages, which causes labor supply to fall in the years it is in force. Specifically, the real wage falls by 3.7 percent 2 years after reform, by 3.2 percent after five

years, by 2.2 percent in the last year of the VAT; once the VAT is removed and capital accumulation increases, the real wage begins to increase, by 2.3 percent 20 years after reform and by 2.1 percent in the long run. As a result, labor supply decreases by 0.4 percent while the VAT is in force, and almost returns to its initial steady state level in the long run once the VAT is removed. Labor supply effects are muted due to the income effects of the increases in GDP and the transfer payments financed by the reduction in interest payments on the national debt.

Finally, because the VAT is partial in nature, consumption subject to the VAT falls while consumption excluded from the VAT base rises. In our simulation, the noncorporate base is narrower than the corporate base, so that during the period the VAT is in effect consumption of the corporate good falls by 3.3 percent, while consumption of the noncorporate good increases by 2.2 percent. Similarly, because housing is not taxed under the benchmark option, housing consumption increases by roughly one to two percent.

Consider next the distributional effects of implementing the 10-year VAT, calculated as the percentage changes in remaining lifetime resources of the 12 representative lifetime income groups in the model. These are captured in Table 2, which shows these welfare changes under the benchmark VAT for lifetime income group 1 (the bottom 2 percent), group 2 (the rest of the first decile), group 3 (the second decile), group 5 (the fourth decile), group 7 (the sixth decile), group 10 (the ninth decile), and group 12 (the top 2 percent).

The distributional effects of enacting a temporary deficit-reducing, temporary VAT reflect the interactions of numerous factors. As a tax based on consumption, the VAT tends to be regressive relative to annual income since consumption is a larger fraction of annual income for the poor, although, as discussed above, this effect is mitigated by our use of a lifetime measure of tax incidence. Moreover, VAT regressivity for the lowest income households is offset with the

means-tested rebate, as well as the indexing of Social Security benefits for price inflation, which implies that the low income elderly are effectively "double-indexed" for VAT-induced inflation and may actually benefit from its enactment.[28] The enactment of the VAT also causes a one-time reduction in the real value of existing assets described previously, which is borne primarily by the higher income elderly at the time of enactment. Finally, although the existence of capital stock adjustment costs implies that interest rates initially rise briefly, the VAT causes a reduction over time in interest rates as the government debt/GDP ratio declines; this has a negative effect on the wealthy as their capital income declines, which significantly increases the likelihood that the VAT will have an overall progressive effect in the long run.

The net results of these factors are shown in Table 2. Consider first those who are elderly at the time of enactment. The lower income cohorts that are ages 40 and above benefit modestly from the combination of the rebate plus the indexing of Social Security benefits, which more than offsets the relatively small hit they experience from a reduction in the real value of their modest assets. By comparison, the middle and upper income groups in these age cohorts are the biggest losers from the temporary VAT, as they experience a reduction in the real value of their assets, a reduction in the return on their assets as interest rates decline, a reduction in the real wage, and do not receive the rebate – although they benefit from the indexation of Social Security benefits. As a result, the temporary VAT is quite progressive for these elderly groups (except at the very top of the income distribution for the retired cohort, although this group nevertheless suffers a significant loss). For example, for the age 60 cohort, the first two lifetime income groups gain modestly from reform, and the losses in percentage terms experienced by the other income groups increase monotonically from 0.2 to 3.5 percent of lifetime resources.

Younger cohorts benefit from the temporary VAT, and their welfare changes increase monotonically as the cohort age at the time of enactment declines. This reflects the long run gains from enacting the deficit-reducing temporary VAT (as well as the declining importance of the one-time hit on capital existing at the time of enactment), attributable to the increase in real wages as capital accumulates due to the reform-induced increases in private investment, as well as the associated increases in consumption, output, and economic efficiency. For example, for individuals who were born in the year of enactment, the welfare increases range from 1.8 to 5.3 percent of lifetime resources (including the value of leisure time). These welfare changes are also quite progressive. For example, for those who are born in the year of enactment, the equivalent variation declines monotonically from the second income group to the highest income group, with the former group experiencing a welfare gain (in percentage terms) that is three times the size of the latter. (The lowest income group benefits somewhat less than the slightly higher income groups because it has a disproportionately high share of transfer rather than wage income.) Indeed, the equivalent variations for all age groups are almost uniformly progressive, indicating that the combination of the means-tested rebate and indexation of Social Security benefits at the low end of the income distribution, and the effects of reform-induced reductions on interest rates at the top of the income distribution are enough to make the debt-reducing temporary VAT a policy that improves economic efficiency and stimulates growth in the long run, and is quite progressive in both its transitional and long run effects.

4.2 Effects of Imposing VAT on Rental Housing and New Construction of Owner-Housing

The benchmark case assumes that the VAT is not applied to housing. However, a broader based approach – for example, one that followed the lead of the New Zealand VAT (Benge, Pallot, and Slack 2013) – might apply to housing in the following way. Although in principle it

would be possible to tax existing owner-occupied housing by calculating imputed rental income accruing to home owners (e.g., by applying an implicit rate of return to housing values as determined for local property taxes), such an approach would be both politically hugely unpopular and administratively cumbersome. An alternative approach would be to exempt existing housing, but to tax purchases of newly constructed housing as a proxy for all future imputed rents on such new construction, and then to apply the tax to rental housing as well. Table 3 shows the macroeconomic effects of reducing the deficit by enacting a temporary VAT with a means-tested rebate, indexed Social Security payments, and a VAT imposed on rental housing and new construction of owner-occupied housing. The aggregate macroeconomic effects are generally similar but slightly larger than those in the benchmark results presented in Table 1. The broader base increases VAT revenues and thus allows for an increase in debt reduction (to 43.3 percent of GDP rather than 45.5 percent), which increases GDP, private investment, and the capital stock by roughly 0.5 percentage points more in the long run than if housing is exempted.

The most significant difference attributable to applying the VAT to housing is on the mix of consumption, especially on the consumption of housing services. In this case, the consumption of housing services declines by 6.2 to 6.8 percent while the VAT is in force. By comparison, in the benchmark simulation the consumption of housing services increased by 2.2 percent two years after enactment of the VAT, by 1.8 percent after five years, and by 1.4 percent after 10 years.

As shown in Table 4, the general pattern of welfare results is again similar to the benchmark simulation, and most of the differences in the welfare changes between this and the benchmark case are fairly small. The most significant effects are increases in the welfare gains

for those who are very young (ages 0 and 10) at the time of enactment of reform, all of whom benefit by between 0.1–0.3 percent of lifetime resources due to the reduced distortion of consumption decisions between housing and other goods and the larger reduction in the deficit.

4.3 Effects of Eliminating the Rebate and Indexation of Social Security Benefits

Finally, although it seems to be a much less likely policy option, it is possible that a debt-reducing VAT would not include a means-tested rebate or indexing of Social Security benefits – for example, on the grounds that all citizens should share in the costs of addressing our nation's fiscal problems. Table 5 shows the macroeconomic effects of reducing the deficit by enacting a temporary VAT without a means-tested rebate or indexation of Social Security payments. In this case, the debt/GDP ratio falls to 40.5 percent, 5 percentage points more than in the benchmark simulation. The resulting macroeconomic effects have a similar pattern to those in the benchmark case, but the increases in GDP, investment, and the capital stock are roughly 17-18 percent larger, indicating the efficiency and economic growth gains obtained from greater deficit reduction in the absence of the rebate and indexation of Social Security benefits.

These results illustrate the classic efficiency/growth and equity tradeoff discussed in the introduction, as demonstrated by comparing the results in Table 6 with those in the benchmark case presented in Table 2. The elimination of the means-tested rebate and indexation of Social Security benefits implies that all low income individuals of age 20 are more negatively affected than under the benchmark VAT. Lower and middle income retirees are especially hard hit, experiencing losses that are 1.0–3.5 percent of lifetime resources larger than in the benchmark case; by comparison, the increases in the losses experienced by higher income retirees are proportionately smaller (0.5–0.7 percent), reducing the progressivity of the reform for this group. The effects of the VAT on progressivity, however, are concentrated in the lower income groups,

for which the rebate and indexation of Social Security benefits are essential to making the debt-reducing VAT a progressive reform. In contrast, at the upper end of the income distribution, the progressivity of the burden of the VAT is largely unchanged. The long run results demonstrate the efficiency gains of reducing progressivity, as all cohorts of age 20 or less at the time of reform experience larger gains than in the benchmark case – on the order of 0.3–0.8 of lifetime resources. Moreover, due to reform-induced declines in interest rates, for these groups the effects of reform are still quite progressive. For example, for those of age 0 at the time of enactment, the welfare gains decline monotonically from 6.1 percent of lifetime resources for group 2 to 2.1 percent for the highest lifetime income group.

5. Conclusion

Devising policies to achieve economic efficiency and promote economic growth while maintaining distributional equity is one of the most difficult problems in economics. Doing so is especially important in the current economic environment, as the need for significant additional revenues to help solve the nation's fiscal crisis implies that efficient tax instruments are sorely needed, increasing income inequality implies heightened concerns about the distributional implications of any tax increases, and concerns about recent low rates of economic growth imply that taxes that are relatively conducive to growth are highly desirable.

In this paper, we conduct a simulation analysis using a large scale dynamic overlapping generations computable general equilibrium model to examine a specific policy proposal in this context – the use of a temporary (ten-year) flat rate VAT with a relatively broad base designed to reduce the government debt/GDP ratio from roughly 75 percent to somewhat under 50 percent, with the precise level of debt reduction depending on the structural details of the VAT utilized.

The VAT is widely recognized as an efficient and growth-friendly instrument for raising

revenues (too efficient, according to the "money machine" argument noted by the President's Advisory Panel on Federal Tax Reform (2005)), but is also widely believed to be regressive. This paper suggests that this concern may be misplaced, as the simulation results indicate that the use the temporary VAT is generally moderately progressive both for cohorts alive at the time of reform and future generations – at least within the context of lifetime measures of tax burden. This progressivity arises because (1) we assume the VAT includes a rebate to relieve the poor of tax and indexation of Social Security benefits to help protect (and in some cases over-protect) the elderly from the full burden of the tax, (2) the VAT results in a one-time decline in the value of existing assets that has a disproportionately large effect on high income elderly individuals, and (3) VAT-induced declines in interest rates have a disproportionately negative effect on higher income owners of capital. In addition, the results show that using a VAT to reverse a fiscal situation in which existing generations have financed consumption with deficit spending naturally implies that current middle-aged and elderly generations must bear a burden to confer a gain, relative to the current status quo, on the young and future generations.

The results of any modeling exercise such as this one are only suggestive, and several caveats – beyond the modeling issues discussed in the introduction – are in order. The most obvious problem with the modeling effort in this paper is the assumption of a closed economy. As noted previously, the question of the degree of openness of the US economy is subject to dispute. Nevertheless, explicit modeling of international flows of goods and capital is certainly desirable. Although opening the economy would have many effects in a general equilibrium context, we believe there would be two main effects. First, the VAT-induced declines in US interest rates would imply that some of the increase in domestic private saving would be diverted to investment abroad, reducing the gains in domestic output and increasing the declines in

domestic consumption. In addition, capital outflows from the United States would temper the interest rate declines that played the key role in making the burden of the temporary VAT with a rebate progressive at higher income levels; sufficiently small interest rate changes could convert the temporary VAT to a roughly proportional or regressive tax at the upper income levels. Second, reductions in the debt would reduce the current level of foreign borrowing that effectively finances US imports, so that some of the reduction in public saving would be reflected in reduced net imports rather than additional domestic investment, thus mitigating the positive effects on investment of the debt-reducing VAT. We leave the exploration of these effects to future research.

APPENDIX 1

Table A.1. Parameter Values Used in the Simulations

Symbol	Description	Value
	Utility Function Parameters	
ρ	Rate of time preference	0.005
σ_U	Intertemporal elasticity of substitution	0.4
σ_C	Intratemporal elasticity of substitution	0.80
σ_H	Elasticity of substitution between composite good, housing	0.8
σ_N	Elasticity of substitution between corporate, noncorporate good	5.0
σ_R	Elasticity of substitution between rental, owner housing	2.0
α_C	Utility weight on the composite consumption good	0.88
α_H	Utility weight on non-housing consumption good	0.76
α_N	Utility weight on corporate good	0.7
α_R	Utility weight on owner-occupied housing	0.74
	Production Function Parameters	
ε_C	Elasticity of substitution for corporate good	1.0
ε_N	Elasticity of substitution for noncorporate good	1.0
$\varepsilon_H, \varepsilon_R$	Elasticities of substitution for owner and rental housing	1.0
γ_C	Capital share for corporate good	0.27
γ_N	Capital share for noncorporate good	0.27
γ_H, γ_R	Capital share for owner and rental housing	0.97
$\beta_X, \beta_N, \beta_H$	Adjustment cost parameters	2
ζ	Dividend payout ratio in corporate sector	0.68
b_C, b_N, b_H, b_R	Debt-asset ratios	0.35
δ_C, δ_N	Depreciation rates in the corporate and noncorporate sectors	0.08
δ_H, δ_R	Depreciation rates in the owner and rental housing sectors	0.018

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Table 1

Simulation Results: Macroeconomic Effects of a 10-Year VAT Used for Deficit Reduction, with a Means-Tested Rebate and Indexed Social Security Benefits

Years After Reform	2	5	10	20	50	100
Δ GDP (%)	0.1	0.2	0.8	1.1	1.5	1.6
Δ Capital (%)	0.4	1.5	3.7	4.8	6.6	6.9
Δ Investment (%)	5.0	6.3	9.7	5.9	7.4	7.2
Δ Labor Supply (%)	-0.4	-0.4	-0.4	0.0	-0.1	-0.1
Δ Consumption (%)	-1.2	-1.0	-0.7	0.9	1.4	1.5
VAT Revenue/GDP (%)	2.9	2.9	2.9	0.0	0.0	0.0
Government Deficit/GDP (%)	0.1	-0.7	-2.1	1.6	1.6	1.6
Δ Deficit/GDP (%)	-2.5	-3.2	-4.6	-1.0	-1.0	-1.0
Government Debt/GDP (%)	73.2	65.5	49.5	45.7	45.5	45.5
Cumulative Δ Debt/GDP (%)	-1.7	-9.4	-25.4	-29.2	-29.4	-29.4
Nominal Interest Rate (%)	7.3	7.2	6.9	6.7	6.5	6.4
Δ Real Wage Rate (%)	-3.7	-3.2	-2.2	2.3	3.1	3.2
Δ Corporate Consumption (%)	-3.2	-3.3	-3.3	0.3	0.5	0.6
Δ Noncorporate Consumption (%)	2.1	2.1	2.1	0.3	0.5	0.6
Δ Housing (%)	2.2	1.8	1.4	-0.6	-0.8	-0.7

Table 2

Simulation Results: Distributional Effects (Equivalent Variations as a Percentage of Remaining Lifetime Resources) of a 10-Year VAT Used for Deficit Reduction, with a Means-Tested Rebate and Indexed Social Security Benefits

Age in Year of Enactment:	0	10	20	30	40	50	60	70
Lifetime Income Groups								
1. Bottom 2 percent	3.6	3.4	2.5	1.6	0.5	0.3	0.0	0.5
2. 2nd to 10th percent	5.3	5.0	3.1	1.9	1.1	0.7	0.2	0.1
3. 2nd decile	4.7	4.5	2.4	1.2	0.6	0.4	-0.2	0.3
4. 3rd decile	4.4	4.1	1.7	0.5	-0.1	-0.3	-0.9	-0.5
5. 4th decile	4.3	4.1	1.6	0.4	-0.2	-0.5	-1.1	-0.8
6. 5th decile	4.1	3.8	1.3	0.0	-0.5	-0.8	-1.3	-1.0
7. 6th decile	3.8	3.5	1.1	-0.1	-0.7	-1.0	-1.5	-1.4
8. 7th decile	3.5	3.3	0.9	-0.3	-0.8	-1.1	-1.6	-1.6
9. 8th decile	3.2	3.0	0.8	-0.4	-1.0	-1.3	-1.7	-1.8
10. 9th decile	3.1	2.8	0.7	-0.6	-1.2	-1.5	-2.0	-2.0
11. 90th to 98th percent	2.6	2.3	0.3	-0.9	-1.8	-2.0	-2.4	-2.0
12. Top 2 percent	1.8	1.5	-0.2	-1.4	-3.2	-3.3	-3.5	-1.7

Table 3

Simulation Results: Macroeconomic Effects of a 10-Year VAT for Deficit Reduction with Rebate, Indexed Social Security Benefits, and a VAT on Rental Housing and New Construction of Owner Housing

Years After Reform	2	5	10	20	50	100
Δ GDP (%)	0.0	0.2	0.8	1.2	1.7	1.7
Δ Capital (%)	0.3	1.3	3.4	5.1	7.1	7.4
Δ Investment (%)	4.1	6.0	10.1	6.5	8.0	7.8
Δ Labor Supply (%)	-0.5	-0.5	-0.4	0.0	-0.1	-0.1
Δ Consumption (%)	-1.1	-1.0	-0.8	0.9	1.5	1.6
VAT Revenue/GDP (%)	3.1	3.1	3.0	0.0	0.0	0.0
Government Deficit/GDP (%)	-0.2	-1.0	-2.5	1.5	1.5	1.5
Δ Deficit/GDP (%)	-2.7	-3.5	-5.0	-1.1	-1.1	-1.1
Government Debt/GDP (%)	73.4	65.1	47.6	43.5	43.3	43.3
Cumulative Δ Debt/GDP (%)	-1.4	-9.8	-27.3	-31.4	-31.6	-31.6
Nominal Interest Rate (%)	7.3	7.1	6.8	6.6	6.4	6.4
Δ Real Wage Rate (%)	-3.8	-3.3	-2.3	2.4	3.4	3.5
Δ Corporate Consumption (%)	-3.0	-3.1	-3.1	0.3	0.5	0.6
Δ Non-corporate Consumption (%)	2.4	2.3	2.2	0.3	0.5	0.6
Δ Housing (%)	-6.2	-6.4	-6.8	-0.7	-0.8	-0.7

Table 4

Simulation Results: Distributional Effects (Equivalent Variations as a Percentage of Remaining Lifetime Resources) of a 10-Year VAT for Deficit Reduction with Rebate, Indexed Social Security Benefits, and a VAT on Rental Housing and New Construction of Owner Housing

Age in Year of Enactment:	0	10	20	30	40	50	60	70
Lifetime Income Groups								
1. Bottom 2 percent	3.9	3.6	2.5	1.5	0.4	0.2	-0.2	0.5
2. 2nd to 10th percent	5.6	5.3	3.2	1.9	1.0	0.6	0.1	0.2
3. 2nd decile	5.0	4.7	2.5	1.2	0.6	0.3	-0.2	0.4
4. 3rd decile	4.7	4.4	1.8	0.5	-0.1	-0.3	-0.9	-0.3
5. 4th decile	4.6	4.3	1.7	0.4	-0.3	-0.6	-1.2	-0.6
6. 5th decile	4.3	4.0	1.4	0.1	-0.6	-0.8	-1.4	-0.9
7. 6th decile	4.0	3.7	1.2	-0.1	-0.7	-1.0	-1.6	-1.3
8. 7th decile	3.7	3.5	1.0	-0.3	-0.9	-1.2	-1.7	-1.4
9. 8th decile	3.5	3.2	0.8	-0.4	-1.1	-1.4	-1.9	-1.7
10. 9th decile	3.3	3.0	0.7	-0.6	-1.3	-1.6	-2.1	-1.9
11. 90th to 98th percent	2.8	2.5	0.3	-0.9	-1.9	-2.1	-2.5	-1.8
12. Top 2 percent	1.9	1.6	-0.2	-1.5	-3.5	-3.5	-3.8	-1.4

Table 5

Simulation Results: Macroeconomic Effects of a 10-Year VAT for Deficit Reduction, with No Rebate and No Indexation of any Transfer Payments

Years After Reform	2	5	10	20	50	100
Δ GDP (%)	0.1	0.3	1.0	1.4	1.8	1.9
Δ Capital (%)	0.4	1.8	4.3	5.7	7.8	8.1
Δ Investment (%)	6.1	7.5	10.9	7.1	8.7	8.5
Δ Labor Supply (%)	-0.4	-0.4	-0.3	0.0	-0.1	-0.1
Δ Consumption (%)	-1.4	-1.1	-0.7	1.1	1.6	1.8
VAT Revenue/GDP (%)	2.9	2.9	2.9	0.0	0.0	0.0
Government Deficit/GDP (%)	-0.5	-1.3	-2.7	1.4	1.4	1.4
Δ Deficit/GDP (%)	-3.0	-3.8	-5.3	-1.2	-1.2	-1.2
Government Debt/GDP (%)	72.8	63.6	45.0	40.7	40.6	40.5
Cumulative Δ Debt/GDP (%)	-2.1	-11.3	-29.9	-34.2	-34.3	-34.4
Nominal Interest Rate (%)	7.3	7.1	6.8	6.6	6.3	6.3
Δ Real Wage Rate (%)	-3.6	-3.0	-1.9	2.7	3.7	3.8
Δ Corporate Consumption (%)	-3.4	-3.4	-3.3	0.3	0.6	0.7
Δ Non-corporate Consumption (%)	1.9	1.9	2.0	0.3	0.6	0.7
Δ Housing (%)	2.0	1.6	1.3	-0.7	-0.9	-0.8

Table 6

Simulation Results: Distributional Effects (Equivalent Variations as a Percentage of Remaining Lifetime Resources) of a 10-Year VAT for Deficit Reduction, with No Rebate and No Indexation of any Transfer Payments

Age in Year of Enactment:	0	10	20	30	40	50	60	70
Lifetime Income Groups								
1. Bottom 2 percent	4.2	4.0	1.3	-0.1	-1.1	-1.4	-2.0	-2.9
2. 2nd to 10th percent	6.1	5.8	2.5	0.8	0.0	-0.5	-1.2	-3.0
3. 2nd decile	5.5	5.2	2.2	0.8	0.1	-0.2	-0.9	-3.2
4. 3rd decile	5.1	4.8	2.0	0.6	0.0	-0.3	-0.9	-3.2
5. 4th decile	5.0	4.7	2.0	0.6	-0.1	-0.5	-1.1	-3.1
6. 5th decile	4.7	4.4	1.7	0.4	-0.3	-0.6	-1.2	-3.1
7. 6th decile	4.4	4.1	1.6	0.2	-0.4	-0.8	-1.4	-3.0
8. 7th decile	4.1	3.8	1.3	0.0	-0.6	-1.0	-1.5	-2.9
9. 8th decile	3.8	3.5	1.1	-0.2	-0.8	-1.2	-1.7	-2.8
10. 9th decile	3.6	3.3	1.0	-0.3	-1.1	-1.5	-1.9	-2.7
11. 90th to 98th percent	3.0	2.8	0.6	-0.7	-1.7	-2.0	-2.4	-2.6
12. Top 2 percent	2.1	1.8	0.0	-1.4	-3.3	-3.6	-3.8	-2.2

ENDNOTES

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[1] For two opposing perspectives, see Mankiw, Weinzierl, and Yagan (2009) and Diamond and Saez (2011).

[2] See Banks and Diamond (2010) for a recent review of the debate.

[3] See Zodrow (2007) and Auerbach (2008) for discussions of these arguments.

[4] See Zodrow and Diamond (2013) for a recent survey of the use of CGE models to analyze tax reforms.

[5] Although interest in the VAT in the United States has increased in recent years and use of the VAT is widespread in the developed and developing world, there is still considerable opposition to using the tax in the United States, as demonstrated by the 2010 Senate non-binding resolution, passed by a 83-13 margin, opposing the introduction of a VAT, and the unwillingness of the President's Advisory Panel on Federal Tax Reform (2005) to include a VAT as one of its recommended tax reform options.

[6] For example, a recent report by the Organisation for Economic Co-operation and Development (OECD) concludes that corporate income taxes are the most harmful to economic growth,

followed by personal income taxes, then consumption taxes like the VAT, and finally property taxes on immovable property (Johannsson, Heady, Arnold, Brys, and Vartia 2008). For thorough discussions of the advantages and disadvantages of the VAT, see the recent analyses of Toder and Rosenberg (2010), Gale and Harris (2010), and Bird and Gendron (2010); for earlier discussions, see Gillis, Mieszkowski, and Zodrow (1996), and McLure (1987).

[7] As is well known (e.g., see the excellent discussion in Fullerton and Rogers (1993)), measuring tax incidence on an annual basis overstates the regressivity of consumption-based taxes, relative to lifetime measures of taxes and income, as consumption is high (low) relative to income in the earlier and later years (middle) of the life cycle.

[8] A separate issue, discussed by Gillis, Mieszkowski, and Zodrow (1996) but not addressed in this paper, is the interaction of the VAT with existing state sales taxes; note, however, that an important advantage of a well-designed VAT is that it provides full credits for business purchases and thus does not result in the "tax cascading" that characterizes state sales taxes in the United States, which are often assessed on business purchases (Ring 1999) and thus may be applied multiple times during the production and distribution process.

[9] This paper draws on an earlier analysis of an alternative VAT reform by Carroll et al. (2010).

[10] No attempt is made to model an "optimal" debt/GDP ratio in the model; however, as in most such models, the parameterization of the model implies that the economy is saving too little relative to a golden rule path, so that additional saving and capital formation results in increases in steady state consumption levels (Summers, 1981). In addition, the level of public services is assumed to be fixed throughout the analysis.

[11] See Zodrow (2002) for further discussion of the transitional issues associated with consumption tax reforms.

[12] Another approach to deficit and debt reduction would of course be to reduce government spending. For example, Carroll et al. (2010) examine the effects of reducing government transfers, which would be more efficient but also have different distributional effects than the temporary VAT analyzed in this paper.

[13] The imputed value of financial services reflects services received by consumers, such as free checking or free online bill payment, that are implicitly purchased with below-market interest rates (often at or near zero) on deposits. Note that interest expense is not deductible under a VAT.

[14] We do not consider the effects on the actual VAT rate of any tax avoidance or evasion, or the effects of revenue declines due to any "announcement effects" in the form of increases in consumption prior to the enactment of the VAT.

[15] Note that the double indexation of Social Security benefits might affect the retirement decisions of elderly poor near the retirement age; since the retirement age is fixed in our model, we do not capture this effect (although we do capture changes in labor supply near the fixed retirement age due to anticipated larger future benefits).

[16] Following most of the models in this literature, we consider an economy characterized by perfect certainty. This admittedly strong assumption has been relaxed in the dynamic stochastic general equilibrium literature; for example, see Kocherlakota (2010).

[17] Following Fullerton and Rogers (1993, 1996) we assume a target bequest that is fixed in nominal terms. The use of the target bequest motive tempers the savings responses in the model

(a higher interest rate implies that the target bequest is more easily attained), and thus reduces concerns that the savings responses of the far-sighted life-cycle consumers in the model are unreasonably large (Gravelle 2002). Savings responses would be larger under the alternative "joy of giving" bequest motive assumed by Altig et al. (2001); Kopczuk and Lupton (2007) provide some empirical support for this approach.

[18] The individual utility functions, however, are identical across the various lifetime income groups, which implies that the parameters that determine behavioral responses, including those associated with changes in labor supply and saving, are identical across the various lifetime income groups; allowing variation by lifetime income group of these parameters in order to better capture differences in their behavioral responses is a topic of future research.

[19] In this formula, marginal q is the shadow price of new investment and can be related to average Q, the ratio of the market value of capital to its replacement cost (Hayashi 1982; Chirinko 1993).

[20] See, for example, Feldstein and Horioka (1980) and the voluminous subsequent literature, reviewed in Zodrow (2010), as well as Gravelle and Smetters (2006), who argue that capital is less than perfectly mobile and that imperfect substitutability between domestic and imported goods also inhibits international capital flows.

[21] Note that this implies the model does not include the possibility that the productivity growth rate may be endogenous and thus affected by tax factors – although the assumption that the effects of a temporary VAT on the productivity growth rate would be minimal seems reasonable.

[22] The analysis assumes that investment as a fraction of the capital stock that is in excess of the steady state level is subject to quadratic adjustment costs; the adjustment cost parameter is proportional to the marginal adjustment costs associated with such incremental investment.

[23] The per capita transfer offset would be approximately equivalent to using these revenues to finance increased payments for a universally available and roughly uniform expenditure program such as Medicare.

[24] With a debt/GDP ratio of 75 percent in the initial steady state and a growth rate (of population plus productivity) of 3.3 percent, the deficit/GDP ratio must be 2.5 percent initially to maintain a constant debt/GDP ratio. The steady state deficit/GDP ratio falls to 1.6 percent when the debt/GDP ratio falls to 50 percent.

[25] Note that the long run increases in investment and the capital stock are not identical because the mix of capital changes.

[26] The interest rate in the initial steady state equilibrium, not shown in the table, is 7.5 percent.

[27] The VAT is fully shifted forward in the model, which is consistent with most empirical evidence; see Zodrow et al. (2011).

[28] Note that this differs slightly from the current policy of indexing Social Security benefits using a wage index since prices rise by more than wages in our simulations.