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Tax plan debates in the US presidential election: A dynamic CGE analysis of growth and redistribution trade-offs☆

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ABSTRACT

The two major candidates in the 2016 presidential election made sharply different proposals for reforming the Federal tax code. Donald Trump proposed cutting taxes to provide "tax relief for middle-class Americans", and lowering corporation taxes to boost economic growth, while Hillary Clinton proposed modest increases in taxes on high-income Americans, with a view to increasing the "fairness" of the tax code. We have simulated the effects of these two proposals, using a two-tier modeling design, with a large dynamic computable general equilibrium model to address the macroeconomic magnitudes, linked to a micro-simulation tax calculator model to measure the distributional effects. The Trump proposals would boost economic growth, but sharpening the incentives to work and to save/invest would be regressive, with 70% of the benefits accruing to those in the top income decile. The budget deficit could only be maintained if spending were to be cut sharply; and if spending were reduced more modestly, the deficit would rise greatly. The Clinton proposals would have little net effect on 90% of households, which is at odds with her promise of tax relief for working people, but would reduce net income in the top decile by almost 2%. They would slow economic growth slightly. Although he was elected president, Donald Trump's proposals are likely to be altered, mainly so that the budgetary effects are much smaller, before being presented to Congress. But the rationale, shape, and tone of the proposals will likely remain the same.

1. Introduction

The President is the top executive of the US government and is elected by the people every four years. Although all major proposals have to be approved by Congress, presidents have considerable influence on the direction of policy, including tax policy. The two major candidates in the 2016 presidential election – Donald Trump and Hillary Clinton – offered strikingly different proposals for tax reform. The Trump proposals aimed to simplify, and substantially lower, tax rates on personal and corporate income, with the intention of providing tax relief for "middle-class" Americans and boosting economic growth (Trump, 2016). The focus of the Clinton proposals was on restoring "basic fairness" to the tax code, mainly by increasing taxes somewhat on high-income households and closing some corporate tax "loopholes" (Clinton, 2016).

The impetus for tax reform comes from two competing directions. On the one hand is it widely held that the existing U.S. tax system is highly inefficient, particularly in the way that it discourages business investment, and individual work effort (NCFRR, 2010; President's Advisory Panel, 2005). Two relatively recent high-profile official commissions have proposed changes to the tax system, first in 2005 (President's Advisory Panel), and then in 2010 (NCFRR), and both emphasized the importance of improving the efficiency of Federal taxes by broadening the tax base and reducing the top marginal rates.

The other source of pressure for tax reform is the increasing popular concern about rising inequality in the U.S., and a sense that

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the tax system does less than before in moderating this inequality (Piketty and Saez, 2007). McCaffery (2014) argues that opinion polls that solicit public views on taxes are biased, and that helps explain why Americans are consistently so supportive of tax cuts, even when they are highly regressive. There is a tension between the goals of efficiency and equity, and they are constrained by the need for government to raise enough revenue to function properly.

The goal of this paper is to estimate the efficiency, equity, and revenue effects of the Trump and Clinton tax proposals. While the results are interesting in their own right, they also allow us to determine whether the proposals would achieve the candidates' stated goals. And they help provide some insight into what tax changes may be proposed to Congress in the course of the Trump presidency.

The approach we take is to simulate the effects of the different tax proposals using a micro-macro model. The micro-simulation tax calculator mainly uses data from the public use sample of personal income tax returns from the Internal Revenue Service, augmented with detailed data from the Current Population Survey and the Consumer Expenditure Survey. This information is also used to help construct the social accounting matrix that forms the informational foundation of a large dynamic computable general equilibrium (DCGE) model, which in turn is used to simulate the growth, employment, income, and sectoral effects of the tax changes. These are then fed back into the micro-simulation model in order to measure the "dynamic" impact of the tax proposals on the distribution of income.

To the best of our knowledge, no full dynamic CGE model has been used to assess and compare the tax proposals of presidential candidates, although simpler models have been used, and we compare our results with two of these below.

We discuss the structure of our dynamic CGE and tax calculator models, and relate them to the relevant literature, in Section 2; the Appendix provides more technical details on the DCGE model. Then we assess the revenue, growth and redistributive impacts of the Trump proposals in Section 3, and of the Clinton proposals in Section 4. We compare the outcomes of the tax proposals with their stated goals, in Section 5, and then compare the main policy implications of the two tax reform proposals in Section 6, finishing with our conclusions in Section 7.

2. The DCGE and tax calculator models

In order to trace the effects of tax changes on the economy, we use a two-tier model. A large dynamic computable general equilibrium (DCGE) model is used to simulate the effects of tax changes on economic growth and employment over time, for twenty-seven industrial sectors and ten income groups. Separately, a tax calculator model, based on detailed household data, is used to measure more precisely the impact of the changes on the ten deciles, first independently of the DCGE results (the "static" estimates), and then allowing for the model-based income growth. This micro-macro modelling is now the preferred approach to estimating the distributional effects of tax changes (Bourguignon et al., 2010; Feltenstein et al., 2013; Cockburn et al., 2010; Bussolo et al., 2008). In additional to making a comparison between the tax plans of two major presidential candidates, what sets our model apart is that it is large, dynamic, and up-to-date, and has micro and macro tiers that allow for a consideration of both the macroeconomic and distributional impacts of the tax proposals.

2.1. The DCGE model

The purpose of our DCGE model is to examine the effects of U.S. tax policy changes on major economic indicators, including Gross Domestic Product (GDP), capital investment, private sector employment, and government tax revenues, employment and spending. The main structure of the model is based on Bhattarai (2007), and has a structure that is somewhat similar to the one used by Mirrlees et al. (2010) to analyse tax reform.

Economists have long recognized that taxes have measurable effects on the macroeconomy, and on income distribution. A recent and extensive literature review notes that most studies find that federal taxes, particularly corporate and income taxes, have deleterious effects on economic performance in the United States (McBride, 2012), although the pathways through which such effects occur are not always clear. Romer and Romer (2010), for instance, find a strong negative relationship between federal taxes and economic performance, but note that their "results are largely silent concerning whether the output effects operate through incentives and supply behaviour or through disposable income and demand stimulus" (p.799). Taxes at the state level are also found to have an effect on economic activity (Laffer et al., 2015).

Some argue that differences in tax levels and structures help explain the comparative performance of national economies. In a widely-quoted paper, Prescott (2003) argues that lower American tax rates induce workers to allocate more time to work than their European counterparts. This conclusion follows from an understanding of the sensitivity ("elasticity") of labor supply to taxes on labor income (Prescott and Wallenius, 2008). International comparisons are, however, easily muddied by the difficulty of inferring causality: if high-income countries have higher tax rates, is it because taxes (and the associated spending) helped them achieve affluence, or does the affluence permit them to impose higher taxes without much harm? In our static incidence part of our analysis we ignore the behavioral effects of changing taxes, but the CGE model allows taxes to change the behavior of firms and households, as explained below.

It is widely held that dynamic CGE models are the most appropriate tools for assessing the macroeconomic impacts of taxes (Burfisher, 2011). For instance, Diamond and Zodrow (2014) analyze the macroeconomic effects of the tax proposals put forward by Congressman Camp in 2014; their overlapping generations model is based on Zodrow and Diamond, which is well suited for the macroeconomic analysis, but less suitable for allocating tax incidence across income deciles. The effects of changes in corporate tax rules in the European Union have been explored with a somewhat similar model by Bettendorf et al. and de Mooij and Devereux. Jorgenson and Yun (2012) also explore the growth and efficiency effects of taxation with a CGE model, but they do not wed it with the microeconomic data that would be needed for an analysis of the distributional effects. Devarajan and Robinson (2005) make the case that CGE models have proven to be useful in discussions of policy because they impose consistency, force policy makers to confront tradeoffs, and sometimes yield surprising, yet plausible, results that might not otherwise be apparent.

In a recent study, Bhattarai et al. (2016) found significant efficiency benefits from the implementation of a national retail sales tax (the "FairTax") in the United States. That study utilized a tax model similar to the one in Bhattarai et al. (2017), and was purpose-built to show how a particular tax proposal would affect the economy. The dynamic CGE model that we use is based on a revised version of the model used by Bhattarai et al. (2016), and is similar to the one described in Bhattarai et al. (2017). The model we use is calibrated using micro-consistent data from an updated Social Accounting Matrix.

In our DCGE model, households maximize the present value of their utility, which they derive from consumption and leisure. Their incomes come from (after-tax) labor earnings and the return on capital, based on production by firms in 27 industrial sectors, as well as transfers received from government. These firms mix inputs (in fixed proportions) with labor and capital (for which substitution is allowed) to produce output, while the households are disaggregated into ten deciles (from poorest to richest). When taxes change, the behavior of firms and individuals changes, and the effects reverberate across the economy in ways that our DCGE model is able to capture.

The model identifies 11 types of taxes, including eight at the federal level. Over the 53-year solution period of the model – it runs from 2017

through 2070 – government revenues must balance spending on average. Large deficits are possible in any given year, but have to be financed; as shown below, we model the effects of the Trump tax proposals under two scenarios, one where government spending is cut to match tax revenue, and another where the government cuts spending modestly, and runs large deficits.

The underlying data, which come from a variety of sources, are organized in a 55 by 55 social accounting matrix. The optimization is done over a 53-year time horizon; altogether the model has 89,098 variables.

2.2. The micro-simulation tax calculator

While the DCGE model is well-adapted to measuring the macro-economic effects of tax changes, it is not sufficiently detailed for tracking the distributional effects. For this we developed a micro-simulation model. We begin with the IRS Individual Public-Use Micro-Data files on individual federal income tax returns for 2009 (the most recent year available). After excluding cases filed by dependents or married couples filing separately, we are left with 153,948 tax returns that represent households. To this we added 11,480 households from the 2009 Current Population Survey (CPS) who did not file federal tax returns. We then augmented this file with information from the 2009 Consumer Expenditure Survey, using a synthetic matching procedure (as in Feenberg et al. (1997)), which allowed us to create a broader measure of income than would be possible with the IRS data alone. Our measure of broad income includes cash income, and also employee and employer contributions to health insurance, and in-kind transfer receipts such as food stamps. Following common practice (Chanfreau and Burchardt, 2008) we divided household income by the square root of household size to get a measure of broad income per adult equivalent, which we then used to sort households into deciles.

We use this micro-database to estimate the amount of personal income tax paid without, and then with, the proposed tax changes. We assume that the burden of the personal income tax is borne by households; that the incidence of corporate income tax falls equally on capital income and labor income; and that the estate and gift tax hits high-wealth households only. The “static” revenue and incidence effects reported below just use this micro-simulation model, and do not incorporate any behavioral responses on the part of taxpayers. The “dynamic” effects require three steps: first use the tax calculator to obtain an initial measure of incidence; then use this information in the DCGE model to work out the effects on income and spending by decile; and finally use that output back in the tax calculator model to get a revised set of measure of incidence. Using the terminology of the Feltenstein et al. (2013) survey, we integrate the micro-simulation and DCGE models using both a “bottom-up” and “top-down” approach.

2.3. The model in context

In the past, there have been several studies that evaluated the impacts of tax reforms; see Shoven and Whalley (1984) for a review of early literature. Jorgenson and Yun (1990) used a representative agent, dynamic general equilibrium model of the US economy to evaluate the impacts of the 1986 tax reforms on growth, and found positive impacts. Our analysis is more decentralized, as it includes 10 deciles of households and 27 industries. Our dynamic CGE model is more comprehensive than the static models of Fæhn (2015) for Norway, or the ifomod model of Radulescu and Stimmelmayr (2010) for Germany. Similarly the micro-econometric models of the Institute of Fiscal Studies in the UK, and the studies in Mirrlees et al. (2010) do not contain dynamic general equilibrium models for decentralized firms and households. The growth and redistribution impacts of taxes in the UK and four EU economies in the studies by Bhattarai (2007, 2016) have a more relevant structure, but were not applied to the US economy. Bhattarai et al. (2016) use a dynamic CGE model of the US economy to assess the growth and redistributive impacts of a FairTax – a flat consumption tax with universal exemptions, to replace all income taxes – but that study does not examine proposals like those made by Trump and Clinton. While there is evidence that high inequality may be detrimental to economic growth (Ostry et al., 2015), this does not necessarily imply that efforts to redistribute will help (p.4). At any rate, CGE models are not yet adapted to addressing this important, if knotty, issue.

Our DCGE model also differs from the widely-cited Tax and Growth (TAG) model of the Tax Foundation. The TAG model is a simple small-scale model based on estimated key parameters from the BEA's macro time series (McBride, 2012). It is inadequate for studying growth and redistribution together, as it does not include details on households and sectors, or on the taxes, transfers and spending required for a more realistic analysis. Our dynamic CGE model improves on the TAG model on five main grounds: 1) The TAG model does not have explicit derivations of demand and supply functions of production, based on dynamic optimization. Therefore solutions of the TAG model cannot show optimal allocations of resources in the economy. 2) Our DCGE model is based on a 55-sector social accounting matrix (SAM) structure, and has detailed micro-foundations for households and firms based on data from the CPS, IRS and CES, while the TAG simulation model is more heuristic, and with representative households is potentially subject to aggregation errors; 3) The mechanism for the accumulation of capital is not explicitly stated in the TAG model; instead it applies shares and growth factors in projecting the economy. 4) Our DCGE model links households and firms in a decentralized way, and therefore it is able to connect the size and functional distributions of income. Thus the DCGE model can be applied to study the impacts of taxes on inequality over time. 5) The extent of income and substitution effects in the economy are very limited in the TAG model, as this model has very few relative prices that matter in the analysis of the dynamic efficiency of the economy as a whole, yet they play a crucial role in the DCGE model.

The Trump and Clinton tax proposals differ significantly in their goals, designs, and potential impacts on growth and redistribution in the US economy. In analyzing both proposals, we assume that they go into effect in the 2017 calendar year, and we measure all changes against a baseline, no-tax-change scenario.

More details on the microfoundations and macro-policy applications are found in Haughton et al. (2016), which is also a complementary study to this one. An application of a similar model to policy debates may be found in Villarreal (2016).

3. The Trump tax plan (TTP)

The Trump tax plan calls for a federal personal income tax with four brackets – 0 percent, 10 percent, 20 percent, and 25 percent (See Table 1). It would eliminate the marriage penalty, the estate tax, and the Alternative Minimum Tax (AMT), but would retain the deductions

Table 1
Trump proposed tax rates on personal income.
Source: Donald Trump (2016) Tax Reform that will make America Great Again: The Goals of Donald J. Trump's Tax Plan,” Accessed February 8, 2016. https://www.donaldjtrump.com/positions/tax-reform.

Income tax rate (%)	Long-term capital gains (%)	Single filers ($)	Married filers ($)	Heads of household ($)
0	0	0–25,000	0–50,000	0–37,500
10	0	25,001–50,000	50,001–100,000	37,501–75,000
20	15	50,001–150,000	100,001–300,000	75,001–225,000
25	20	150,001 and up	300,0001 and up	225,001 and up

for charitable giving and mortgage interest.

The Trump plan calls for offsets to "pay for the tax cuts." It would eliminate "loopholes" for exceptionally high income earners, phase out itemized deductions, and end the tax exemption for life insurance interest. It would end the favorable tax treatment of carried interest, reform corporate taxation (with a 10 percent repatriation tax on overseas holdings), and impose a cap on business interest expenses.

4. Revenue effects

While the Trump plan sets out clearly the proposed tax rates and brackets, it is far less detailed in the treatment of exemptions and deductions: The plan states, "those within the 10% bracket will keep all or most of their current deductions" (Trump, 2016). Since the Trump plan provides no further details, we assume all current deductions remain in this bracket. It goes on to say, "those within the 20% bracket will keep more than half of their current deductions. Those within the 25% bracket will keep fewer deductions. Charitable giving and mortgage interest deductions will remain unchanged for all taxpayers" (Trump, 2016). We assume that half of deductions are retained for the 20 percent bracket, and that only the charitable giving and mortgage interest deductions are retained for the 25 percent bracket.

The Trump plan also calls for new tax brackets to which the rates on long term capital gains and dividends would apply, and would put in place a 15% tax on business income. We take these important details into account in the micro-simulation tax calculator.

The revenue effects of these tax changes are shown in Table 2. These result from "dynamic" simulations, in that the changes are first run through the tax calculator, then those effective rates are applied in the DCGE model, and the macroeconomic changes in that model are then carried back to the micro-simulation tax calculator. In the first year, the personal income tax cuts would reduce U.S. Treasury revenue by $423 billion, or by $559 billion in 2026. Corporate income tax collected would be $250 billion lower in 2017 than in the CBO baseline projection, and $325 billion lower in 2026. Overall, the Trump tax plan would reduce federal revenue by $674 billion (a decrease of 21 percent) in 2017. Some taxes would produce more revenue, given the expected expansion in the economy. These taxes include social security taxes, excise taxes, trade duties, and state and local.

5. Economic effects

The simulated economic effects of the Trump tax proposals are set out in Table 3, and show the percentage changes in variables relative to the CBO benchmark projections. There are two variants: In the first scenario, the government cuts spending to match the fall in revenue, so that the budget deficit remains unchanged. In the second scenario government cuts spending by "only" about five percent, and finances the resulting large deficit domestically. In both cases "closure" is achieved by adjustments to the private saving rate.

Table 3
Economic effects of the Trump Tax Plan.

	Scenario 1: Spending adjusts		Scenario 2: With deficit	
	2017	2026	2017	2026
	% change relative to baseline			
Private Employment	1.7	1.5	– 0.1	– 0.3
Public Employment	– 13.4	– 15.4	– 5.3	– 7.2
Total Employment	– 0.5	– 1.0	– 0.9	– 1.3
Government revenue	– 13.3	– 14.7	– 14.8	– 16.2
Government spending	– 13.0	– 14.4	– 5.1	– 6.8
Budget deficit	0.0	– 2.9	127.6	112.5
Real GDP	1.4	3.2	1.5	1.3
Personal Income	2.2	2.2	0.4	0.4
Private saving	2.3	4.6	11.1	13.4
Business Investment	2.2	4.7	2.0	4.5
Capital stock	0.0	3.4	0.0	3.5
Imports	0.8	2.6	0.8	2.6
Exports	1.1	3.2	1.2	3.3
Net Trade Balance	– 2.0	– 2.5	– 2.5	– 3.1

Note: Based on DCGE model simulations

Under both scenarios, the reduction in the corporate tax rate increases the incentive to invest, and the rise in investment eventually pulls up the capital stock, which has a growth-enhancing effect. The additional investment has to be financed, and this is achieved with a small increase in private saving in Scenario 1 (when the government deficit does not widen), but requires a very large rise in private saving in Scenario 2, in order to finance both the extra investment and the large government deficit.

As expected, government revenue would fall sharply, only slightly offset by faster economic growth. The reduction in public employment, which represents just under 15% of all employment, would be substantial, and would not be fully offset by any expansion in private employment, although this effect is sensitive to the assumptions made about the responsiveness of labor supply to wages – an issue to which we return below.

Our simulations show that GDP would rise by about 1.4% in the first year (relative to the benchmark); if the budget deficit is kept under control, the effect on GDP would rise over the subsequent decade, but there would be no such improvement if the government were to allow the deficit to expand massively.

The incidence of the proposed Trump tax changes on households is shown in Table 4, based on the calculations of our micro-simulation tax calculator. Focusing solely on the tax effects, and ignoring any behavioral responses, the Trump plan would reduce the tax burden of all households, but 70 percent of this reduced tax burden would be enjoyed by households in the richest decile, who would pay about 31 percent less in taxes. Only 1.8 percent of the reduced tax burden would

Table 2
Changes in revenue relative to the benchmark: the Trump plantaxes.

Change in Revenue	2017		2026		2017–2026 cumulative	
	Change ($billion)	% Change	Change ($billion)	% Change	Change ($billion)	% Change
Federal Revenue	– 674	– 21.4	– 893	– 21.8	– 7769	– 21.6
Social Security Tax	15	1.2	10	0.6	135	1.0
Personal Income Tax	– 423	– 30.3	– 559	– 30.8	– 4880	– 30.5
Corporate Income Tax	– 250	– 81.1	– 325	– 81.2	– 2859	– 81.1
Excise Taxes	2	2.8	3	3.6	25	3.2
Estate and Gift Taxes	– 21	– 100.0	– 28	– 100.0	–245	– 100.0
Trade Duties	1	2.8	2	3.6	13	3.2
Other Taxes and Fees	3	2.8	5	3.6	43	3.2
State and Local Revenue	66	2.5	94	2.8	807	2.7
Total Government Revenue	– 608	– 10.6	– 798	– 10.64	– 6962	– 10.6

Note: Based on DCGE model simulations for scenario with no change in budget deficit.

Table 4
Changes in federal taxes paid by deciles: Trump proposals vs. current rules.

Deciles	Tax paid: current rules	Tax paid: Trump proposal	Change in tax paid	% change in tax paid	% of tax cuts	Tax change as % of income
	dollars per capita in 2017			*percentages*		
1 (poor)	197	− 99	− 296	− 150.4	1.8	− 3.6
2	108	− 296	− 404	− 374.5	2.5	− 2.3
3	776	527	− 248	− 32.0	1.7	− 0.9
4	466	388	− 78	− 16.7	1.6	− 0.2
5	8701	7411	− 1290	− 14.8	2.3	− 2.9
6	8032	6685	− 1347	− 16.8	4.0	− 2.5
7	9978	8319	− 1659	− 16.6	5.6	− 2.5
8	13,345	11,554	− 1791	− 13.4	6.4	− 2.2
9	17,695	16,662	− 1032	− 5.8	4.0	− 1.0
10 (rich)	52,082	36,185	− 15,897	− 30.5	70.1	− 6.7
Total	10,827	8645	− 2182	− 20.2	100.0	− 3.2

go to the lowest income decile, a tax cut that represents 3.6% of their income.

Thus it is obvious that Trump plan is biased in favor of upper-income groups, and would increase income inequality in the United States. This is also clear from Table 5, which shows our estimates of the distribution of income, before and after tax, by decile. When the dynamic effects on work and saving are taken into account (under Scenario 1, with no rise in the budget deficit), an individual in the richest decile would receive 30 percent more net income in 2017, compared with a gain of less than 10% in most deciles, as shown in column (6) of Table 5.

Fig. 1 presents the distributional effects of the proposed tax changes in another way, by looking at the present value of the welfare changes, by decile. Welfare comes from consumption of goods and services, as well as leisure, and also from goods and services provided by government. When all of these are taken into account, we see that the poorest Americans would lose, while those in the upper-middle part of the distribution would gain relatively the most. The comparatively modest relative gain by those in the top decile may seem surprising; in part it masks the high absolute gains that would go to this group, but it also reflects the fact that this group would enjoy less leisure (i.e. work more), and save more (i.e. spend relatively less).

Table 5
Gross and net income per adult equivalent deciles under Trump Reforms, estimated, 2017.

	Baseline		Trump: Static analysis		Trump: Dynamic analysis*	
	Gross income $/ae/ year (1)	Net income $/ae/ year (2)	Net income $/ae/ year (3)	% change to baseline (4)	Net income $/ae/ year (5)	% change to baseline (6)
Deciles						
1 (poor)	7548	6946	7851	13.0	8062	16.1
2	16,924	16,589	17,842	7.6	18,152	9.4
3	24,446	21,628	22,530	4.2	22,990	6.3
4	31,542	26,317	27,188	3.3	27,827	5.7
5	39,655	31,303	32,541	4.0	33,294	6.4
6	49,482	37,066	39,149	5.6	40,065	8.1
7	61,605	44,146	47,049	6.6	48,204	9.2
8	77,537	53,003	56,296	6.2	57,652	8.8
9	102,728	68,520	70,516	2.9	72,413	5.7
10 (rich)	244,440	132,084	166,379	26.0	169,298	28.2
Total	66,829	44,389	49,542	11.6	50,618	14.0

Note: Based on DCGE model simulations; see Haughton et al. (2016) for the details; ae = adult equivalent * Scenario 1, with no change in budget deficit.

5.1. Robustness

Our dynamic CGE model is large and complex, which makes it difficult to determine how robust are the simulations based on it. We do, however, examine the sensitivity of our results to changes in two of the most important parameters, the intertemporal elasticity of substitution (which we put at 1.0) and the elasticity of substitution in consumption (for which our baseline value is 2.5). In Appendix B we show the effects of the Trump proposals on GDP, employment, and the personal welfare of those in the top and bottom deciles, for 2017 and 2047, under different measures of the elasticity of substitution (we use 0.9, and 1.0), and the consumption elasticity (where we also try a value of 1.5).

It is clear that our results are not very sensitive to changes in these parameters, at least for the values we consider. For instance, thirty years after the Trump proposals are implemented, our simulations show GDP to be 4.9% higher than the no-change baseline (under Scenario 1); with a lower consumption elasticity this falls to 4.7%; with a lower inter-temporal elasticity of substitution it falls to 4.8%.

6. The clinton tax plan

This section presents the results of applying our DCGE and micro-simulation models to the Clinton tax plan, as articulated in the course of her presidential campaign.[1] Essentially these plans called for modestly higher taxes on high-income earners, and on estates and gifts. They also included restrictions on corporate inversions, and the abolition of tax incentives for the coal, oil and gas industries.

6.1. Personal income tax

The current Federal personal income tax has seven distinct non-zero tax rates, ranging from 10% to 39.6%. Income from labor and capital is adjusted for certain expenses to give adjusted gross income, which is then reduced by subtracting personal exemptions as well as deductions (either at a standard rate, or itemized) to give taxable income. Somewhat lower tax rates are applicable to capital gains. And for relatively high-income taxpayers – with modified adjusted gross income of over $250,000 per year for married taxpayers filing jointly – there is an additional 3.8% tax on investment income which includes dividends and royalties as well as capital gains. The amount of tax payable may then be further reduced if the taxpayer is eligible to claim tax credits, such as the earned income credit (Erb, 2016).

The Clinton plan would alter the personal income tax in a number of ways. The most important proposed changes are as follows:

1. Add a surcharge of 4% on adjusted gross annual income above $5 million.
2. Limit the value of deductions (except for contributions to charity) to no more than 28% of their value.
3. Ensure that every taxpayer with a modified adjusted gross income of $1 million or more would pay at least 30% of their income in taxes (the “Buffett Rule”).
4. Increase the tax rates applicable to capital gains for those in the top income tax bracket, by applying the standard tax rate to capital gains on assets held less than two years rather than the current one year,

[1] The details are found in a number of places, including: Hillary for America “Raising incomes and fighting inequality: A plan to raise American incomes, https://www.hillaryclinton.com/issues/plan-raise-american-incomes/ Accessed July 12, 2016. https://www.hillaryclinton.com/briefing/factsheets/2016/06/22/stronger-together-hillary-clintons-plan-for-an-economy-that-works-for-everyone-not-just-those-at-the-top/ We also refer to plan details outlined by the Tax Policy Center http://www.taxpolicycenter.org/publications/analysis-hillary-clintons-tax-proposals/full and the Tax Foundation, http://taxfoundation.org/article/details-and-analysis-hillary-clinton-s-tax-proposals

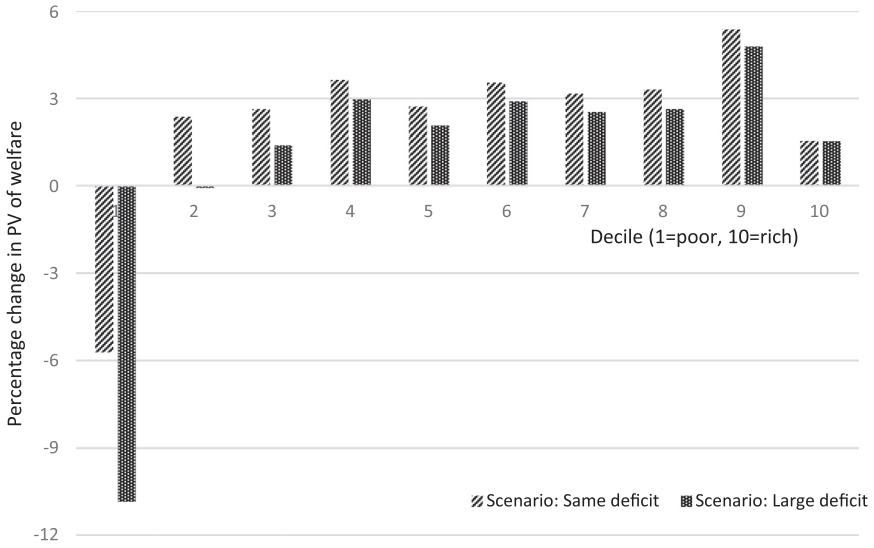

Fig. 1. Welfare effects of Trump proposed tax changes.

and phasing in the preferential capital gains rates gradually so that they would only apply completely to assets held for six or more years.

5. Repeal carried interest, which is a provision that allows general partners in some businesses to book most of their earnings as (low-taxed) capital gains rather than labor income.

6.2. Corporate income tax

Under current rules, the income of C corporations is taxed on a sliding scale that rises from 15% for taxable income below $50,000 per year and eventually levels off at 35% for profit – i.e. "corporate income" – above $18.3 million annually. Most of the taxable income is earned by large firms, so in 2013 the average tax rate was 34.8% (IRS-SOI 2016, Table 5). When state and local corporation income taxes are included, the U.S. has, on paper, one of the highest tax rates in the world, and this has led to widespread calls for reforming the tax.

The Clinton proposal would make modest changes to the tax code that applies to corporations – eliminating some tax incentives for fossil fuels, and making it harder to avoid U.S. taxes by holding profits overseas. It would disallow certain deductions for insurance companies and "cut the billions of wasteful tax subsidies oil and gas companies have enjoyed for too long and invest in clean energy."[2]

Here, we only model the cut to subsidies for oil and gas companies. We use the Joint Committee on Taxation's report *Estimates of Federal Tax Expenditures for Fiscal Years 2015–2019* for fossil fuel subsidies. Table 6 displays the results. The tax expenditures for oil and gas companies total $38.3 billion over ten years, which translates into corporate tax rate changes of 0.9 percentage points in 2017, rising to 1.41 percentage points in 2026.

6.3. Estate tax

Upon death, the estate of the deceased may be subject to an estate tax if the amount exceeds $5.45 million. The tax rate begins at 18% but the statutory rates rise fairly quickly, reaching 40% on the value of estates in excess of $6.45 million. There are numerous ways to avoid all or most of the tax, so that only an estimated 0.2% of estates pay this tax (Huang and Debot, 2015). The Clinton proposal calls for a reduction of the threshold to $3.5 million, and a new top statutory rate of 45%, which would return the tax structure to the one in effect in 2009.

[2] Hillary Clinton, The Issues, Climate Change, https://www.hillaryclinton.com/issues/climate/.

Table 6
Revenue effects of cutting subsidies for oil and gas companies, $ billion, 2017–2026. Source: Joint Committee on Taxation, Estimates of Federal Tax Expenditures for Fiscal Years 2015–2019.

	$ billion, 2017–2026
Expensing of exploration and development costs	12.6
Excess percentage over cost depletions	19.6
Amortization of geological and geophysical expenditures	1.2
Amortization of air pollution control facilities	3.6
Depreciation recovery 15-year MACRS for natural gas distribution line	1.3
Total	**38.3**

7. Revenue estimates

Based on our micro-simulation tax calculator model, we estimate that, on a static basis, the Clinton personal income tax proposals would raise $39 billion in new revenue in 2017, rising to $96 billion in 2026. When changes to the estate tax, and corporation tax, are included, revenues would be expected to rise by $816 billion over the decade 2017–2026, with 85% of the additional revenue coming from the proposed changes in the personal income tax. The details are shown in Table 7. The 4% surtax on very high incomes would raise $117 billion over ten years, but the biggest revenue gain would come from limiting the tax value of non-charitable deductions to 28% of their total value. The proposed changes in the capital gains tax would reduce revenue in the short-term, as high-income individuals delay realizing their capital gains, but would increase revenue over the long run.

The micro-simulation model provides static estimates of the change in tax rates that apply to the personal income tax for each decile, and we use these in the CGE model to arrive at the impact on economic magnitudes such as GDP and employment. This also allows us to measure the "dynamic" revenue changes, which are reported in Table 8.

In 2017, the Clinton personal income tax hikes would increase U.S. federal tax revenue by $54 billion relative to the CBO baseline, and federal revenues would increase by $71 billion in 2026. Because the tax increases would restrain economic growth, there would be some reduction in state tax collections, so that overall government revenue – including federal, state, and local levels – would rise by just under $50 billion in 2017 and almost $60 billion in 2026.

It is clear from Table 8 that most of the incremental revenue would come from the proposed changes in the federal personal income tax. Over the 2017–2026 period, receipts from the federal personal income tax would rise by a total of $548 billion; the expansion of the estate and

Table 7
Static revenue estimates of the clinton plan relative to benchmark.
Source: Authors' calculations, and Haughton et al. (2016).

	2017	2026	2017–2026
	billions of dollars		
Personal Income Tax			
Surtax only	9	14	117
Limited value of deductions	36	55	449
Buffett rule	5	8	65
Capital gains tax	– 10	20	75
Subtotal, PIT	**39**	**96**	**693**
Estate tax	6	11	81
Corporate tax changes	4	6	42
Total	**49**	**113**	**816**

Table 8
Dynamic revenue effects of the clinton plan relative to CBO benchmark.
Source: Based on micro-simulation tax calculator, and DCGE, models.

	Change in revenue					
	2017		**2026**		**Cumulative, 2017-26**	
	$ billion	*%*	*$ billion*	*%*	*$ billion*	*%*
Federal Revenue	54.1	1.6	70.5	1.4	**615**	1.7
Social Security Tax	– 2.5	– 0.2	– 7.0	– 0.3	**– 47**	– 0.3
Personal Income Tax	47.6	2.9	63.0	3.0	**548**	3.4
Corporate Income Tax	3.6	1.1	5.3	1.0	**43**	1.2
Excise Taxes	– 0.1	– 0.1	– 0.2	– 0.2	**– 1**	– 0.2
Estate and Gift Taxes	5.7	26.1	9.7	25.9	**75**	30.8
Trade Duties	– 0.0	– 0.1	– 0.1	– 0.2	**– 1**	– 0.2
Other Taxes and Fees	– 0.1	– 0.1	– 0.3	– 0.2	**– 2**	– 0.2
State and Local Revenue	– 4.6	– 0.2	– 10.7	– 0.3	**– 78**	– 0.3
Total Government Revenue	**49.5**	**0.9**	**59.8**	**0.7**	**538**	**0.8**

gift tax would bring in an additional $75 billion, and the elimination of corporate tax incentives for fossil fuel development would yield a further $43 billion. Since the higher tax rates would negatively affect the tax base for Social Security taxes, excise taxes, trade duties and other taxes and fees, revenues from these taxes would decrease by $51 billion over the ten-year period.

As discussed earlier, tax policy proposals create changes in economic activity, through the effects they have on work and saving. The DCGE model works through these effects in a consistent way, with the results that are shown in Table 9. In 2017, the Clinton tax changes would lead to 207,000 fewer private sector jobs, which represent a reduction of 0.14 percent against the baseline (i.e. no-change) projections. This would be offset to some extent by an expansion in public employment of 49,000 jobs; the net effect would be a reduction of 159,000 jobs in 2017, and 211,000 jobs in 2026.

Real GDP would decrease by $103 billion in 2017, or by 0.59 percent, and there would be measurable reductions in personal income (down $47 billion) and private business investment (down $19 billion). By 2026, real GDP would be $184 billion lower than it would have been in the absence of the tax changes, representing a reduction of 0.9%.

7.1. Revenue estimates compared

In Table 10 we compare our estimates of the revenue effects of the Clinton proposals with those of the Tax Foundation and the Tax Policy

Table 9
Economic effects of the clinton tax proposals.
Source: DCGE model of the US economy.

	Change relative to CBO baseline			
	2017		2026	
	'000 jobs	*%*	*'000 jobs*	*%*
Total Employment	**– 159**	**– 0.1**	**– 211**	**– 0.1**
Private Employment	– 207	– 0.1	– 265	– 0.1
Public Employment	49	1.9	54	2.1
	$ billion	*%*	*$ billion*	*%*
Real GDP ($billion)	– 103	– 0.6	– 184	– 0.9
Personal Income	– 47	– 0.3	– 103	– 0.4
Business Investment	– 19	– 0.7	– 48	– 1.1
Imports	– 2	– 0.1	– 7	– 0.2
Exports	– 2	– 0.1	– 8	– 0.2

Table 10
Federal revenue estimates from clinton plan.
Sources: Tax Foundation: Pomerleau and Schuyler (2016), dynamic estimates; Tax Policy Center: Auxier et al. (2016); DCGE: Table 8, dynamic estimates.

	Tax Foundation 2016–25 *$ billions*	Tax Policy Center 2016–26	DCGE 2017–26
Individual	173	781	548
Corporate	12	136	43
Estate	102	161	75
Other taxes	– 95	0	– 51
Total	**191**	**1077**	**615**

Center. All three estimates report the cumulative revenue effects over about a decade: the Tax Policy Center reports revenues over 11 years, including the year before the changes are implemented, arguing that there would be a (modest) early and temporary boost to revenue as some high-income taxpayers realize their capital gains in advance of the increase in tax rates on short-term capital gains.

The Tax Foundation arrives at a remarkably low estimate of expected revenue. In part this is because it largely ignores the effects of the changes on revenue from the corporate income tax, but mainly because it believes that the changes in the personal income tax will not raise much revenue, and even these changes will have a major effect in slowing economic growth and reducing revenue from other sources such as the payroll tax.

Like the Tax Foundation, we estimate the dynamic effects of the tax changes, but our extensive CGE model finds that the incorporation of the effects of slower economic growth would lower expected revenue by a quarter and not by 60%, as the Tax Foundation claims; it is highly unusual for the offsetting effects of "dynamic scoring" to exceed about 25%. The differences in the estimates may be ascribed to the assumptions that are used on the behavioral responses in each model. The Tax Foundation uses an elasticity calculated by the Congressional Budget Office and the Joint Committee on Taxation, while our DGCE model draws from a wider group of estimates from the economic literature.

The Tax Policy Center discusses the possibility of dynamic effects, but does not seek to quantify them, which goes some way to explaining their high revenue estimate. Their static measure of revenue from the changes in the personal income tax ($781 billion over a decade) is not dramatically different from our estimate of $693 billion; on the other hand, they are more optimistic about the revenue effects of changes to the estate tax, and they take a stab at estimating more of the revenue effects of changes to the corporate tax code even if some of these estimates are somewhat speculative.

The impacts on income distributions are clear if one looks into the pattern of income distribution emerging from the implementation of the Clinton tax proposals, as shown in Table 12. Greater taxes reduce

Table 11
Changes in taxes paid: clinton plan vs. current rules.

Deciles	Tax paid: current rules	Tax paid: Clinton	Change in tax paid	% change in tax paid	% of tax increases	Tax change as % of income
	dollars per capita in 2017			*percentages*		
1 (poor)	143	153	11.2	7.9	1.4	0.19
2	78	75	– 2.7	– 3.4	– 0.3	– 0.02
3	559	558	– 0.9	– 0.2	– 0.1	– 0.00
4	336	336	0.5	0.1	0.1	0.00
5	6,276	6,287	11.0	0.2	1.3	0.03
6	5,794	5,807	13.2	0.2	1.6	0.03
7	7,197	7,220	22.6	0.3	2.7	0.05
8	9,626	9,652	26.1	0.3	3.1	0.04
9	12,763	12,798	35.1	0.3	4.2	0.04
10 (rich)	37,567	38,282	714.7	1.9	86.0	0.42
Total	7,810	7,899	83.1	0.8	100.0	0.17

Note: Deciles refer to broad income per adult equivalent. (See also Haughton et al. 2016).

Table 12
Gross and net income per adult equivalent, 2017 under the clinton proposal, estimated. *Source:* DCGE model, the CPS, IRS and CES.

	Baseline		Static analysis		Dynamic analysis	
Deciles	Gross income $/ae/ year (1)	Net income $/ae/ year (2)	Net income $/ae/ year (3)	% change to baseline (4)	Net income $/ae/ year (5)	% change to baseline (6)
1 (poor)	7548	6946	6880	– 0.95	6897	– 0.70
2	16,924	16,589	16,578	– 0.07	16,600	0.06
3	24,446	21,628	21,614	– 0.06	21,627	– 0.01
4	31,542	26,317	26,294	– 0.09	26,298	– 0.07
5	39,655	31,303	31,272	– 0.10	31,271	– 0.10
6	49,482	37,066	37,019	– 0.13	37,011	– 0.15
7	61,606	44,146	44,070	– 0.17	44,054	– 0.21
8	77,537	53,003	52,914	– 0.17	52,888	– 0.22
9	102,728	68,520	68,405	– 0.17	68,354	– 0.24
10 (rich)	244,440	132,084	129,574	– 1.90	129,568	– 1.91
Total	66,829	44,389	44,078	– 0.70	44,076	– 0.71

See Haughton et al. (2016) for the details; ae = adult equivalent

the income for each decile slightly, but these are less than one percent of the income for an average individual, as shown in columns (5) and (7) from deciles 1 to 9. The richest households would see a 1.9% reduction in net income. These losses would be largely offset if the positive externalities of the expansion in public services were taken into account; in our simulations, we assume that government spending continues to follow the CBO projections.

8. Could the tax proposals deliver?

In this section we ask whether the outcomes of the model are consistent with the claims made by the candidates.

Donald Trump has claimed that his proposals would provide tax relief for middle-class Americans, simplify the tax code, and boost economic growth, while not adding to the Federal budget deficit or increasing the national debt (Trump, 2016).

There is no consensus about what constitutes the "middle class" in the United States, but if we take this group to consist of those in the fifth through ninth deciles of the income distribution – i.e. excluding the poorest 40% and richest 10% of the population – then our simulations show that the middle class would see a reduction of 13% in their federal tax payments, an amount equivalent to $1,400 per person per year. This does indeed constitute tax relief. One can also make the case that the reduction in the number of rates, and larger standard deductions, would simplify the personal income tax somewhat. And our model estimates that after a decade, GDP would be as much as 3.2% higher than in the CBO baseline projection.

These changes would be accompanied by a very large reduction in Federal tax revenue for the foreseeable future: over the coming decade, the Federal government would collect about $8 trillion less, representing a drop of 22% relative to the baseline. Unless spending were cut commensurately – and this was not proposed by the candidate – then the publicly-held Federal debt in 2026 would stand at 110% of GDP rather than 86% as projected by the Congressional Budget Office.

Hillary Clinton articulated a different vision of the role of tax policy, expressing a commitment "to restoring basic fairness in our tax code", and ensuring that the wealthiest Americans and large corporations pay their "fair" share while "providing tax relief to working families" (Clinton, 2016). She saw this as good for economic growth, because the tax proceeds would be spent on "bold investments that leave our economy more competitive over the long run," paid for "in a fiscally responsible way."

It is difficult to judge what is "fair", but it is correct to say that her tax increases would have mainly fallen on wealthy Americans: 86% of the incremental revenue would have come from those in the top decile of the income distribution. Her proposed tax changes would not have provided perceptible tax relief for working families: as Table 11 shows, the tax changes would have been less than a dollar per person per month for at least four-fifths of all households. Whether economic growth would have been boosted is disputable; the DCGE model suggests a modest (0.7%) reduction in GDP relative to the CBO baseline, but this does not take into account the possible effects of spending on infrastructure. In the absence of any new Federal spending, her tax plans would reduce the Federal deficit from a projected 86% of GDP in 2026 to 82%, which is relatively fiscally responsible.

The tax proposals of Candidate Trump, as discussed here, are unlikely to be enacted in their current form. The largest stumbling block may be the Byrd Rule, which stipulates that tax changes that would permanently increase the Federal budget deficit must automatically expire after ten years. The Republican-controlled Congress, as of September 2017, has not succeeded in repealing the Affordable Care Act, which would have cut spending on health care and opened up more room for revenue-cutting tax changes. Nor does public sentiment support lower taxes on the rich. In April 2017, Gallup polls found that two thirds of Americans thought that corporations paid too little tax, and 63% believed that "upper-income people" paid too little tax. Nonetheless, it is very likely that a significant tax reform package will be presented to the U.S. Congress during the early part of the Trump presidency, and that it will include many of the elements of the Trump proposals (fewer personal income tax rates, lower taxes on corporations, expensing), blended with some of the details set out in the *Better Way* tax plan proposed in mid-2016 by the congressional Republican leadership (Tax Reform Task Force, 2016).

9. Comparing the Trump and clinton tax plans

Three central conclusions emerge for the Trump proposal. First, the tax changes would reduce Federal tax revenue by about $8 trillion over the decade 2017–2026. Second, every income group, except for the poorest decile, would benefit directly from the tax cuts, at least to some extent. Third, the benefits would flow disproportionately to the households with the highest incomes, so the changes would be highly regressive: seven-tenths of the dollar value of the benefits would accrue to those in the top ten percent of the income distribution, with four percent of the benefits going to those in the bottom half.

The central focus of the Clinton tax plan is fairness. To reach "broadly shared prosperity," in a slow-growth environment, it seeks to promote growth and equity by shifting the tax burden to high-income taxpayers. The proposals are clearly intended to diminish income inequality and to bring greater equity and efficiency in the US economy.

The Clinton plan would increase federal revenue by $615 billion over 10 years, with personal income taxes comprising $548 billion of that amount. Over the same period, estate and gift taxes would increase by $75 billion.

9.1. Caveats

We have had to interpret Trump's tax proposals in order to operationalize the distributional analysis, because in some areas they lacked specifics. For instance, we assumed that a rule that would only allow C-corporations to deduct half of their interest expenses constitutes a "reasonable" limit on interest deductibility, but this may not be perfectly correct.

Although our conclusions are rooted in high-quality data, from the IRS public use sample, the Current Population Survey, and the Consumer Expenditure Survey, they also rest on a number of assumptions that, while we believe they are reasonable, could be questioned. We assume that the incidence of the income tax falls on those who receive labor and capital income; that half of the weight of the corporate income tax falls on earners, and half on those who own capital; and that the estate tax is borne by those who have large fortunes. The appropriate assumptions to make about the incidence of the corporate income are controversial, and this issue is not yet settled.

We also had to make other practical decisions: we constructed a measure of welfare that consists of a relatively broad form of income divided by the square root of the (truncated) family size, in order to assign households to deciles. A strong case can be made that expenditure is a more reliable guide to long-term wellbeing than is income, but the difficulty here is that our measure of spending is synthetic, glued on to the income data in a way that is defensible, but not robust as a support for inferences about wellbeing. Our method for adjusting for adult equivalence, while commonly used, is only one of at least 50 possible methods that have been used; fortunately, the results are not sensitive to the particular adjustment used here. The measure of income itself is not complete; it does not adequately include the implicit income from owning one's home, which turns out to be difficult to quantify satisfactorily, and the treatment of retirement income is imperfect and also inherently difficult to incorporate.

We have chosen to ignore the distributional effects of Trump's suggested tariffs on imports from China, Mexico, and Japan, treating these as bargaining positions rather than serious proposals. However, if implemented, they would erode the income of poorer households – cutting their real spending by as much as 18% – while hitting high-income households relatively less heavily with a cut in real income of 3% (Tuerck et al., 2016). Thus these tax changes too would have a regressive effect.

Despite these caveats, the conclusion is inescapable: the proposed tax cuts by Trump would increase the Federal deficit (or greatly reduce spending), benefit almost all taxpayers somewhat, but disproportionately favor high-income Americans.

10. Conclusions

The two major candidates in the 2016 presidential election made sharply different proposals for reforming the Federal tax code. With populist rhetoric, Donald Trump proposed cutting taxes to provide "tax relief for middle-class Americans", and lower corporation taxes to boost economic growth. Meanwhile, Hillary Clinton proposed modest increases in taxes on high-income Americans, with a view to increasing the "fairness" of the tax code.

We have simulated the effects of these two proposals, using a two-tier modeling design, with a dynamic computable general equilibrium model to address the macroeconomic magnitudes, linked to a micro-simulation model to measure the distributional effects.

Neither candidate's proposals are internally consistent. While Trump's proposed tax cuts would provide tax relief for most Americans (for now), simplify the tax code somewhat, and likely lead to somewhat faster economic growth, they would also create very large budget deficits for the foreseeable future, or punishing reductions in government spending. In a modeling context, this is possible if the deficits are followed by offsetting surpluses in the more-distant future, but whether markets would finance the deficits in practice is less clear: a strategy of first-the-gain, then-the-pain, risks stalling after the first phase.

Clinton's proposed tax increases would make the distribution of net income less unequal, but would not provide the promised "tax relief to working families", and might lower economic growth slightly. As befits the candidate of continuity rather than change, her tax proposals are modest in scope, and perhaps too cautious to have bought her much electoral support.

The importance of the tax debates to the outcome of the presidential election is not clear, but the fact that both candidates articulated relatively detailed plans, and spoke about them often, reflects a recognition of the importance of public perceptions of the need for tax reform. It also had the effect that regardless of the outcome of the election, tax reform was destined to be on the work agenda for the new president.

Donald Trump will not see all of his tax proposals enacted, although efforts will be made to make substantial changes along the lines he has proposed – with fewer individual tax rates, and lower corporation taxes, mainly benefitting those in the top decile of the income distribution. As they stand, the revenue loss would be too large and disruptive, especially as he would like to spend more on items such as the military, and infrastructure. He will also need the support of Republicans in Congress, and they have their own ideas about the changes they would like to see, such as the *Better Way* (2016) proposals made by Paul Ryan and the Republicans in the House of Representatives.

Nonetheless, our simulation exercise helps to clarify the differences between the candidates, and gives a good sense of the nature, and potential effects, of tax reform proposals that are ahead. It makes particularly clear the tradeoff between growth and equity, and reminds us of the need to make choices. Tax policy can help make the United States richer, or more equal, but cannot easily achieve both at the same time.

Appendix A. Overview of the BHI dynamic CGE model

An appropriate tool for quantifying the changes in taxes, transfers and spending is a Dynamic Computable General Equilibrium (DCGE) model. Since their beginnings in the 1970s, CGE models have been used to address tax issues, and are routinely used by government agencies such as the U.S. Treasury, the Congressional Budget Office, and International Trade Commission for policy analysis. A very clear early exposition is provided in Shoven and Whalley (1984, 1992).

We have constructed a large, 89,000-variable, disaggregated national DCGE model of the United States economy. The essence of our model is shown in Fig. A-1, which is heavily inspired by Berck et al. (1996) and Bhattarai et al. (2016), and where arrows represent flows of money (for

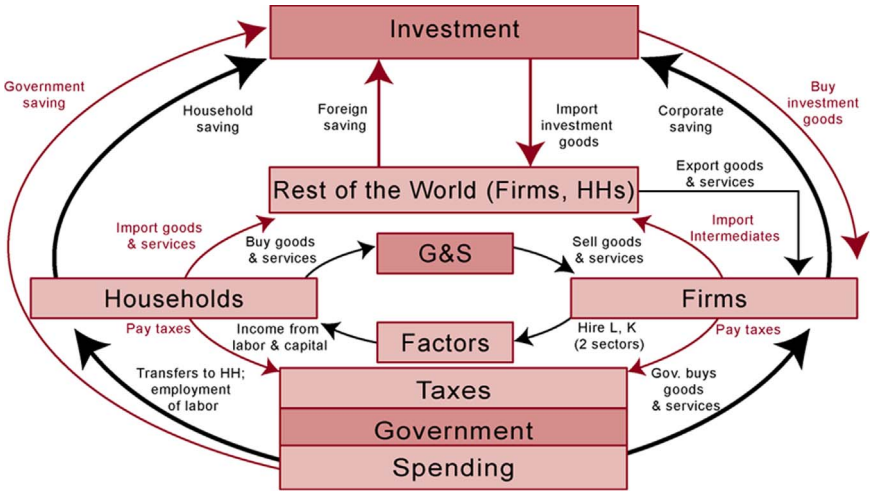

Fig. A-1. Circular flow in a CGE model.

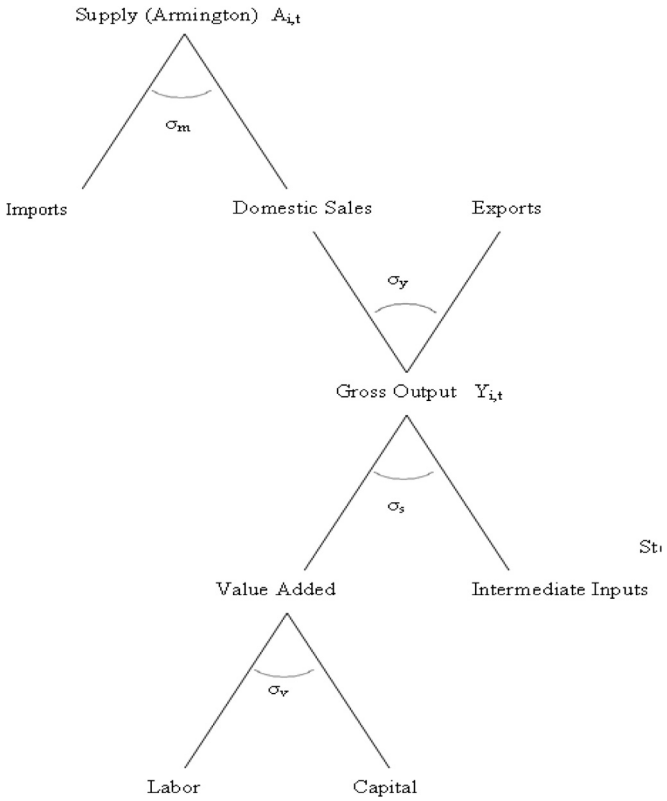

Fig. A-2. Nested structure of production and trade.

instance, households buying goods and services) and goods (for instance, households supplying their labor to firms).

Households own the factors of production – land and capital – and are assumed to maximize their lifetime "utility", which they derive from consumption (paid for out of after-tax income) and leisure, both now and in the future. Households must decide how much to work, and how much to save. They are also forward-looking, so that if they see a tax change in the future, they may react by changing their decisions even now. The other major actor is the government, which imposes taxes and uses the revenue to spend on goods and services, as well as to make transfer payments to households.

There is a production sector where producers/firms buy inputs (labor, capital, and intermediate goods that are produced by other firms), and transform them into outputs. Producers are assumed to maximize profits and are likely to change their decisions about how much to buy or produce depending on the (after-tax) prices they face for inputs and outputs. Capital depreciates over time, and is reconstituted through investment, which is

Table A-1
Basic parameters of the dynamic CGE model.

Steady state growth rate for sectors (g)	0.03
Net interest rate in non-distorted economy (r *or* ϱ)	0.03
Sector specific depreciation rates (δ_i)	0.02–0.19
Elasticity of substitution for composite investment, σ	1.5
Elasticity of transformation between U.S. domestic supplies and exports to the Rest of the World (ROW), σ_ε (can be sector-specific)	2.0
Elasticity of substitution between U.S. domestic products and imports from the Rest of the World (ROW), σ_m	0.5–1.5
Inter-temporal elasticity of substitution, σ_{Lu}	0.98
Intra-temporal elasticity of substitution between leisure and composite goods, σ_u	1.5
Elasticity of substitution in consumption goods across sectors, σ_C	2.5
Elasticity of substitution between capital and labor, σ_v	1.2
Reference quantity index of output, capital and labor for each sector, Q_{rf}	$(1+g)^{t-1}$
Reference index of price of output, capital and labor for each sector, P_{rf}	$1/(1+r)^{t-1}$

undertaken in anticipation of future profits. A tax policy can increase the levels of investment and capital stock by removing the sector-specific distortions caused by the existing tax system in the benchmark economy.

To complete the model, there is a rest-of-the world sector that sells goods (U.S. exports) and purchases goods (U.S. imports). Trade is represented by the standard Armington assumption, which uses a constant-elasticity-of-transformation function to determine the allocation between domestic sales and exports. The model assumes an ultimate steady-state growth rate for quantities of all goods and services. We have calibrated the model to the micro-consistent benchmark equilibrium from the base year data in SAM 2017.

Complex as it may seem, Fig. A-1 is still relatively simple, because it lumps all households into one group, and all firms into another. To provide further detail it is necessary to create *sectors*; our model has 55 economic sectors. Each sector is an aggregate that groups together segments of the economy. We separate households into ten deciles, and firms into 27 industrial sectors. In addition, we distinguish between 11 types of taxes and funds (eight at the federal level and three at the state and local level) and two categories of government spending. To complete the model, there are three factor sectors (labor, capital, and retained earnings), an investment sector, and a sector that represents the rest of the world. The choice of sectors was dictated by the availability of suitably disaggregated data (for households and firms), and the purposes of the model. The underlying data are gathered into a 55 by 55 social accounting matrix, which includes an input-output table as one of its components.

The formal specification of the model

Infinitely-lived households allocate lifetime income to maximize the present value of lifetime utility (LU^h), which itself is a time-discounted Constant-Elasticity-of Substitution (CES) aggregation of a composite consumption good (C_t^h) and leisure (L_t^h), with an elasticity of substitution between consumption and leisure given by σ_u^h (as in Bhattarai (2001, 2007)). Note that the composite consumption good is in turn a Cobb-Douglas aggregation of 27 domestically-produced, and 27 imported, goods and services.

The representative household faces a wealth constraint where the present value of consumption and leisure cannot exceed the present value of its full disposable income (J_t^h), which gives lifetime wealth (W^h). Under current tax rules, this implies

$$\sum_{t=0}^{\infty} \mu(t)(P_t(1+t^{vc})C_t^h + w_t^h(1-t_l)L_t^h) = W^h \tag{1}$$

where $\mu(t)$ is a discount factor, P_t is the price of consumption, C_t^h is composite consumption, t^{vc} is the sales tax on consumption, t_l represents taxes on labor income, and w_t^h is the wage rate.

The structure of production is summarized in Fig. A-2. Starting at the bottom, and for each of the 27 production sectors, producers combine labor (which comes from seven different categories of households) and capital (using a CES production function, with elasticity of substitution σ_v) to create value-added, which is in turn combined with intermediate inputs – assumed to be used in fixed ("Leontief") proportions – to generate gross output. This output may be exported or sold domestically, modelled with a constant elasticity of transformation (CET) export function between the U.S. markets and all other economies. The domestic supply is augmented by imports, where we use a CES function between domestically supplied goods and imports.

The underlying growth rate in the DCGE model is determined by the growth rate of labor and capital. Labor supply, which is equivalent to the household labor endowment less the demand for leisure, rises in line with population. The capital stock (K) for any sector in any period is given by the capital stock in the previous period (after depreciation) plus net investment (I). On a balanced-growth path, where all prices are constant and all real economic variables grow at a constant rate, the capital stock must grow at a rate fast enough to sustain growth. This condition can be expressed as:

$$I_{i,T} = K_{i,T}(g_i + \delta_i) \tag{2}$$

where the subscript T denotes the terminal period of the model, δ_i is the depreciation rate, and g_i is the steady state growth rate for sector i and is assumed uniform across sectors for the benchmark economy.

Although the time horizon of households and firms is infinite, in practice the model must be computed for a finite number of years. Our model is calibrated using data for 2017 and stretches out through 2070 (i.e. for 53 years). To ensure that households do not eat into the capital stock prior to the (necessarily arbitrary) end point, a "transversality" condition is needed, characterizing the steady state that is assumed to reign after the end of the time period under consideration. We assume, following Ramsey (1928) that the economy returns to the steady state growth rate of three percent at the end of the period.

The model also requires a number of identities. After-tax income is either consumed or spent on savings. Net consumption is defined as gross consumption spending less any consumption tax. The flow of savings is defined as the difference between after-tax income and gross spending on

Table B.1
Percentage changes, relative to baseline, of selected outcomes, under different parameter assumptions, Trump scenario, no change in deficit.
Source: Simulations by authors based on dynamic CGE model.

Elasticity of substitution in consumption		2.5	1.5	2.5
Intertemporal elasticity of substitution		1.00	1.00	0.90
GDP	2017	1.4	1.4	1.4
	2047	4.9	4.7	4.8
Private employment	2017	1.7	1.5	1.8
	2047	1.0	1.0	1.0
Welfare, poorest decile	PV	-5.7	-5.7	-5.7
Welfare, richest decile	PV	+1.5	+1.6	+1.5

consumption, and gross investment equals national saving plus foreign direct investment.

A zero trade balance is a property of a Walrasian general equilibrium model; export or import prices adjust until the demand equals supply in international markets. However, foreign direct investment (FDI) plays an important role in the U.S. economy, as exports and imports are not automatically balanced by price adjustments. Therefore our Walrasian model is modified here to incorporate capital inflows so that the FDI flows in whenever imports exceed exports. Thus

$$FDI_t = \sum_i PM_{i,t} M_{i,t} - \sum_i PE_{i,t} E_{i,t} \tag{3}$$

where for period t, FDI_t is the amount of net capital inflows into the U.S. economy, $\sum_i PM_{i,t} M_{i,t}$ is the volume of imports and $\sum_i PE_{i,t} E_{i,t}$ is the volume of exports. We assume inflows and outflows of FDI balance out to zero intertemporally by the last year of the model horizon.

We have crafted two versions of the model, each with different closure rules. Under Scenario 1, the government deficit remains unchanged. Thus tax reductions are necessarily associated with a commensurate cut in government spending. Investment is driven by the after-tax profit of firms, and savings from all sources has to adjust in order to finance investment (and the budget deficit). The current account balance is driven by an essentially-fixed amount of available net FDI.

Under Scenario 2, tax reductions are coupled with little or no change in government spending. The net result is an increase in the budget deficit, which is financed by greater savings, so that tax collections from individuals are largely replaced by savings.

Calibration to steady state

The model is truly "dynamic" in that it is optimized over time, and is calibrated using data for 2017. The model is programmed in GAMS (General Algebraic Modeling System), a specialized program that is widely used for solving CGE models (Brooke et al., 1998). The core of the model is programmed in the mathematical programming system of Arrow–Debreu type general equilibrium (MPSGE) software, which was developed by Thomas Rutherford (1995) to facilitate the development of market-clearing dynamic CGE models; see also Lau et al. (2002).

The model is calibrated to ensure that the baseline grows along a balanced growth path. In the benchmark equilibrium, all reference quantities grow at the rate of labor force growth, and reference prices are discounted on the basis of the benchmark rate of return. The balance between investment and earnings from capital is restored here by adjustment in the growth rate g_i that responds to changes in the marginal productivity of capital associated with changes in investment. Readjustments of the capital stock and investment continue until this growth rate and the benchmark interest rates become equal. If the growth rate in sector i is larger than the benchmark interest rate, then more investment will be drawn to that sector. The capital stock in that sector rises as more investment takes place, leading to diminishing returns on capital. Eventually the declining marginal productivity of capital retards growth in that sector.

Behavioral elasticities of substitution in consumption and production

Our DCGE model simulates the effects of tax changes. The structure of the model depends not only on the magnitudes in the social accounting matrix, but also on the behavioural parameters, which reflect how consumers and producers react to changes in prices. These parameters are mainly in the form of elasticities of substitution, but also include depreciation and discount rates, share parameters, and an assumed steady-state growth rate. The parameters we use are set out in Table A-1, and are comparable to those found in the existing literature, including Bhattarai (2007, 2016), Tuerck et al. (2016), Bhattarai and Whalley (1999), Killingsworth (1983) Kotlikoff (1993, 1998), Kydland and Prescott (1982), Ogaki and Reinhart (1998), Piggott and Whalley (1985) and Reinert and Roland-Holst (1992).

A few further comments are in order. The *intertemporal elasticity of substitution* (σ_{Lu}) measures the responsiveness of the composition of a household's current and future demand for the composite consumption good to relative changes in the rate of interest, and is a crucial determinant of household savings. There is little consensus in the literature about a reasonable value for this elasticity: Ogaki and Reinhart (1998) estimate it to be between zero and 0.1 in the case of durable goods; Hall (1988) finds it to be very small, even negative, while Hansen and Singleton (1983) note the lack of precision in the estimates of σ_{Lu}. Auerbach and Kotlikoff (1987) assume it to be about 0.25; Kydland and Prescott (1982) assume it to be 1.0. We use a value of 0.98, but test for the robustness of the results to changes in this number.

The *intratemporal elasticity of substitution between consumption and leisure* (σ_u) determines how consumers' labor supply responds to changes in real wages. Indirect evidence on this elasticity is derived from various estimates of labor supply elasticities that are available in the literature (Killingsworth, 1983). Here we adopt a value of 1.5 for this substitution elasticity. Further discussion on how to derive numerical values of substitution elasticities from labor supply elasticities is provided in earlier studies on tax incidence analysis (Bhattarai and Whalley, 1999).

The *intratemporal elasticity of substitution among consumption goods* (σ_C) captures the degree of substitutability among goods and services in private final consumption. A higher value implies more variation in consumption choices when the relative prices of goods and services change. Consistent with Piggott and Whalley (1985), we specify a value of 2.5 for this parameter.

The *Armington elasticity of transformation* (σ_e) determines the sale of domestically-produced goods between the home and foreign markets in response to relative prices between these two markets. The *Armington substitution elasticity* (σ_m) determines how the domestic and import prices affect the composition of demand for home and foreign goods. Higher values of these elasticities mean a greater impact of the foreign exchange rate in domestic markets. Reinert and Roland-Holst (1992) report estimates of substitution elasticities for 163 U.S. manufacturing industries and find these elasticities to be between 0.5 and 1.5. Piggott and Whalley (1985) suggest central tendency values of these elasticities to be around 1.25.

Early estimates of the *elasticity of substitution between capital and labor* (σ_v) may be found in Arrow et al. (1961). They estimated constant elasticities of substitution for U.S. manufacturing industries using a pooled cross country data set of observations on output per man hour and wage rates for a number of countries; we use a value of 1.2.

Appendix B. Sensitivity of simulation results to choice of parameters

See Table B.1.

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