Trump v. Cruz:

The Comparative Economic Effects of Two Tax Proposals

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Abstract

Taxes impinge on individual and business decisions to work, save and invest. Using a dynamic computable general equilibrium model that we created for the National Center for Policy Analysis (the "NCPA-DCGE Model"), we simulate the effects on the U.S. economy of tax proposals by Donald Trump and Ted Cruz. We find that both proposals result in significant positive impacts on output, investment, employment and household well-being, compared to a baseline estimate. We find that the Cruz plan has a stronger positive effect on the economy and causes a smaller decrease in government tax revenue than the Trump plan.

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Introduction

Amid the sound and fury of the ongoing 2016 presidential campaign, there has been comparatively little scrutiny of the candidates' tax reform proposals. With this report, the Beacon Hill Institute begins the process of increasing that scrutiny. In doing so, we apply the academic literature to the problem of explaining the effects of proposed tax changes on wages, earnings, saving and investment. We apply a computer model to simulate the behavioral responses to such tax changes and how they flow through the U.S. economy. This paper summarizes the results of our application of that model to two proposals that have come out of the presidential campaign.

The debate over a particular tax plan ties into the broader debate over how best to satisfy three competing goals of any tax policy proposal:

(1) to increase economic efficiency, as measured by the performance of standard economic indicators, such as GDP and private sector employment;

(2) to increase equity, as measured by the proposal's fairness toward low-income earners and

(3) to provide revenues to finance government expenditures.

While the tension between these objectives is unavoidable in any tax reform debate, there is a growing consensus that the existing U.S. tax system is highly inefficient, particularly for how it discourages business investment and household work effort. Thus a key goal of the analysis is to answer the question: How do the candidates' plans improve upon these inefficiencies?

Another consideration is whether it is best to tax income or consumption and which of the two tax bases creates a tax system that is more efficient and equitable. Reaching back to Thomas Hobbes and David Hume, the economics literature favors consumption taxation over income

taxation (Gillis, 2008). A consumption tax removes the bias against saving and investment that is inherent to an income tax. Opponents argue that a consumption tax is regressive since the fraction of income spend on consumption varies inversely with income. One answer to this criticism is to say that it is consumption that measures well-being, not income, and that a proportional tax on consumption is therefore more equitable than a proportional, or even a graduated tax, on income. In this report, we focus on the efficiency effects of the Trump and Cruz plans, leaving the debate over equity for another time.

Both of the tax proposals considered here have the effect, on balance, of reducing tax rates on personal and business income. Both, therefore, increase economic efficiency and expand the economy, as shown by their predicted, positive effects on such indicators as GDP and private sector employment. Both also cause a loss in government revenues. Of the two proposals, one – the Cruz proposal – causes a smaller loss in government revenue than the other *and* results in a more pronounced increase in efficiency. One reason that the Cruz plan trumps the Trump plan on both counts (minimizing the loss in revenue and increasing efficiency) is that the Cruz plan goes further than the Trump plan toward turning the tax code into a tax on consumption.

Our analysis is the first based on the dynamic computable general equilibrium model the Beacon Hill Institute has built under contract with the National Center for Policy Analysis – the NCPA-DCGE Model. (Analyses of other national tax reform proposals from the presidential campaign will be examined in future papers.)

The purpose of the NCPA-DCGE Model is to examine U.S. tax policy changes for their effects on major economic indicators, including:

- Gross Domestic Product (GDP);
- capital investment;

- private sector employment; and
- Government tax revenues, employment and spending.

Dynamic CGE models are the most appropriate tools for assessing the impacts of taxes.[1] In an earlier study, we found significant benefits from the implementation of a national retail sales tax, (Bhattarai, Haughton and Tuerck, 2007; see also Jokisch and Kotlikoff, 2005). That study utilized a tax model that was built to show only how a particular tax proposal would affect the economy. This study is based on micro-consistent data from a Social Accounting Matrix (SAM 2017) for benchmarking a model that can be applied to a wide variety of proposed tax changes.

It has taken some time for the economic literature –as well as public sentiment – to recognize that taxes impose measurable negative effects on the economy. A recent and extensive literature review notes the deleterious effects of taxes – particularly corporate and income taxes – on economic performance.[2] The relationship between federal taxes and economic performance is stronger than once believed (Romer and Romer, 2010). Similar analyses can also be found in the results of various studies at the state level (Laffer, Moore, Williams, 2015).[3]

Tax rates are critical for explaining the comparative performance of national economies (Prescott, 2003). In a widely quoted paper, Prescott (2002) explains that lower American tax rates induce workers to allocate more time to work than their European counterparts. This

[1] For a useful primer on CGE models see "Taxes in a CGE Model," Mary E. Burfisher in *Introduction to Computable General Equilibrium Models*, (New York: Cambridge University Press, 2011) 174-207.
[2] William McBride, "What Is the Evidence on Taxes and Growth?" Tax Foundation (December 18, 2012) http://taxfoundation.org/article/what-evidence-taxes-and-growth.
[3] For a thorough review of recent literature on taxes and growth see Arthur Laffer, Stephen Moore and Jonathan Williams, "Policy Matters: How States Can Compete to Win," in *Rich States, Poor States: The American Legislative Exchange Laffer State Economic Competitiveness Index*, 8th edition, (2015):30-63.

conclusion follows from an understanding of the sensitivity of labor supply (the "elasticity" of labor supply) to taxes on labor income.[4]

The economy does not remain in its current state when governments raise or lower taxes. Taxes influence behavior and set into action a series of events that change economic behavior. Consider the work-leisure calculus. Taxpayers divide their time between work and non-work, which we call "leisure." Lower tax rates on work make leisure less attractive and thus induce taxpayers to work more. Higher tax rates make leisure more attractive and thus induce taxpayers to work less.

Consider also the saving-consumption calculus. Taxpayers must decide how to allocate their after-tax income between consumption and saving. That matters to the economy because capital spending is financed from saving, and capital spending increases production and raises the demand for labor. Lower tax rates on the return to saving induce taxpayers to save more, thus fueling investment. Higher tax rates have the opposite effect. It is in this way that taxes are important for economic performance.[5]

It is thus important to understand how economic "agents" (taxpayers) respond to incentives and disincentives to work and save brought about by tax law changes. It is also important to understand how tax law changes affect federal, state and local government revenues. Lower tax rates usually reduce revenues but less so to the extent that they encourage work and saving.

[4] Edward C. Prescott, and Johanna Wallenius, (2008). "The Modern Theory of Aggregate Labor Supply and the Consequences of Taxes," in *Cutting Taxes to Increase Prosperity*, (Reykjavik, RSE, Icelandic Research Center of Social and Economic Affairs, 2008) 9-24.
[5] Burfisher, 195-198.

Higher tax rates usually increase revenues but less so to the extent that they discourage work and saving.

The Trump and Cruz tax proposals generally decrease tax rates. In order to understand how they affect the economy, it is necessary to explain how we interpret them for modeling their economic effects. We provide that explanation in the sections that follow. In analyzing both proposals, we assume that they go into effect in calendar year 2017. All changes are against a baseline, no-tax-change scenario.

The Trump Tax Proposal

The Trump plan calls for a federal personal income tax with four brackets – 0 percent, 10 percent, 20 percent, and 25 percent (See Table 1).[6] It eliminates the marriage penalty, the estate tax and

Table 1: Trump Tax Rates on Personal Income

Income Tax Rate (%)	Long-term Capital Gains (%)	Single Filers ($)	Married Filers ($)	Heads of Household ($)
0	0	0 to 25,000	0 to 50,000	0 to 37,500
10	0	25,001 to 50,000	50,001 to 100,000	37,501 to 75,000
20	15	50,001 to 150,000	100,001 to 300,000	75,001 to 225, 000
25	20	150,001 and up	300,0001 and up	225,001 and up

the Alternative Minimum Tax (AMT). It retains the deductions for charitable giving and mortgage interest.

The Trump plan calls for offsets to "pay for the tax cuts." It eliminates "loopholes" for exceptionally high income earners, phases out itemized deductions and ends the tax exemption for

[6] "Tax Reform that will make America Great Again: The Goals of Donald J. Trump's Tax Plan," https://www.donaldjtrump.com/positions/tax-reform. Accessed February 8, 2016.

life insurance interest. It also ends favorable tax treatment of carried interest for "speculative partnerships." It calls for reforming corporate taxation, with a 10 percent repatriation tax on overseas holdings. It reduces or eliminates certain "loopholes" and imposes a cap on business interest expenses.

BHI Modeling of the Trump Plan

As noted in Table 1, the Trump Plan provides for specific new tax rates on personal income but provides few details as to what is included in the tax base.

Our approach to the task of modeling the changes in personal income tax rates is relatively straightforward. We begin by showing how the Trump tax rates would change the tax schedule for income filers. This means changing existing tax brackets to match those proposed by Trump.

For the lowest and highest three current tax brackets, we were able to apply the new Trump rate directly to the current rate because the current brackets fall completely within new Trump tax brackets. For example, single filers with income from zero to $9,225 fall completely into the new zero-percent Trump income tax bracket of $0 to $25,000, and thus we reduced the rate to zero from the 10 percent for filers who currently fall in that bracket. Conversely, for the highest bracket with income over $413,201 for single filers, with a rate of 39.6 percent falls completely in the Trump top bracket of income over $150,000, and we changed the rate for the entire tax bracket to 25 percent.

However, several tax brackets under current law differ from the Trump plan, requiring us to adjust the Trump rates to match the current brackets. For example, the current 15 percent

bracket with income from $9,226 to $37,450 overlaps the lowest Trump zero percent bracket for income from $0 to $25,000 and the 10 percent bracket for income from $25,001 to $50,000.

To adjust the current tax code to the new rates, we calculate the Trump tax rate based on the proportion of income in the old bracket that would fall into the new Trump bracket. Income from $9,226 to $25,000 would be taxed at a rate of zero and the income from $25,001 to $37,450 would be taxed at the 10 percent rate under Trump. The total amount of income taxed at 15 percent under current law is $28,224 ($37,450 - $9,226). Of this amount, $12,449 ($37,450 - $25,001) is taxed at 10 percent under Trump. We divide $12,449 into $28,224 to get 44.1 percent, which is the fraction of income currently taxed at 15 percent that would be taxed by Trump at 10 percent. The remaining 55.9 percent of income currently taxed at 15 percent becomes tax free under Trump. We multiply the 10 percent rate by 44.1 percent to get the rate of 4.41 percent for the new 10 percent Trump bracket. We repeated this process for the other current tax brackets that overlap more than one Trump bracket.

The Trump plan is far less detailed in the treatment of exemptions and deductions, and thus we must make assumptions about its treatment in each bracket. The plan states, "For those within the 10% bracket will keep all or most of their current deductions."[7] Since the Trump plan provides no further details, we assume all current deductions are kept intact.

The Trump plan also states, "For those within the 20% bracket will keep more than half of their current deductions [sic]. Those within the 25% bracket will keep fewer deductions. Charitable giving and mortgage interest deductions will remain unchanged for all taxpayers."[8] We assume

[7] Ibid.
[8] Ibid.

that 51 percent 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.

To model these assumptions, we reduce the amount of the deductions for each Trump tax bracket by the percentage outlined above. For the 25 percent tax bracket, we used *Statistics of Income* (SOI) data from the IRS for deductions and exemptions for 2013, the year for which the latest data are available, to determine the share of total deductions attributable to charitable giving or home mortgage, allowing us to eliminate all other deductions.[9]

The Trump plan also calls for new tax brackets to which the rates on long term capital gains and dividends would apply. Currently the long term capital gains tax rate of 15 percent applies to gains that begin at the 28 percent tax rate, or income at or exceeding $90,751 for a single filer. The current 20 percent long term capital gains rate applies to income beginning with the 39.6 percent rate, or income at or exceeding $413,201 for a single filer.

The Trump plan would actually lower the income thresholds at which these capital gains rates apply and thus effectively raise tax rates on long term capital gains and dividends. The 15 percent rate would begin at $50,001 instead of $90,751 and the 20 percent rate would begin at $150,000 instead of $413,201.

To simulate the Trump tax plan on dividends and capital gains, we again turn to the SOI data from the IRS to calculate the amount of tax revenue generated under each tax regime and use the difference as our modeling input. Using taxable capital gains and ordinary dividend income as

[9] Based on (Charitable giving deduction + mortgage interest deductions) / (total deductions).
See Internal Revenue Service, SOI Tax Stats - Individual Income Tax Returns Publication 1304 (Complete Report) https://www.irs.gov/uac/SOI-Tax-Stats-Individual-Income-Tax-Returns-Publication-1304-%28Complete-Report%29.

our base and using the current tax rate, we estimate that these taxes raise a total of $133.7 billion under the current tax system. Again using taxable capital gains and ordinary dividend income as our base and the new Trump tax brackets, we estimate that the Trump plan would raise $137.736 billion in tax revenue. The difference between the two revenue estimates shows that the Trump plan would increase capital gains and ordinary dividend tax revenues by $4.039 billion annually.

As stated above, the Trump plan calls for the elimination of the inheritance and gift tax. This is a straight forward input into the model. The plan calls for a 15 percent corporate income tax rate, which we use as our input to the model. Table 2 displays the results against a baseline of no tax policy change.

Table 2: Changes in Revenue Relative to Benchmark: The Trump Plan

Change in Revenue	2017		2026		2017-2026 10-year cumulative	
	Change ($billion)	% Change	Change ($billion)	% Change	Change ($billion)	% Change
Federal Revenue	-673.68	-21.41	-892.65	-21.78	-7,768.79	-21.56
Social Security Tax	14.58	1.21	9.67	0.62	134.90	0.98
Personal Income Tax	-423.35	-30.31	-559.31	-30.76	-4,880.13	-30.51
Corporate Income Tax	-249.62	-81.09	-325.38	-81.21	-2,859.40	-81.14
Excise Taxes	1.89	2.77	3.16	3.55	25.00	3.19
Estate and Gift Taxes	-21.38	-100.00	-27.82	-100.00	-244.70	-100.00
Trade Duties	0.96	2.77	1.61	3.55	12.70	3.19
Other Taxes and Fees	3.24	2.77	5.42	3.55	42.84	3.19
State and Local Revenue	65.73	2.52	94.41	2.77	807.28	2.69
Total Government Revenue	-607.96	-10.57	-798.24	-10.64	-6,961.51	-10.56

In 2017, the Trump personal income tax cuts would cost the U.S. treasury $423.35 billion (measured against baseline). In 2026 the cost would be $559.31 billion. Corporate income taxes collected would be $249.62 billion lower in 2017 and $325.38 billion lower in 2026.

The Trump tax plan would diminish federal revenue by $673.68 billion (a decrease of 21.4 percent) in 2017. Some taxes would produce more revenue, given the expansion in the economy. These taxes include social security taxes, excise taxes, trade duties, certain other taxes and, most notably state and local, taxes. The increase in demand for housing, for example, would increase property tax collections for local governments and personal income taxes for state governments.

The Cruz Tax Plan

The Simple Flat Tax, a main feature of the Cruz plan, creates a single-rate flat income tax rate for individuals. (See Table 3) The existing seven different individual income tax rates give way to a 10 percent tax rate. Additionally, payroll taxes such as Social Security, are eliminated. To benefit low- and middle-income taxpayers, the Cruz plan includes a $10,000 standard deduction and $4,000 personal exemption. The plan, like the Trump proposal, keeps the charitable giving deduction and the mortgage interest deduction intact. Senator Cruz claims that under his plan the first $36,000 of income for a family of four would be tax free.

The Cruz plan would also eliminate the corporate income tax, which currently ranges from 15 percent to 39 percent, depending on the amount of taxable income reported by a corporation. In place of the corporate tax, Cruz proposes a 16 percent Business Flat Tax which would have a tax

Table 3: Cruz Tax Plan

Action	Tax	Notes
Reforms	Personal Income Tax Single Rate: 10%	First $36,000 for family of 4 tax free
Preserves	Earned Income Tax Credit Child Tax Credit	
Retains	Charitable Tax Deduction Home Mortgage Deduction	
Establishes	Universal Savings Accounts (USA)	Enables tax deferred savings
Eliminates	Death Tax Overseas Profits Tax Alternative Minimum Tax ACA Taxes Payroll Taxes	
Establishes	Value Added Tax ("Business Flat Tax")	Replaces corporate tax

base consisting of "revenue minus expenses such as equipment, computers, and other business investment."[10]

BHI Modeling of the Cruz Plan

We modelled the personal income tax change by reducing everyone's tax rate to 10 percent and increasing the standard deduction while eliminating all deductions other than those for charitable contribution and mortgage interest payments. Using IRS data, we determined the share of total deductions attributable to charitable giving or home mortgage, allowing us to eliminate all other deductions.[11] Senator Cruz proposes to reduce fraud and create "pro-marriage reforms" of the Earned Income Tax Credit but does not supply enough details to determine the effect to revenue due to this policy, so it was not included in our modelling.

[10] TedCruz2016, "The Simple Flat Tax Plan," https://www.tedcruz.org/tax_plan/. Accessed February 8, 2016.
[11] Based on (Charitable giving deduction + mortgage interest deductions) / (total deductions).
See Internal Revenue Service, SOI Tax Stats - Individual Income Tax Returns Publication 1304 (Complete Report) https://www.irs.gov/uac/SOI-Tax-Stats-Individual-Income-Tax-Returns-Publication-1304-%28Complete-Report%29.

The Business Flat Tax is similar to the Value Added Tax (VAT) levied in many European countries and can be thought of as having a base equal to final consumption by households and governments. (See Appendix B for an explanation of how we model the tax base under the Cruz plan.)

Table 4 below displays the results of the Cruz plan against a baseline of no tax policy change.

Table 4: Changes in the Revenue Relative to Benchmark: The Cruz Plan

Change in Revenue	2017		2026		2017-2026	
	Change ($billion)	% Change	Change ($billion)	% Change	Change ($billion)	% Change
Federal Revenue	-512.73	-16.30	-603.41	-14.72	-5,549.34	-15.40
Social Security Tax	-1,200.84	-100.00	-1,563.78	-100.00	-13,753.25	-100.00
Personal Income Tax	-920.88	-65.94	-1,213.89	-66.75	-10,610.01	-66.34
Corporate Income Tax	-307.83	-100.00	-400.65	-100.00	-3,523.76	-100.00
Excise Taxes	0.41	0.60	3.06	3.43	17.10	2.18
Estate and Gift Taxes	-21.38	-100.00	-27.82	-100.00	-244.68	-100.00
Trade Duties	0.21	0.60	1.55	3.43	8.69	2.18
Other Taxes and Fees	0.70	0.60	5.24	3.43	29.30	2.18
Business Flat Tax	1,936.88	-	2,592.87	-	22,527.28	-
State and Local Revenue	16.07	0.62%	56.02	1.65%	403.79	1.35%
Total Government Revenue	-496.66	-8.63%	-547.39	-7.30%	-5,145.55	-7.80%

We modelled the Business Flat Tax as a 16 percent tax on final household and government consumption, allowing for the exemption of employer provided health insurance, which is a carve

out that the Cruz plan would to keep. Revenues from the Business Flat Tax replace some of the revenue loss from reducing or eliminating existing taxes.

In 2017, the federal government would realize $512.73 billion less in revenue (a change of -16.30 percent). This is the net result of the elimination of Social Security and corporate taxes, combined with the reduction of personal income tax revenue and the creation of the Business Flat Tax. Revenues from other federal taxes would rise. These taxes include excise taxes, trade duties and, most notably state and local taxes. State and local government revenue will rise by $16.07 billion in year 1 of the tax plan.

With the introduction of its VAT-like approach, the Cruz plan shifts the tax burden away from saving and onto consumption. The cumulative effect over 10 years will be to raise $22.5 trillion in federal government revenue. These "new" tax dollars only partially offset the losses in other revenues: Social Security revenues fall by $13.7 trillion over the same period, the federal personal income loses $10.6 trillion and the corporate income tax loses $3.5 trillion. Also, the abolition of the estate and gift taxes results in a loss of $244.68 billion. Revenues from other taxes, such as excise and tariff revenues, rise.

The Economic Effects of Trump and Cruz Plans

Changes in tax policy lead to changes in economic activity. Taxpayers who experience an increase in the after-tax reward to work and saving will work and save more. Federal government will see a loss in revenue while state and local governments capture increased tax revenues as a result of the increase in economic activity.

Table 5: Economic Effects of the Trump Tax Plan

	2017		2026	
	Change	% Change	Change	% Change
Private Employment (000)	3,592	2.42	3,846	1.99
Public Employment (000)	-597	-22.92	-778	-22.92
Total Employment (000)	2,995	1.98	3,068	1.56
Real GDP ($billion)	230	1.32	552	2.61
Personal Income ($billion)	698	4.14	924	3.80
Business Investment ($billion)	58	2.19	186	4.04
Imports ($billion)	24	0.73	89	2.12
Exports ($billion)	30	1.10	94	2.71
Net Trade Balance ($billion)	6	0.96	2	0.74

In 2017, the Trump plan will bring about the creation of 3.59 million private sector jobs, a change of 2.42 percent against baseline. Public employment, however, will decrease by 597,000 jobs. Real GDP will increase by $230 billion or by 1.32 percent. Personal income will increase by 4.14 percent and business investment will increase by 2.19 percent. The trade balance will improve by $6 billion. The trend continues in 2026 with the creation of 3.85 million private sector jobs (a change of 1.99 percent) over baseline. Real GDP will increase by 2.61 percent, and the trade balance will improve by 0.74 percent.

Table 6: Economic Effects of the Cruz Tax Plan

	2017		2026	
	Change	% Change	Change	% Change
Private Employment (000)	7,408	4.99	6,557	3.39
Public Employment (000)	-886	-34.05	-1,156	-34.05
Total Employment (000)	6,522	4.32	5,401	2.74
Real GDP ($billion)	439	2.52	1,708	8.07
Personal Income ($billion)	1,205	7.14	1,591	6.54

Business Investment ($billion)	331	12.4	1,000	21.72
Imports ($billion)	40	1.2	284	6.76
Exports ($billion)	42	1.54	278	7.99
Net Trade Balance ($billion)	2	-0.37	-6	0.85

In 2017, the Cruz plan will create 7.41 million private sector jobs, a change of 4.99 percent against baseline. Public employment, however, will decrease by 886,000. Real GDP will increase by $439 billion, representing a change of 2.52 percent. Personal income will increase by 7.14 percent and business investment by 12.4 percent. The trade balance will improve by $2 billion. The trend continues in 2026 with the creation of 6.56 million private sector jobs (a change of 3.39 percent). Real GDP will increase by 8.07 percent above baseline. The trade balance will fall by $6 billion.

Conclusion

The differences between the competing tax plans being offered during the presidential campaigns have implications for the country's economic future. Table 7 provides a glimpse of the differences that the two plans considered here will make in economic activity in 2026.

Table 7: Economic and Revenue Effects of the Trump and Cruz Tax Plans in 2026

Indicator	Trump		Cruz	
	Change	% Change	Change	% Change
Private Employment (000)	3,846	1.99	6,557	3.39
Public Employment (000)	-778	-22.92	-1,156	-34.05
Total Employment (000)	3,068	1.56	5,401	2.74
Real GDP ($billion)	552	2.61	1,708	8.07
Personal Income ($billion)	924	3.80	1,591	6.54
Business Investment ($billion)	186	4.04	1,000	21.72
Imports ($billion)	89	2.12	284	6.76
Exports ($billion)	94	2.71	278	7.99
Net Trade Balance ($billion)	2	0.74	-6	0.85
Total Revenue Effect ($billion)	-798.24	-0.11	-547.39	-7.09

In 2026, there will be 3.85 million more jobs under the Trump plan and 6.56 million more jobs under the Cruz plan. Real GDP will be 2.61 percent above baseline under the Trump plan and 8.07 percent above baseline under the Cruz proposal. The size of the public sector will shrink under both proposals.

The Trump plan will cause total government revenue to be $798.24 billion below baseline, while the Cruz plan will cause total government revenue to be $547.39 billion below baseline. All things taken into consideration, the Cruz plan "costs" less than the Trump plan in terms of revenue sacrificed and provides a stronger stimulus to the economy.

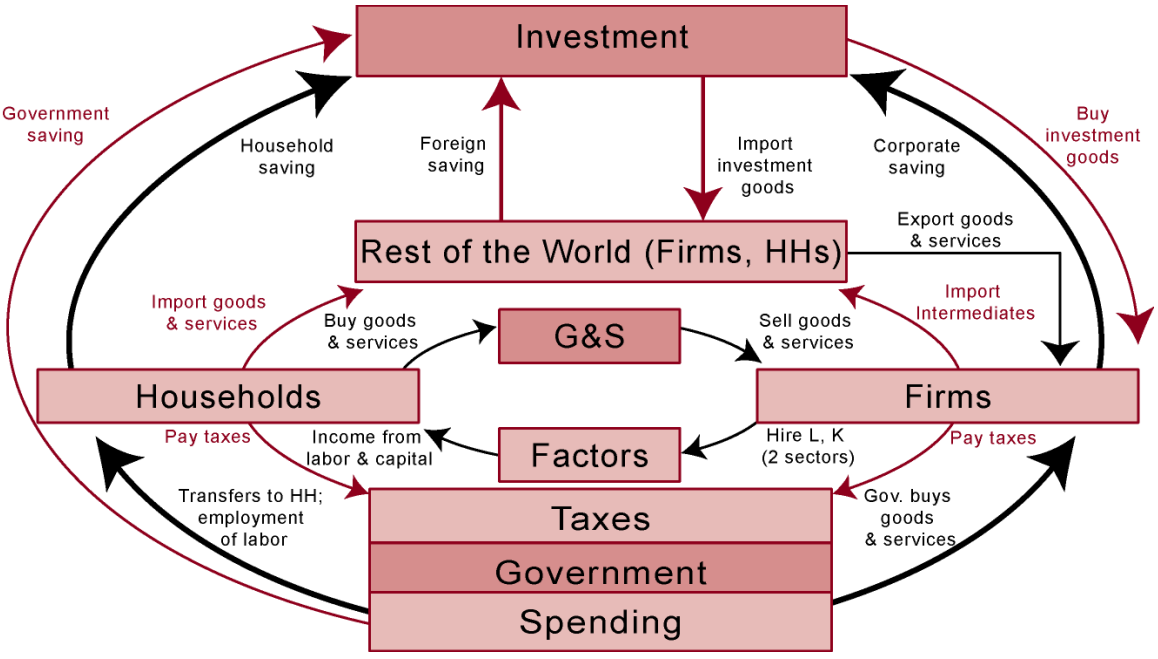
Sorting out the distributional consequences and the spending cuts needed to reach fiscal balance under the two plans is beyond the scope of this paper but will be taken up in future studies. Here we considered only comparative effects on government revenues and on economic efficiency as measured by changes in major economic indicators.

Appendix A: Overview of the BHI Model

The most appropriate tool for quantifying these effects 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, 60,000-variable, disaggregated national DCGE model of the United States economy. The essence of our model is shown in Figure A-1, which is heavily inspired by Berck et al. (1996), and where arrows represent flows of money (for instance, households buying goods and services) and goods (for instance, households supplying their labor to firms).

Figure A-1: Circular Flow in a CGE Model



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. By eliminating the personal income tax, corporate income tax, payroll taxes and estate taxes at the federal level, the proposed tax reforms would raise lifetime utility.

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. We have calibrated the model to the micro-consistent benchmark equilibrium from the base year data in SAM 2017 so that the effects of the tax proposals will be neutral for its effect on the deficit that is, if revenues fall, spending falls by an equal amount.

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 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 a steady-state growth rate for quantities of all goods and services.

Complex as it may seem, Figure 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 classes 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

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

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 Figure 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.

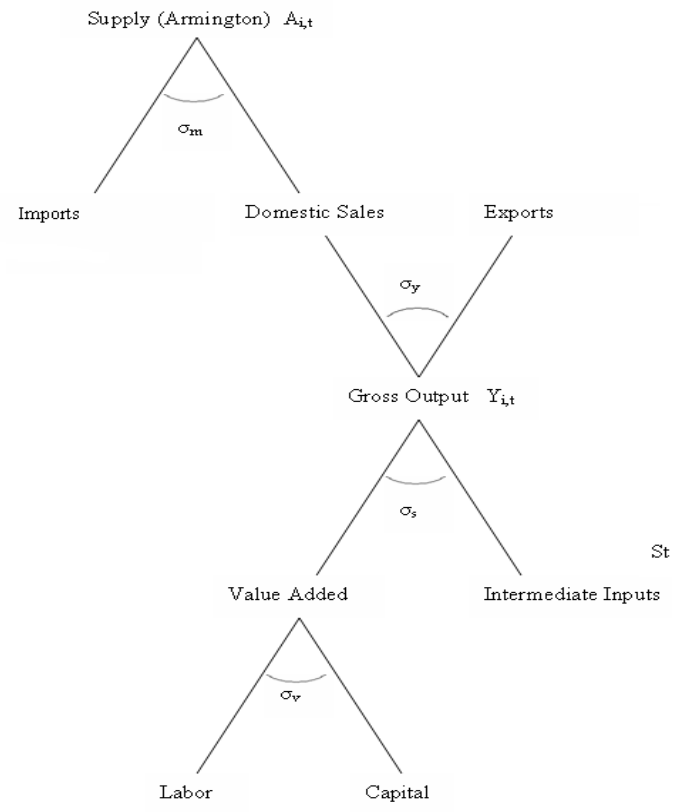
The underlying growth rate in the NCPA-DCGE model is determined by the growth rate of labor and capital. Labor supply, which is equivalent to the household labor endowment less the demand for leisure, rises in line with population. The capital stock (*K*) for any sector in any period is given by the 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.

Figure A-2. Nested Structure of Production and Trade



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 2015 and stretches out for 35 years (i.e. through 2050). 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 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

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

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. For the base run we assume inflows and outflows of FDI to balance out to zero intertemporally by the last year of the model horizon.

Calibration to steady state

The model is truly "dynamic" in that it is optimized over time, and is calibrated using data for 2015. 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 for system of Arrow–Debreu type general equilibrium (MPSGE) code, which was written 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.

To solve the model, we allow for a time horizon sufficient to approximate the balanced-growth path for the economy. Currently the model uses a 35-year horizon, which can be increased if the model economy does not converge to the steady state.

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 Tuerck et al. (2006), Bhattarai and Whalley (1999), Killingsworth (1983), Kotlikoff (1993, 1998), Kydland and Prescott (1982), Ogaki and Reinhart (1998a, 1998b), Piggott and Whalley (1985), and Reinert and Roland-Holst (1992).

Table A-1. Basic Parameters of the NCPA-DCGE 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}	$1/(1+r)^{t-1}$

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 (1998a,1998b) 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 (1998) assume it to be about 0.25; Kydland and Prescott (1982) assume it to be 1.0. We have 0.98 value in this model.

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, Chenery, Minhas, and Solow (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: Calculating the Base for the Cruz Business Flat Tax

According to the Cruz campaign the tax base is "all business profits, less capital investment. This includes the payroll of business, government, and non-profit institutions, as well as net imports. Employer-provided health insurance would continue to be exempt."[12] We derive the Business Flat Tax base in the equations below.

Definitions:

Y = GDP
I = Gross Private Domestic Investment,
G = all government purchases of goods and services
NX = net exports
DEP = depreciation of fixed capital,
$Net\ I$ = net investment
W = total labor compensation
Π = income from capital ("profits")
EMP = employer provided health insurance

Cruz tax base, using NIPA accounts:

(1) $Y = C + I + G + NX$,

or

(2) $Y = C + \text{Net}I + DEP + G + NX$.

Also,

(3) $Y = W + \Pi + DEP$.

Solving for profit, we get

(4) $\Pi = Y - DEP - W.$

The Cruz tax base is then

(5) $B = \Pi - NetI + W - NX - EMP$.

Cruz business tax revenue is

[12] Conversation with Sean Rushton, Senior Policy Advisor, Cruz campaign, February 4, 2016.

(6) $T = .16(\Pi - NetI + W - NX - EMP)$.

But if we substitute equation (2) into (4) and (4) into (5), we get:

(7) $B = C + NetI + DEP + G + NX - DEP - W - NetI + W - NX - EMP$ and

(8) $B = C + G - EMP$.

So Cruz business tax revenue is also

(9) $T = .16(C + G - EMP)$.

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