Trump v. Cruz:

The Economic Effects of Trump's Recently Revised Tax Proposal

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Abstract

Taxes impinge on individual and household 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 the tax proposal recently revised by Republican nominee Donald Trump. We find that the proposal would result in significant positive impacts on output, investment, employment and household well-being compared to a baseline estimate. We find that the revised Trump plan would have a stronger positive effect on the economy than his previous offering over a ten-year period.

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Executive Summary

Compared with other presidential election year cycles, the 2016 campaign takes place in a period of perplexingly slow economic growth. Republican nominee for President Donald Trump proposed a tax reform plan during the primary race in order to jumpstart economic growth. The Beacon Hill Institute applied its NCPA-DCGE model to the tax plan and found that the plan would increase real GDP by 2.61 percent and create 3.846 million new private sector jobs by 2026. The NCPA-DCGE model also found that the plan would also lower tax revenues by $7.769 trillion over the ten-year period to 2026.

In a speech to the Detroit Economic Club on August 8, Trump outlined an economic plan that included revisions to his previous tax reform plan. The revisions included a higher top marginal tax rate of 33 percent on individual income, a 15 percent tax rate on all business income and replacing the current system of depreciation with 100 percent expensing of investment in the first year.

The revised Trump plan would reduce federal revenue by $8.394 trillion over 10 years, with personal income taxes comprising $6.040 trillion. Over the same period, estate and gift taxes would be eliminate, costing the treasury $249 billion. On the corporate tax front, the Trump plan would reduce revenues by $2.682 trillion over a decade.

The NCPA-DCGE model finds that the lower tax rates would boost the tax base for payroll taxes, excise taxes, trade duties and other taxes and fees. As a result, revenues from these taxes would increase by $577 billion over the ten-year period (Table ES-1). In total, the Trump tax proposals would reduce federal revenue by $707 billion in 2017, reduce revenues by $993 billion in 2026, and reduce revenues by $8.394 trillion over the ten-year period. State and local taxes would increase by $1.015 trillion over the same period.

Table ES-1: Dynamic Revenue Effects of the Trump Tax Proposals Relative to CBO Benchmark

	Change in revenue					
	2017		**2026**		**Cumulative, 2017-26**	
	$ billion	*%*	*$ billion*	*%*	*$ billion*	*%*
Federal Revenue	-707	-19.40	-993	-19.69	-8,394	-19.94
Payroll Tax	31	2.63	69	4.33	514	3.81
Personal Income Tax	-486	-26.49	-742	-27.85	-6,040	-27.86
Corporate Income Tax	-236	-64.48	-299	-67.34	-2,682	-67.25
Estate and Gift Taxes	-21	-100	-30	-100	-249	-100
Other Taxes and Fees	5	2.06	9	2.88	63	2.37
State and Local Revenue	62	0.03	139	3.98	1,015	3.49
Total Government Revenue	**-645**	**-10.94**	**-854**	**-10.01**	**-7,379**	**-10.37**

Source: Based on NCPA-DCGE model simulations.

Table ES-2: Economic Effects of the Trump Tax Proposals

	Change relative to CBO baseline			
	2017		2026	
	'000 jobs	*%*	*'000 jobs*	*%*
Total Employment	**2,512**	**1.66**	**3,162**	**1.61**
Private Employment	3,066	2.07	3,762	1.94
Public Employment	-554	-21.31	-601	-23.20
	$ billion	*%*	*$ billion*	*%*
Real GDP ($billion)	985	5.64	1,981	9.36
Personal Income	646	3.83	1,374	5.64
Business Investment	191	7.16	540	11.72
Imports	23	0.69	95	2.26
Exports	27	0.98	97	2.80

Source: NCPA-DCGE model.

These tax cuts would set off changes in taxpayer behavior and provide a substantial boost to the U.S. economy. The private sector stands to gain under the Trump plan (a boost of 3.762 million jobs) and the public sector would have 601,000 fewer jobs by 2026. According to the model, Real GDP in 2026 would be 9.36 percent higher than in the CBO benchmark projection. The lower tax rate on business income would increase investment by 11.72 percent by 2026. The lower tax rates would likely spur economic growth relative to its current sluggish trend.

Introduction

Compared with other presidential election year cycles, the 2016 campaign takes place in a period of perplexingly slow economic growth. The current election year is exhibiting the lowest economic growth of the last 15 election years (excluding the recession year of 2008). U.S. GDP grew at an annual rate of just 1.2 percent in the second quarter of 2016, far below the post-World War II average of 2.6 percent.[1]

To meet their policy objectives, presidential candidates have released tax proposals geared toward promoting growth and equity. Republican Donald Trump's plan emphasizes tax cuts and aims for tax efficiency to help bring economic growth back to its historical trend.

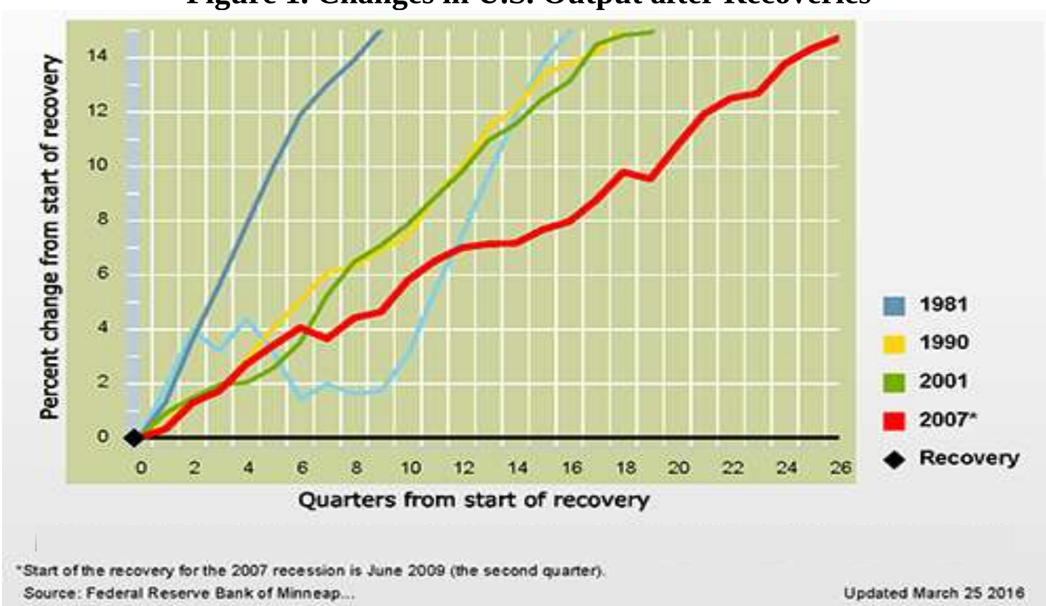
Public spending and lower interest rates have done little to improve the labor force participation rate, GDP growth or productivity. The U.S. unemployment rate is down and most of the jobs lost since 2008 have been recovered, but wages remain mostly flat, with the historically low labor force participation remaining a major issue. While the low participation rate is in part due to the advent of retirement among Baby Boomers, not all of it is demographic.

[1] MarketWatch, Economcy, Economic Calendar, http://www.marketwatch.com/economy-politics/calendars/economic.

Real GDP measured in 2009 dollars is only 11% higher than the pre-crisis peak of 2007.[2] Other indicators also point to a sluggish recovery: As of July 2016, the number of employees had increased by just 4.6% since July 2007.[3] Nearly seven years after the end of the Great Recession, voters continue to believe that the economy is the foremost issue facing the next president.[4]

The recovery from the latest Great Recession has been exceptionally weak in terms of economic growth, compared with the previous 10 recessions. Figure 1, from the Federal Reserve Bank of Minneapolis,[5] contrasts the recoveries from the 1980, 1981, 1990, 2001 and 2007 recessions. Post-Great Recession employment growth shows similar lagging trends.

Figure 1. Changes in U.S. Output after Recoveries



[2] FRED economic data, Federal Reserve Bank of St. Louis. https://fred.stlouisfed.org/series/GDPC1 [Accessed August 17, 2016.]
[3] Bureau of Labor Statistics. http://beta.bls.gov/dataViewer/view/timeseries/CES0000000001 [Accessed Aug 12, 2016.]
[4] Suffolk University Political Research Center, "Suffolk University/USA Today Poll Shows 61 Percent Alarmed about Presidential Election," (June/July 2016) http://www.suffolk.edu/documents/SUPRC/7_11_2016_corrected_final_national_marginals.pdf
[5] Federal Reserve Bank of Minneapolis. (2014). The Recession and the Recovery in Perspective. Retrieved from https://www.minneapolisfed.org/publications_papers/studies/recession_perspective/

While the deepest previous recession took 46 months to restore employment to its previous peak, it took 76 months for employment to return to its previous highest level in the most recent recession.[6]

The Trump tax proposals seek to promote growth and equity by cutting marginal tax rates on high-income taxpayers, combined with large personal deductions to support equity. The Trump proposals make large cuts to the taxation of business income through lower rates on all business income (corporate, partnerships and proprietors) and replacing the current system of investment depreciation with a system of 100 percent immediate expensing. In this report, we focus on the efficiency effects of the Trump tax proposal, leaving the debate over equity for a separate analysis of distributional effects (Haughton et al. 2016).

We rely on standard, mainstream economic methods to perform our analysis. In pursuing this approach, we apply a computer model to simulate the behavioral responses to tax changes, as those responses flow through the U.S. economy. This paper summarizes the results of our application of that model to the Trump proposals, and offers a brief contrast to previously published analyses.

The Debate over Federal Tax Policy

The debate over federal tax policy ties into the broader debate over how best to satisfy three competing goals:

(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.

[6] FRED data set, Federal Reserve Bank of St. Louis. https://fred.stlouisfed.org/series/PAYEMS/ [Accessed August 17, 2016.]

While tension between these objectives is unavoidable, 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 will the Trump plan improve upon the inefficiencies attributable to the existing tax code?

The debate over the short and long-term effects of taxation and its relationship to economic growth is at the center of public finance scholarship.[7] A recent and extensive literature review notes the deleterious effects of taxes – particularly corporate and personal income taxes – on economic performance.[8]

Tax rates are critical for explaining the comparative performance of national economies (Prescott, 2003). In a widely quoted paper, Prescott (2002) 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 of labor supply (the "elasticity" of labor supply) to taxes on labor income.[9]

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.

[7] Cecil E. Bohanan, John B. Horowitz and James E. McClure, "Saying too Little Too Late: Public Finance Textbooks and the Excess Burdens of Taxation." Econ Journal Watch 11(3), September 2014: 277-296.
[8] William McBride, "What Is the Evidence on Taxes and Growth?" Tax Foundation (December 18, 2012) http://taxfoundation.org/article/what-evidence-taxes-and-growth.
[9] 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.

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.

Clearly, economic "agents" (taxpayers) respond to incentives and disincentives to work and save brought about by tax law changes. Lower tax rates usually reduce government revenues, but less so to the extent that they encourage work and saving. Higher tax rates usually increase revenues, but less than a mechanical computation would show, because they also discourage work and saving.

It is important, in analyzing tax policy, to avoid the fallacies that often beset this issue. One of these is the notion of "trickle-down economics." No competent economist defends tax cuts for high-income earners on the argument that the benefits to those earners will somehow trickle down to low-income earners. Rather, insofar as tax cuts raise after-tax profits, they induce taxpayers to expand investment and, in so doing, wages and jobs. Insofar as they raise after-tax wages, they induce taxpayers to enter the labor force and work longer hours. This is not the result of money "trickling down" from one person to another but of the reduction of disincentives to invest and work that are inherent to any tax code.

Finally, it is never acceptable to assume that tax revenues move in proportion to tax rate increases or decreases. On the contrary, the only legitimate approach to tax policy analysis is to take into account the "dynamic," behavioral changes, particularly changes in the willingness of taxpayers to invest and work induced by tax law changes. Indeed, it is essential to estimate these behavioral changes in order to assess the desirability, from the public's point of view, of making changes in tax law.

The Trump tax proposals seek to make the tax code more efficient and progressive. Because that means reducing distortions into the price system, particularly into how that system rewards work, saving and innovation, a priori reasoning leads us to expect that it would promote work, saving and investment. The challenge is to measure the size of these effects, and for this, we use a dynamic computable general equilibrium model that the Beacon Hill Institute has built under contract with the National Center for Policy Analysis – the "NCPA-DCGE Model."

The purpose of the NCPA-DCGE Model is to quantify the effects of changes in U.S. tax policy 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.[10] 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) that we extrapolate to 2017, for benchmarking a model that can be applied to a wide variety of proposed tax changes.

We provide an explanation of our approach to the Trump tax proposal in the sections that follow. After describing his plan, we make several assumptions in running the NCPA-DCGE model. In

[10] 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.

analyzing the Trump proposal, we assume that its components 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 three brackets – 12 percent, 25 percent and 33 percent (See Table 1). [11] The standard deduction, currently $6,300 for single filers and $12,600 for married filing jointly, would rise to $20,000 and $40,000 respectively. The plan would cap itemized deductions at $100,000 for a single filer and at $200,000 for a married couple filing jointly. The Alternative Minimum Tax and Estate and Gift Tax would be abolished.

Within the personal income tax, there would be a tax rate cap of 15% on business income; while long-term capital gains and dividends presumably would be taxed at somewhat lower rates than other forms of income (see Table 3).

Table 3 Personal Income Tax Rates and Brackets under Trump Proposal

	Tax brackets ($ of taxable income per year)			
Trump rates/brackets	Single	Married filing jointly	Married filing separately	Head of household
12% [0% on div/Kgain]	0 -	0 -	0 -	0 -
25% [15% on div/Kgain]	37,650	75,300	37,650	50,400
33% [20% on div/Kgain]	190,150	231,450	115,725	210,800
Memo items				
Standard deduction*	20,000	40,000	20,000	30,000
Personal exemption	4,050	4,050	4,050	4,050

Notes: div/Kgain = dividends and capital gains. Standard deduction (or itemized deductions) and personal exemptions are deducted before the taxes are applied. Under current rules, exemptions are phased out at high incomes (between $311,300 and $433,800 for a married couple filing jointly, for instance). The Trump proposal would limit tax on business income to no more than 15%.

[11] "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.

The Trump plan would cut the corporate tax rate to a flat rate of 15% in line with the rate he proposes for business income filed on the personal income tax forms. The first Trump plan called for “reducing or eliminating some corporate loopholes that cater to special interests” (NTU 2015), and said that it would “phase in a reasonable cap on the deductibility of business interest expenses,” but did not provide further details. We assume that only half of interest payments by businesses will be deductible.

The revised plan also calls for the immediate 100 percent expensing of new investment to replace the current depreciation schedules. We assume that the expensed investment may not be offset against earnings from “old” capital, and that depreciation would no longer be deductible. The net effect would be a substantial drop in revenue for most of the first decade, after which revenue will recover as the new investments yield taxable income.

To determine the revenue and distributional effects of the Trump proposal, one has to simulate the impact using information on U.S. households, which differ widely in the amount and nature of their incomes, composition, and spending. For a detailed description of this process, see Haughton et al. 2016.

1. Revenue Estimates

Based on our tax-calculator model, we estimate that on a static basis, the Trump personal income tax proposals would reduce tax revenues by $546 billion in new revenue in 2017, rising to $834 billion in 2026. When changes to the estate tax, and corporation tax, are included, revenues would fall by $9,756 trillion over the decade 2017-2026. Table 4 displays the details.

Table 4: Static Revenue Estimates of the Trump Tax Proposals Relative to Benchmark

	2017	2026	2017 – 2026
	billions of dollars		
Personal Income Tax	-546	-834	-6,791
Estate tax	-238	-303	-2,716
Corporate tax changes	-21	-30	-249
Total	**-805**	**-1,167**	**-9,756**

Source: Authors' calculations, and Haughton et al. 2016.

The tax calculator 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 NCPA-DCGE 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 Table 5 displays. We assume the Trump tax plan would come into effect in 2017, and report the results for 2017 and 2026. We also report changes in tax revenue over the ten-year period 2017 – 2026.

In 2017, the Trump proposals personal income tax cuts would reduce U.S. federal tax revenue by $707 billion (measured against baseline), and federal revenues would decrease by $993 billion in 2026. Because the tax cuts would spur economic growth, there would be some increase in state tax collections, so that overall government revenue – including federal, state, and local levels – would fall by just $645 billion in 2017 and $854 billion in 2026.

Table 5: Dynamic Revenue Effects of the Trump Tax Proposals Relative to CBO Benchmark

	Change in revenue					
	2017		**2026**		**Cumulative, 2017-26**	
	$ billion	*%*	*$ billion*	*%*	*$ billion*	*%*
Federal Revenue	-707	-19.40	-993	-19.69	-8,394	-19.94
Payroll Taxes	31	2.63	69	4.33	514	3.81
Personal Income Tax	-486	-26.49	-742	-27.85	-6,040	-27.86
Corporate Income Tax	-236	-64.48	-299	-67.34	-2,682	-67.25
Estate and Gift Taxes	-21	-100	-30	-100	-249	-100
Other Taxes and Fees	5	2.06	9	2.88	63	2.37
State and Local Revenue	62	0.03	139	3.98	1,015	3.49

Total Government Revenue	**-645**	**-10.94**	**-854**	**-10.01**	**-7,379**	**-10.37**

Source: Based on NCPA-DCGE model simulations.

It is clear from Table 5 that most of the revenue loss 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 fall by a total of $6.040 trillion; the elimination of the estate and gift tax would cut an additional $249 billion, and the changes to the corporate tax would cut a further $2,682 trillion. Since the lower tax rates would positively affect the tax base for payroll taxes and other taxes and fees, revenues from these taxes would increase by $577 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 NCPA-DCGE model works through these effects in a consistent way, with the results that are shown in Table 6.

In 2017, the Trump tax changes would create 3.066 million private sector jobs, which represents an increase 1.66 percent against the baseline (i.e. no-change) projections. This gain would be offset to some extent by a drop in public employment of 554,000 jobs; the net effect would be an increase of 2.512 million jobs in 2017, and 3.162 million jobs in 2026.

Table 6: Economic Effects of the Trump Tax Proposals

	Change relative to CBO baseline			
	2017		2026	
	'000 jobs	*%*	*'000 jobs*	*%*
Total Employment	**2,512**	**1.66**	**3,162**	**1.61**
Private Employment	3,066	2.07	3,762	1.94
Public Employment	-554	-21.31	-601	-23.20
	$ billion	*%*	*$ billion*	*%*
Real GDP ($billion)	985	5.64	1,981	9.36
Personal Income	646	3.83	1,374	5.64

Business Investment	191	7.16	540	11.72
Imports	23	0.69	95	2.26
Exports	27	0.98	97	2.80

Source: NCPA-DCGE model.

Real GDP would increase by $985 billion in 2017, or by 5.64 percent, and there would be a measurable increases in personal income (up $646 billion) and private business investment (up $191 billion). By 2026, real GDP would be $1.981 trillion higher than it would have been in the absence of the tax changes, representing an increase of 9.36 percent.

Conclusion

2. Conclusion

As currently presented, the Trump tax proposals would reduce taxes on all taxpayers regardless of income level to increase efficiency and spur faster economic growth. According to our NCPA-DCGE model, the plan would reduce $8.394 trillion in revenue over 10 years, with most of that reduction coming from the federal personal income tax. The benefit to the economy would be a net gain of 3.162 million jobs by 2026, and an increase in real GDP of 9.36 percent.

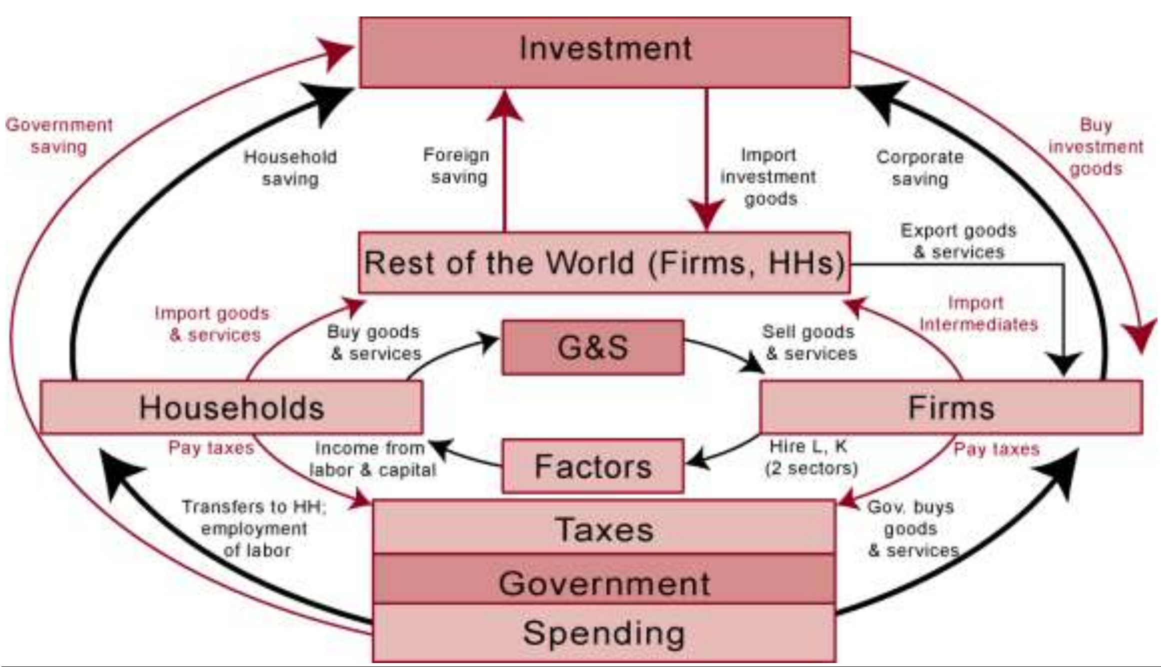
We began this paper by documenting the slowness of the U.S. economic recovery since the 2007-08 recession, and asked whether the tax changes proposed by Donald Trump might speed up further recovery. On this, our conclusion is clear: the lower tax rates would likely increase economic growth.

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

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

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.

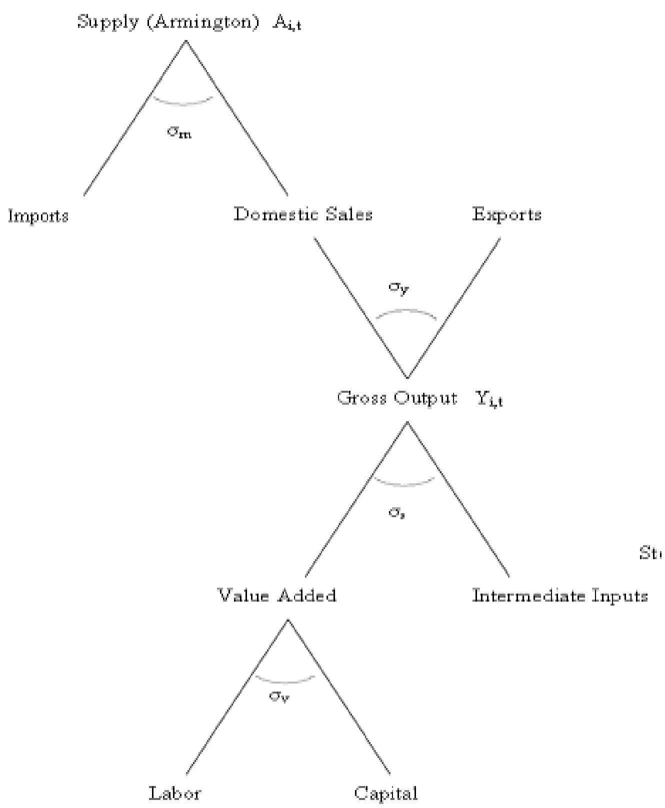
The structure of production is summarized in Figure A-2. Starting at the bottom, and for each of the 27 production sectors, producers combine labor (which comes from seven different categories of households) and capital (using a CES production function, with elasticity of substitution σ_v) to create 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 constant elasticity of substitution (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

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

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. 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 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) $\mathrm{B} = C + NetI + DEP + G + NX - DEP - W - NetI + W - NX - EMP$,
and

(8) $\mathrm{B} = C + G - EMP$.

So Cruz business tax revenue is also

(9) $\mathrm{T} = .16(C + G - EMP)$.

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