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The Effects of State Tax Reform on Tax Revenue Volatility

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Abstract

Recent literature has established that state tax revenues have grown significantly more volatile relative to previous decades. Consequently, this is a growing concern for state policymakers who increasingly need stable revenue sources to meet spending obligations. In this paper, the consequences of comprehensive state tax reforms on subsequent tax revenue volatility are studied using the reforms of Utah (2007) and North Carolina (2013) as case studies. Using a synthetic control methodology, graphical evidence suggests that North Carolina's tax reform resulted in lower subsequent revenue volatility, but that Utah's reform likely did not have such an effect on revenue volatility.

Summary

Recent literature has demonstrated that state tax revenue volatility has risen substantially since the beginning of the 21st century (see Seegert 2016). This can be a substantial problem for state governments that need stable sources of revenue to meet growing spending obligations because they have limited means to borrow to cover spending deficits. The literature has suggested that economic shocks are a primary determinant of revenue volatility, but so too is the type of tax policy that a state implements. This paper primarily seeks to exploit recent major state tax reforms in order to determine the effect that these policies had on the states' subsequent level of revenue volatility.

The two states studied in this paper, Utah and North Carolina, passed major tax reforms in 2007 and 2013, respectively, with broadly similar policy goals. Both states lowered and/or flattened rates of major taxes and reformed policies towards income tax deductions, credits, and exemptions. Theory suggests that some of these policies would be likely to have a downward causal effect on revenue volatility. This claim is tested using synthetic control models for both states in order to determine the likely treatment effect that these reforms had on the subsequent volatility of affected revenue sources in North Carolina and Utah. A synthetic control model is essentially a modified difference in difference which compares pre- and post-treatment trends in an outcome variable between a treatment and control case in order to estimate a treatment effect. The control essentially acts as a counterfactual that can approximate what would have happened to the treated case in the absence of a treatment. However, rather than the control being selected in an ad hoc fashion based on its resemblance to the treatment case, a synthetic control is selected in a data-driven manner as a weighted average of all available control units (in this case,

states). Control units are weighted based on their resemblance to the treatment along various predictor variables. The goal of this is to create a counterfactual that can more credibly hypothesize what would have happened to the treatment case in the absence of a treatment, and thus more accurately determine the treatment effect.

Using this methodology, I present five synthetic control models (three for North Carolina and two for Utah) which plot the volatility of different revenue sources (individual income taxes, corporate income taxes, and total taxes) for both the reforming state and its corresponding synthetic control. The results of these models suggest that North Carolina's tax reform likely had a downward effect on future revenue volatility, as theory would predict. However, a similar effect cannot be determined for Utah based on its synthetic control models, which show no convincing graphical evidence for a causal effect. The reason for these different results could lie in the timing of each of the reforms, as North Carolina implemented their reform in the middle of an economic expansion while Utah implemented theirs in the middle of the Great Recession. In addition, there could be policy reasons for the different results due to each state's slightly different treatment of the sales tax, as well as income tax deductions, credits, and exemptions. Future research could more precisely determine the more subtle reasons for the results shown, but the synthetic models implemented here show promise as an empirical tool for studying the effects of tax policy on revenue volatility.

Introduction

One of the chief concerns of state policymakers, especially in an environment of near-universal balanced budget requirements, is determining ways to generate sufficient and predictable streams of revenue to reliably meet expected spending obligations. This is not straightforward. Like the national economy, states are subject to larger macroeconomic shocks as well as changing regional economic conditions that can affect their tax bases, and thereby their revenue. This can result in financial hardship during difficult economic times if states are not able to spend more than they take in and at the same time must meet obligations such as social spending, debt service, and employee pensions. It is reasonable to assume that states would prefer a predictable stream of revenue to a more volatile stream subject to the whims of the market. If states are to orient their tax policy with this goal in mind, it is imperative that policymakers understand the effects of previous instances of tax policy reform on the reforming state's subsequent revenue volatility. North Carolina's 2013 and Utah's 2007 tax reform both offer such a case. Both states overhauled their respective tax codes, which included lowering personal income tax rates, instituting a flat individual income tax rate (for Utah), and a flat corporate income tax rate (for North Carolina). In this paper, I ask the question, "what were the effects of this reform on subsequent volatility in revenues?" Using a synthetic control methodology, I compare pre- and post-reform revenue and volatility trends of North Carolina and Utah to their synthetic counterparts in order to isolate the marginal effect of the reforms on volatility. Based on a review of the literature, this methodology is novel in the field of revenue volatility studies and would thus make a valuable contribution to the body of knowledge on this topic.

In the following section, I briefly detail the historical context of both states' reform efforts as well as the major provisions of the reforms. Understanding the provisions of the policies are important to understanding their likely effects on their states' revenue volatility. Both of the reforms moved their state towards a tax code (particularly on incomes) with lower rates broader bases. Theory would suggest that, on first blush, these changes would lower the volatility of revenues for two reasons. First, the shifting of tax rates which change the composition of a state's "tax portfolio" would be expected to similarly change the volatility of that portfolio based on the inherent volatility of taxes being changed. In other words, if a state becomes less reliant on a very volatile tax, then the state's portfolio will necessarily be less volatile. Income taxes, both individual and corporate, generate relatively volatile revenue streams (Groves and Kahn, 1952), so one would expect a reform that lowers income tax rates (as was the case for North Carolina and Utah) to lower their overall tax revenue volatility. Second, it is possible that progressive rates for taxes on income make those revenues even more volatile because shifts in income concentrated in high-income individuals or corporations cause the subsequent shifts in revenue to be greater than they otherwise would. In other words, progressive tax rates make income tax revenues more dependent on high-income individuals and income is more volatile at the upper reaches of the income distribution. An income tax with a flat rate might therefore be expected to exhibit lower volatility, other things equal.[1]

Though the focus of this research is in studying tax policy as it relates to revenue volatility, it should be noted that taking this focus does not presume that the stability of revenues is the only or even most important criteria in evaluating tax policies. Governments may also consider adequacy, growth, or fairness in adopting tax policies and preferences vary depending

[1] See Seegert (2013), which establishes a tradeoff between progressivity and revenue stability in state tax systems.

on the context in which policies are being considered. In addition, there are always tradeoffs between such criteria that generally keep governments from obtaining maximum amounts of fairness, growth, stability in their policies. For example, revenue stability may come at the expense of some standards of fairness because some relatively stable sources of revenue are also relatively regressive (e.g. the sales tax). This paper will thus proceed focusing on revenue volatility, but the omission of further discussion of other criteria does not denote a position that revenue stability is necessarily the most important lens through which to judge tax policy.

The Tax Reforms of Utah and North Carolina

North Carolina

In some sense, North Carolina was ripe for a major tax reform as 2012 ended. The November elections of that year had seen a Republican governor and Republican majorities in the state House and Senate come to power at the same time for the first time in over a century, and incoming Governor Pat McCrory had campaigned to reform the tax code, stating "[a]t a minimum, I'd like to at least have our income tax and our corporate tax be competitive with our neighboring states of South Carolina and Virginia" (Binker and Leslie, 2012). To the incoming governing coalition, North Carolina's tax code was outdated, a relic of its manufacturing economy of the 1930s, with relatively high tax rates and large numbers of loopholes and exemptions (Binker and Leslie, 2012). Indeed, by 2012 some of the state's tax rates were quite high when compared to the rest of the country; the top income tax rate was the 12th highest in the nation at 7.75 percent while the lowest income tax rate was the highest bottom bracket rate in the nation at 6 percent. Essentially, the Republican coalition planned to affect more or less the entire tax code by lowering corporate and income tax rates, simplify the tax code for businesses,

and broaden the sales tax base by eliminating exemptions and extending the sales tax to services (Binker and Leslie, 2012).

The plan was not without opposition though; opponents of the proposal expressed equity concerns, arguing that the reform could end up being regressive by shifting more of the tax burden to lower-income households via an expanded sales tax base and 3 reduced income tax exemptions. Opponents were also skeptical of its ability to strengthen the state's economic competitiveness and lead to greater job creation. The final vote suggested that these concerns were not quelled, as HB 998 (named the Tax Simplification and Reduction Act) passed the House and Senate almost completely along party lines (North Carolina General Assembly, 2013).

The key provisions of the Tax Simplification and Reduction Act related to individual and corporate income taxation will be covered here. First and foremost, the reform significantly reduced the rates at which individual and corporate income was taxed, replacing the previous three individual income brackets of 6, 7, and 7.75 percent with a flat rate of 5.8 in 2014 , and gradually lowering the corporate income rate from 6.9 percent to 6 percent in 2014, 5 percent in 2015, and possibly 3 percent by 2017 conditional on the state meeting prescribed revenue targets.[2] The bill also revised provisions of the tax code on exemptions, credits, and deductions. For example, it eliminated personal exemptions (a standard deduction from taxable income claimed on a per-person basis), capped the combined deduction on mortgage interest and property taxes that itemizers could take at $20,000; eliminated various credits for child care, disability, education expenses, and charitable contributions for non-itemizers, and eliminated a

[2] Revenue targets were met and the corporate income tax rate is currently 3 percent.

deduction for government and private retirement income (Binker, 2013). It eliminated a deduction for personal business income in which individuals could deduct up to $50,000 of business earnings that counted against their personal taxes. A legislative analysis estimated that "60 percent of individual tax returns with business income that qualifies for the $50K business income deduction would see a tax increase" (Binker, 2013). The bill partially offset the elimination of these exemptions and credits by raising the standard deduction[3] for all filers and the child tax credit for households with incomes below $40,000.

The revisions to the corporate income tax were similar but less extensive. In addition to lowering the tax rate, the bill allowed a number of business tax credits to expire, including the film production tax credit and various credits aimed at attracting businesses to the state.

Utah

Utah enacted its tax reform over their 2006 and 2007 legislative sessions. Pre-reform, Utah's tax system was in a different position than that of pre-reform North Carolina. While North Carolina was viewed as having a generally inefficient and burdensome tax system, Utah already had a relatively "business-friendly" tax structure, ranking 18th in the Tax Foundation's *State Business Tax Climate Index* in 2006 (Tax Foundation, 2018).

Over the 2006-2007 legislative sessions, Utah enacted major changes to the state's individual income tax and sales tax. Prior to the reform, Utah had a progressive, six bracket income tax with rates ranging from 2.3 to 7 percent. The reform replaced the progressive system with a single flat rate of 5.35 percent for all filers in 2007, lowering it to 5 percent in 2008. The

[3] For example, the standard deduction for married couples filing jointly increased from $6,000 to $15,000.

initial reform from the 2006 session made the flat-rate system optional for one year because some filers would have actually seen a tax increase under the new system. Changes to the sales tax were less dramatic. The general sales tax rate was lowered from 4.75 to 4.65 and the sales tax rate on food was lowered to 1.75 percent, resulting in a net decrease in sales tax revenue of approximately $80 million (Utah Office of Legislative Research and General Counsel, 2007). In addition to lowering rates, Utah changed its treatment of deductions, exemptions, and credits, replacing its standard deduction, allowance for personal exemptions, and deduction for retirement income with credits which phase out as income increases (Cornia, Johnson, and Nelson 2017)

Literature Review

The following section will give a brief background on important theoretical and empirical concepts that inform this study, as well as the work that has developed these concepts. To this end, I will first briefly review the literature on the income elasticities of tax revenues, which is essential to understanding revenue volatility. Previous work on this is rather extensive, so this review will not be exhaustive. Following this, I will give a brief overview of the literature on tax revenue volatility in relation to the revenue diversification hypothesis, which is important because a large portion of the scholarship on tax revenue volatility has used the revenue diversification hypothesis as its *raison d'être*. I will then review other important work on tax revenue volatility that does not study the revenue diversification hypothesis. Finally, I will review the literature on synthetic control, the empirical methodology I use in this research.

Income Elasticity of Tax Revenue

Central to understanding the volatility and variability of a tax revenue stream is understanding its elasticity with respect to income.[4] Elasticity in this context can be defined as the ratio of the percentage change in tax revenue to a given percentage change in income. This can be more informally thought of as the degree to which a tax revenue stream is sensitive to changes in income or economic activity. Taxes with an income elasticity greater than one are income elastic, meaning that a one percent increase in income results in a greater than one percent increase in revenue. Taxes with an income elasticity less than one are income inelastic, meaning that a one percent increase in income results in a less than one percent increase in revenue. Given this framework, taxes that are relatively income inelastic are more stable because they are less sensitive to changes in economic conditions, while elastic taxes are relatively volatile because they are more sensitive to changes in economic conditions. Understanding the volatility of a government's tax revenues is therefore closely related to understanding the income elasticities of the taxes in its tax portfolio. The seminal study in this area by Groves and Kahn (1952), posited that the stability of tax revenue streams is a function of their income elasticity. However, because of this there is necessarily a tradeoff between the stability and potential for growth in revenues because more income elastic taxes, though they are less stable, increase disproportionately to increases in income and may grow rapidly. In the study, taxes with low income elasticity included the property tax and various excise taxes such as the motor fuel tax and cigarette tax, while taxes with medium to high income elasticity included the sales tax and individual income tax. Work following this has largely expanded up this by seeking to understand the long and short term dynamics of the income elasticity of tax bases (e.g. Bruce,

[4]In this context, income may be synonymous with GDP or some other indicator of economic output.

Fox, and Tuttle 2006, Sobel and Holcombe 1996) as well as dynamics of specific taxes, such as Fox and Cambell's (1984) study which examined the stability of state sales tax revenues.

Revenue Diversification Hypothesis

Much of the work in the public finance literature has hypothesized a different (though not mutually exclusive) explanation for the level of revenue volatility in a government's overall revenue stream: revenue source diversification. The theory is essentially that governments diversify their tax "portfolio" in order to stabilize their revenue streams from year to year in the same way that investors in the stock market diversify their portfolio in order to reduce risk. Early studies examining this question generally found a negative relationship between diversification and volatility. Misiolek and Elder (1988) were among the first to find significant evidence of a negative relationship between revenue diversification and volatility. More recent work looked at municipalities in the Chicago metropolitan region and showed similar results (Hendrick 2002). The recession resulting from the 2008 financial crisis spurred additional research on the question, as state and local governments were forced to cope with severe revenue shortfalls. Jordan and Wagner (2008) studied revenue diversification in Arkansas cities over a 10-year period and found that revenue diversification can mitigate severe revenue fluctuations. Though his work doesn't deal directly with the revenue diversification hypothesis, Nathan Seegert's work has studied state taxation from the context of tax "portfolios", finding that the riskiness of a state's tax portfolio, determined by the mix of taxes that make up a state's revenue stream, significantly affects the volatility of revenues (Seegert 2015).[5]

Synthetic Control

[5] Other work by Seegert (Seegert 2016) deals extensively with state tax revenue volatility and informs aspects of this paper's empirical strategy.

Before moving on, a brief overview of the existing literature on synthetic control (the empirical methodology of this study) should be given. Synthetic control, first developed by Abadie and Gardeazabol (2003) and Abadie, Diamond, and Hainmueller (2010), has been called "arguably the most important innovation in the policy evaluation literature in the last 15 years" (Athey and Imbens, 2017, 9). It functions similarly to difference in differences in that applications of the method are quasi-experimental and the causal effect of a policy intervention is hypothesized based on a comparison of trends of an outcome variable for a control and treated unit. Difference in difference studies generally compare trends in an outcome variable between the treated unit (often a city, state, region, country, etc.) and a comparable unit which exhibits parallel trends in the outcome variable in the pre-treatment. Card's (1990) seminal study of the effects of a wave of Cuban immigration to Miami on the city's labor market is a good example of this, which compared the trends in various labor market indicators in Miami and comparable cities in the pre- and post-immigration period, finding that the wave of immigration had "essentially no effect on the wages or employment outcomes of non-Cuban workers in the Miami labor market" (Card, 1990, 255). This approach is particularly strong and causally valid if the treated and control unit are reasonably similar and the outcome variable(s) display parallel trends in the pre-treatment period. The synthetic control method functions similarly to this, but the control unit is generated based on a "weighted average of the available control units" that most closely match the pre-treatment trends of the treated unit (Abadie, Diamond, and Hainmueller, 2010, 494). It is a strong alternative to difference in differences when "no single untreated unit provides a good comparison for the unit affected by the treatment or event of interest" (Abadie, Diamond, and Hainmueller, 2014, 500). This method has most notably been utilized to estimate the effect of California's Proposition 99 on cigarette consumption (Abadie, Diamond, and

Hainmueller, 2010), that of conflict in the Basque region of Spain on its economic outcomes (Abadie and Gardeazabal, 2003), and the effect of German reunification on West Germany's economy (Abadie, Diamond, and Hainmueller, 2010). This method is relatively new, but it has been widely used in a number of case studies which examine the effects of major policy interventions or events on large jurisdictions for which macro-level data is available [see: (Rieger, Wagner, and Bedi, 2017), (Barlow, 2017), and (Munasib and Rickman, 2015)].

Data Collection and Research Design

Data Collection

I gathered yearly data on tax revenues, tax rates, economic variables, and population for all 50 states between 1980 and 2017. I collected data on tax revenues between 2002 and 2017 from the Census Bureau's Census of State and Local Government and data on tax rates from the same years from the Council of State Government's yearly *Book of the States*. Tax rate and revenue data from 1980 to 2001 was collected from the World Tax Database of the University of Michigan's Office of Tax Policy Research. Tax rates collected included the top and bottom individual income tax rate, the top corporate income tax rate, and the general sales tax rate. Revenue sources collected were general sales tax revenue, individual income tax revenue, corporate income tax revenue, and total tax revenue. No individual state tax revenue data exists for the year 2003, so all revenue data for this year in my panel data set were interpolated based on a simple linear time trend.

Economic variables and population figures were gathered from the Bureau of Economic Analysis. I collected yearly state GDP and personal income data for all states between 1980 and 2017. Nominal dollar figures for tax revenues, state GDP, personal income are deflated to 2012 dollars in order to make results comparable across time.

In addition to this economic data, I use the State Coincident Index, a monthly economic indicator produced by the Federal Reserve Bank of Philadelphia. The index combines monthly nonfarm payroll employment, average hours worked in manufacturing by production workers, the unemployment rate, and wage and salary disbursements deflated by the consumer price index in order to summarize current economic conditions (Federal Reserve of Philadelphia 2020). The indicator is similarly utilized as an economic indicator in another tax revenue volatility study (Seegert 2016) and is thus used in this model. As it is a monthly indicator, the 12 monthly values in a given state and year are averaged to produce a yearly value for each state from 1980 to 2017.

Measuring Volatility

In this research, volatility will be calculated using the "squared residual" measure.[6] The measure, detailed below, for a given state and year is simply the square root of the squared residual from a state-specific time trend.

$$\rho_{it} = \beta t + \varepsilon_{it}$$

$$squared\ residual = \sqrt{\varepsilon_{it}^2}$$

ρ in this measure is the total yearly revenues by source. The squared residual is a more conservative measure of volatility than a simple year over year change $[(x_t - x_{t-1})/x_{t-1})]$ because it nets out state-specific time trends that would otherwise be included in a year over year measure of volatility. In order to produce state specific time trends for a given measure of revenue (i.e. income tax revenue, corporate tax revenue, total tax revenue, etc.), the measure of revenue for a given source of revenue was regressed on time from 1980 to 2017 to create predicted values for each state and year. The residual was then calculated by subtracting actual yearly revenues for a given state and year from the predicted value. The treated states, North

[6] This measure was originally used in Seegert (2016)

Carolina and Utah, were treated differently than the control states in that two time trends were calculated for them, a pre- and post-reform trend, in order to account for the revenue effects the reform may have had. In other words, changing the tax rates can be expected to have substantial effects on the absolute value of tax revenues, however the post-reform revenues may be more or less volatile based on the predicted values of post-reform revenues.

Measuring Tax Revenues

Total tax revenues for a given state and year in this study are measured as the sum of individual income tax revenues, corporate income tax revenues, and general sales tax revenues. Similarly used in Seegert (2016), the purpose of this measure is to make revenue figures more comparable across states due to the "large differences in the importance of oil and mineral revenues across states, and differences in property assessments [*which*] make it impossible to compare property tax rates" (Seegert 2016).

Research Design

As briefly described earlier, the synthetic control method used in this this report is a similar to a difference in difference in that the pre- and post-treatment trends are compared between a treatment case (Utah and North Carolina) and a control case (in this case, the "synthetic control"). More formally, if we seek to know the treatment effect of some policy intervention using a difference in difference methodology, we obtain the effect through the following operation: $(Treament_{Post} - Control_{Post}) - (Treatment_{Pre} - Control_{Pre})$ where each term is the pre- or post-treatment average of the outcome variable that captures the effect of the policy intervention[7]. In this case, the outcome variable is revenue volatility, calculated as the squared residual from a state-specific time trend. With the synthetic control methodology, though we still

[7] We also must assume that, in the absence of reform, the treatment and control case exhibit parallel trends in the outcome variable in the post-treatment periods.

calculate the treatment effect of the policy intervention by differencing the differences between the treatment and control average values of the outcome variable in the pre- and post- period, the outcome variable of our control unit is a "synthetic" construction, a weighted average of all available control units that optimally resembles the treated unit in all relevant characteristics (predictor variables) in the pre-treatment period. In the synthetic control model, all weights assigned to available control units (or "donor pool" (Abadie, Diamond, and Hainmueller 2011)) are greater than or equal to zero and the sum of all weights are equal to one. In this research, the available control are all states besides either Utah or North Carolina and the predictor variables upon which the weights assigned to the donor pool are determined are tax rates, economic variables, and volatility measures in the pre-treatment period. The purpose of the predictor variables and weights assigned to the donor pool are to recreate to come as close as possible to the values of the treatment unit's outcome variable and predictor variables in the pre-treatment period so that the synthetic control can be a credible counterfactual to the treated case in the post-treatment period.

In this study, multiple synthetic control models are run for each state. Because both states made substantial changes to their personal and/or corporate income tax systems, I am interested in how those reforms affected the volatility of those individual revenue sources in addition to what I define as total tax revenues. Because of that, I run three synthetic control models for North Carolina and two for Utah. For North Carolina, there is one for total tax revenues, one for corporate income tax revenues, and one for individual income tax revenues. For Utah, there is one for total tax revenues and one for individual income tax revenues, but none for corporate income tax revenues because their 2007 reform did not make substantial changes to the corporate income tax code.

Predictor variables chosen for each synthetic control model depend on the type of tax (or taxes) that the revenue source entails. In general, each synthetic control contains predictor variables on tax system characteristics and state economic conditions in order to synthesize a "state" that most resembles the treatment state. For the total tax revenue model, the predictor variables are given in Table 1.

Table 1: Predictor Variables for Total Tax Revenue Model

Predictor Variable	Notes
Top Individual Income Tax Rate	
Bottom Individual Income Tax Rate	
Sales Tax Rate	
Top Corporate Income Tax Rate	
Has Individual Income Tax Has Sales Tax Has Individual Income Tax	Dummy variables with a value of 1 if the state has that tax
Region	Dummy variable with a value of 1 if the state is in the same Census-designated region (North, South, Midwest, or West)
Log(GDP Per Person)	
Log(Personal Income Per Person)	
Coincident Index	
Residual Trend (Year)	Value of the residual trend volatility measure for the revenue source in question

The predictor variables for the corporate income tax model and the individual income tax model are given in the following table.

Table 2: Predictor Variables for Individual and Corporate Income Tax Revenue Models

Predictor Variables	
Individual Income Tax	**Corporate Income Tax**
Top Individual Income Tax Rate	Top Corporate Income Tax Rate
Bottom Individual Income Tax Rate	
Has Individual Income Tax	Has Corporate Income Tax
Region	Region
Log(GDP Per Person)	Log(GDP Per Person)
Log(Personal Income Per Person)	Log(Personal Income Per Person)
Coincident Index	Coincident Index
Residual Trend (Year)	Residual Trend (Year)

In all three of these models, the same kinds of predictor variables are included in the synthetic control model in order to generate a "synthetic" North Carolina or Utah. In order to generate a synthetic control with similar economic conditions to the treated states in the pre-treatment period, the natural logarithms of GDP per capita and personal income per capita, as well as the yearly average of the state coincident index are inserted in the synthetic control. The indicator variable of region is inserted in the model so that states in the same region as the treated state are given extra weight in the final synthetic control. This is done in order to control for regional economic, political, and social factors that may influence the revenue volatility of the treated state. In addition, in order to give appropriate weights to states in the donor pool, states are selected based on how similar their tax system is to that of the treated state. The predictor variables that capture these factors are tax rates and the "Has [tax]" indicator variables, so that states are given weight based on how similar their tax rates are to the treated state and whether or not they have the tax (or taxes) in question. Finally, values of the residual trend volatility measure in each of the three years leading up to the reform are included as predictor variables in order to select for states that exhibit similar pre-reform trends in the revenue volatility of the tax in question. With these predictor variables, it is more likely that a credible counterfactual to the treated states can be generated because the synthetic control is a weighted average of states with similar tax system characteristics, as well as economic and regional characteristics.

Results

In the following section, I present results for each of the five synthetic control models I run for North Carolina and Utah. For each synthetic control model, I will present pre-treatment means for the predictor variables of the synthetic and treated state in order to establish whether

or not the synthetic control closely tracks the treated state along the lines of the predictor variables. I will also display the weights given to states based on the synthetic control model in question. Finally, I will display a graph showing the pre- and post-treatment trends of revenue volatility for the treated state and its synthetic counterpart, followed by a brief interpretation of results.

North Carolina

Individual Income Tax

Table 3: Synthetic Control State Weights and Pre-Reform Predictor Variable Means

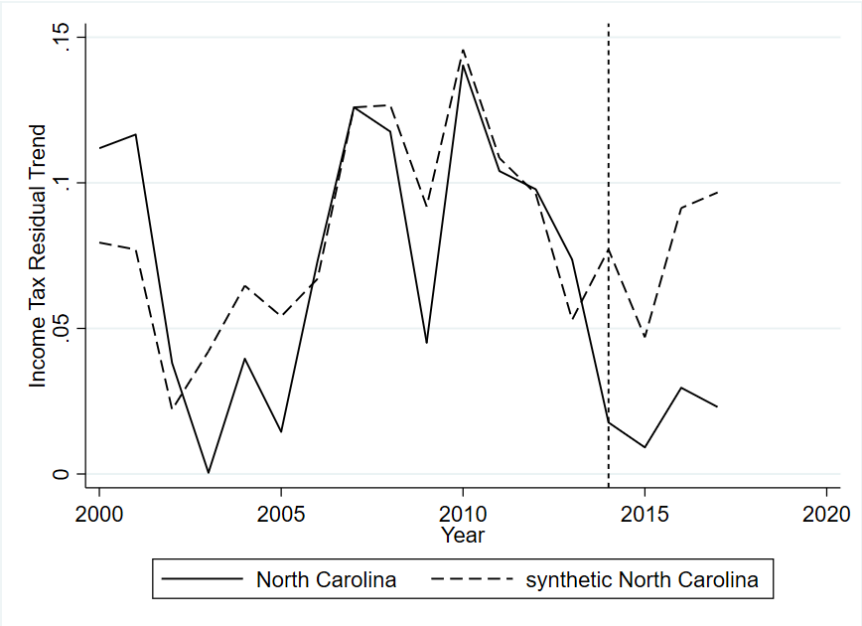
State	Unit Weight
Delaware	0.164
Louisiana	0.29
Minnesota	0.206
Mississippi	0.34

Predictor Variable	Treated	Synthetic
Top Income Tax Rate	7.447	6.188
Bottom Income Tax Rate	5.933	3.004
South	1	0.794
Log(GDP Per Person)	10.727	10.715
Log(Personal Income Per Person)	10.527	10.529
Coincident Index	101.035	100.818
Residual Trend (2011)	0.104	0.109
Residual Trend (2012)	0.098	0.096
Residual Trend (2013)	0.074	0.053

The synthetic control for the volatility of North Carolina's individual income tax revenue is modeled as the weighted average of four states: Delaware, Louisiana, Minnesota, and Mississippi. Mississippi and Louisiana were given the most weight based on the synthetic control models. As can be seen above, the pre-treatment means of the predictor variables of the synthetic control for the most part closely reflect those of North Carolina, particularly those of the economic predictor variables and the values of the volatility measures in the three years leading up to the reform. The figure below plots the annual values of the squared residual volatility measure for North Carolina and its synthetic counterpart from 2000 to 2017. The two cases follow parallel trends in the years leading up to the reform, especially from 2006 to 2013, which lends to the validity of the model. Most importantly however, the two states diverge sharply in

their revenue volatility in the years following the reform; the real North Carolina's income tax revenue volatility drops sharply after the reform while the same volatility measure for the synthetic control sees no such fall in volatility. In 2014 (the first post-reform year), the volatility of North Carolina's income tax revenues drops to roughly a 2% deviation from the time trend, while that of the synthetic North Carolina rises to about a 7.5% deviation. That the revenue volatility of income tax revenues for North Carolina and the synthetic control display parallel pre-reform trends and a sharp divergence after the reform is evidence that the changes made to North Carolina's income tax system had a downward causal effect on the revenue source's volatility in the years subsequent to the reform.

Figure 1: Individual Income Tax Revenue Volatility for North Carolina and Synthetic Control



[8]

Corporate Income Tax

[8] The vertical dotted line is marked at 2014, the first post-reform year.

Table 4: Synthetic Control State Weights and Pre-Reform Predictor Variable Means

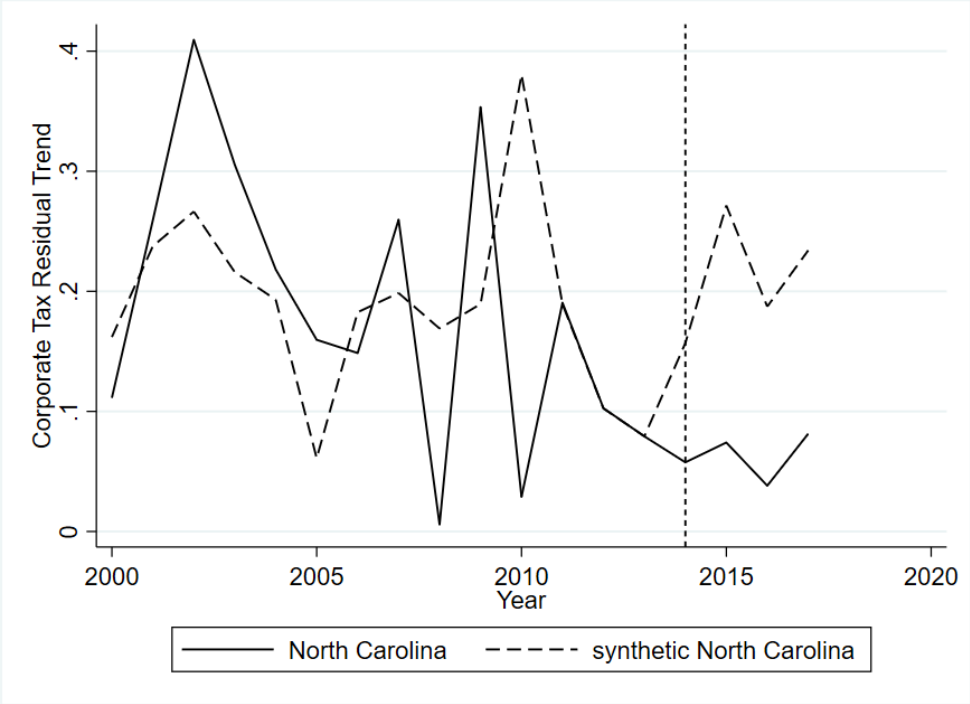
State	Unit Weight
Alabama	0.147
Arkansas	0.131
Delaware	0.307
Georgia	0.011
Louisiana	0.085
Mississippi	0.239
South Dakota	0.01
Virginia	0.069

Predictor Variable	Treated	Synthetic
Log(GDP Per Person)	10.716	10.705
Log(Personal Income Per Person)	10.509	10.498
Coincident Index	95.393	95.295
South	1	0.989
Top Corporate Tax Rate	6.836	6.817
Has Corporate Tax	1	0.999
Residual Trend (2011)	0.191	0.189
Residual Trend (2012)	0.103	0.102
Residual Trend (2013)	0.079	0.079

The synthetic control for the volatility of North Carolina's pre-2014 corporate income tax revenues is modeled as a weighted average of eight states, with two states (Delaware and Mississippi) making up just over half of the total weight. The pre-treatment means of the predictor variables for North Carolina and the synthetic control are similar, which is evidence that the synthetic control is a credible counterfactual for North Carolina. However, as can be seen in the graph below which plots the volatility of corporate income tax revenues for North Carolina and its synthetic counterpart, the pre-2011 trends for North Carolina and the synthetic control do not generally move parallel to one another, which may raise concern that the synthetic control isn't a credible counterfactual. Nevertheless, the values of the volatility measure in the three years leading up to the reform are nearly identical between North Carolina and the synthetic control, which is evidence that the synthetic control meets the parallel trends assumption. Similar to the synthetic control model for individual income tax revenues, North Carolina and the synthetic control see a sharp divergence in the volatility of their corporate income tax revenues in the years following the reform. The volatility of revenues for North Carolina stabilizes around a 10% deviation from the time trend, while the volatility of the synthetic control unit's revenues rises sharply in the post-reform years. However, as can be seen in Figure A.2 in Appendix A, the linear time trend for corporate income tax revenues after the

reform is actually negative due to the revenue effects of the lower rates. This decline in volatility is thus not necessarily positive if the revenue growth is the criteria for the success of the policy because revenues in this case merely decline steadily rather than grow steadily.

Figure 2: Corporate Income Tax Revenue Volatility for North Carolina and Synthetic Control



Total Tax Revenue

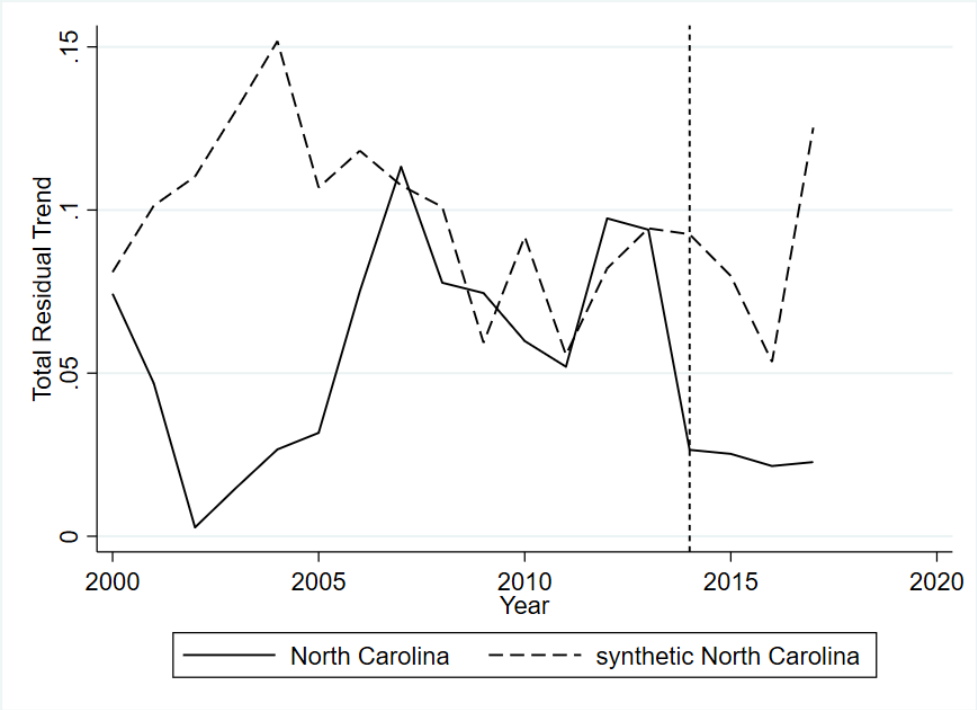
Table 5: Synthetic Control State Weights and Pre-Reform Predictor Variable Means

State	Unit Weight
West Virginia	0.302
New York	0.239
North Dakota	0.228
Mississippi	0.124
Oregon	0.07
Arkansas	0.014
South Carolina	0.013
Louisiana	0.011

Predictor Variable	Treated	Synthetic
Top Income Tax Rate	7.447	6.715
Bottom Income Tax Rate	5.933	3.067
Sales Tax Rate	4.639	4.981
Top Corporate Tax Rate	6.317	7.143
Has Corporate Tax	1	1.001
Has Sales Tax	1	0.931
Has Income Tax	1	1.001
South	1	0.464
Log(GDP Per Person)	10.727	10.713
Log(Personal Income Per Person)	10.527	10.573
Coincident Index	101.035	100.186
Residual Trend (2011)	0.052	0.056
Residual Trend (2012)	0.097	0.082
Residual Trend (2013)	0.094	0.094

The synthetic control for the volatility of North Carolina's pre-reform total tax revenues (defined as the sum of income, corporate, and sales tax) is modeled as a weighted average of eight states, with West Virginia and New York being the two most heavily weighted states. The synthetic control matches or comes close to matching the pre-reform means of North Carolina's predictor variable values, though there are a few exceptions. For example, the synthetic control's bottom individual income tax rate is nearly three percentage points lower than that of North Carolina and the absolute difference between the top and bottom income tax rate is roughly two percentage points greater than it is for North Carolina in the pre-reform years, indicating that the synthetic control's pre-reform income tax structure is more progressive than that of North Carolina. In addition, three out of eight states that comprise the weighted average of the synthetic control are in a different region than North Carolina, which may bias the synthetic control based on regional economic or political effects that North Carolina is not subject to. Nevertheless, the volatility measure of North Carolina and the synthetic control follow parallel trends, particularly in the three years leading up the reform, which is evidence that the synthetic control may be a strong counterfactual. Similar to the results from the previous two models, North Carolina and its synthetic control experience a sharp divergence in the volatility of their respective tax revenues in the post-reform years, with the volatility of North Carolina's total tax revenues experiencing a sharp decline compared to that of the synthetic control. Again, this is evidence that North Carolina's tax reform had a downward causal effect on the volatility of the state's tax revenues.

Figure 3: Total Tax Revenue Volatility for North Carolina and Synthetic Control



Utah

Individual Income Tax

Table 6: Synthetic Control State Weights and Pre-Reform Predictor Variable Means

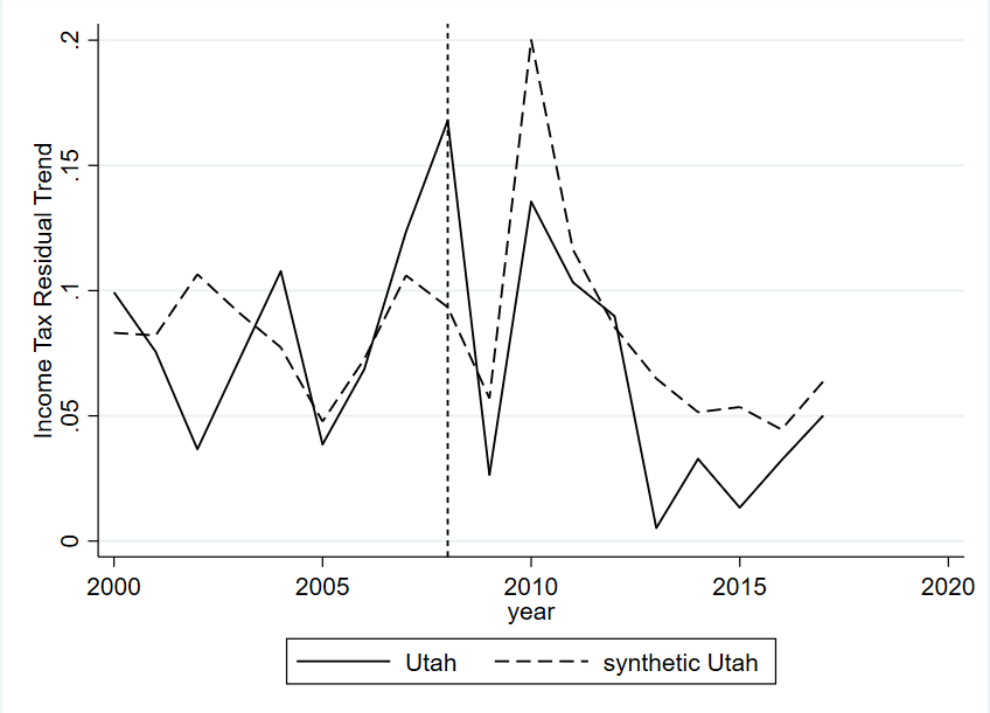
State	Unit Weight
Montana	0.349
Oregon	0.263
Idaho	0.238
Arizona	0.101
Texas	0.05

Predictor Variables	Treated	Synthetic
Top Income Tax Rate	7.00	8.04
Bottom Income Tax Rate	2.3	2.66
Has Income Tax	1	0.951
West	1	0.951
Log(GDP Per Person)	10.651	10.577
Log(Personal Income Per Person)	10.386	10.446
Coincident Index	85.166	88.790
Residual Trend (2005)	0.039	0.048
Residual Trend (2006)	0.069	0.073
Residual Trend (2007)	0.123	0.106

The synthetic control for the volatility of Utah's income tax revenue is modeled as the weighted average of five states, with Montana and Oregon making up over half of the total weight. For the most part, the pre-reform means of the predictor variables for Utah and its

synthetic control are close to one another, strengthening evidence that the synthetic Utah is a believable counterfactual. In addition, the volatility measures of both cases follow nearly parallel trends in the pre-reform period, especially after 2003. However, unlike the same model for North Carolina, there does not appear to be strong visual evidence for a causal effect of Utah's tax reform on the subsequent volatility of its individual income tax revenues. Though the volatility of Utah's income tax revenues spike relative to its synthetic control in 2008, the first post-reform year, the two follow parallel trends in the 3 following years, suggesting that the reform didn't have a significant effect on Utah's income tax revenue volatility. Though Utah's volatility drops relative to its synthetic counterpart in the last 4 years, the difference is not sufficiently wide that statistical noise can be ruled out. Based on the graphical evidence, a clear causal effect of Utah's reform on subsequent volatility cannot be determined

Figure 4: Individual Income Tax Revenue Volatility for Utah and Synthetic Control



[9]

[9] The vertical dotted line is marked at 2008, the first post-reform year.

Total Tax Revenue

Table 7: Synthetic Control State Weights and Pre-Reform Predictor Variable Means

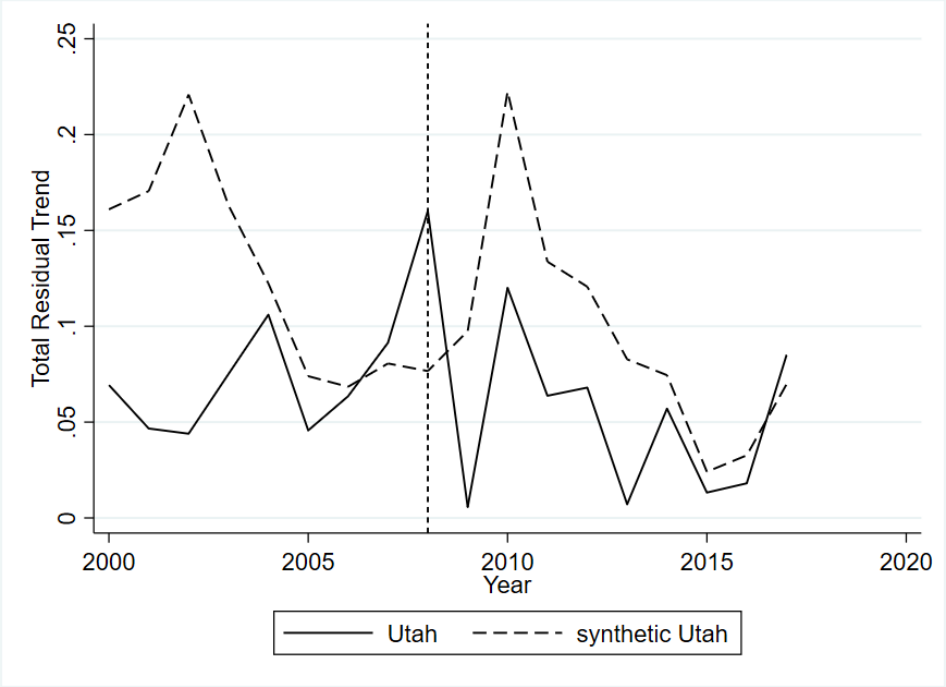
State	Unit Weight
Idaho	0.571
New Mexico	0.173
Colorado	0.092
Washington	0.086
Oregon	0.067
Arizona	0.011

Predictor Variables	Treated	Synthetic
Has Sales Tax	1	0.933
Has Corporate Tax	1	0.914
Has Income Tax	1	0.914
Log(GDP Per Person)	10.651	10.609
Log(Personal Income Per Person)	10.386	10.451
West	1	1
Coincident Index	85.166	88.144
Top Income Tax Rate	6.998	6.783
Bottom Income Tax Rate	2.3	2.058
Top Corporate Tax Rate	5	6.658
Sales Tax Rate	4.75	4.822
Residual Trend (2005)	0.046	0.074
Residual Trend (2006)	0.063	0.068
Residual Trend (2007)	0.091	0.081

The synthetic control for the volatility of Utah's pre-reform total tax revenues (defined as the sum of income, corporate, and sales tax) is modeled as a weighted average of six states, all from the same region as Utah, with Idaho and New Mexico being the two most heavily weighted states. Though the pre-reform means of the predictor variables are quite similar between Utah and the synthetic control, the volatility measure of the two (as seen in the graph below) often do not follow parallel trends in the years leading up to the reform. This does not lend itself to the validity of the model, as pre-treatment parallel trends are an essential condition of the causal validity of a difference in difference model such as this. The volatility trends of Utah and the synthetic control post-reform are similarly "noisy"; though Utah sees a sharp increase in volatility (relative to the control) in the first year after the tax reform, it dips below that of the control in the years following, though the difference between the two shrinks with time.

Similarly to Utah's income tax model, the graphical evidence does not point towards any probable causal effect in this case.

Figure 5: Total Tax Revenue Volatility for Utah and Synthetic Control



Discussion and Conclusion

The results seem to beg the question: why did broadly similar tax reforms in North Carolina and Utah not have the same effects on the volatility of subsequent revenues? For example, the volatility of individual income tax revenues dropped sharply in North Carolina after the reform (relative to the synthetic control), but those of Utah initially rose sharply before stabilizing at a lower level in subsequent years. The most likely explanation could be the timing of each of the reforms. The Utah tax reform was implemented in 2008, the first year of the Great Recession, while North Carolina's was implemented in 2014, in the middle of one of the longest periods of economic expansions in American history. Given that changes in economic conditions are a key determinant of the tax revenue volatility (Seegert 2016), different changes could interact differently with generally similar tax reforms to produce varied effects on subsequent

revenue volatility. This cause additionally cannot be ruled out because the difference in results between North Carolina and Utah is not so great that a major policy difference between the two reforms would be significantly more likely to explain the results. In general, most of the models show that volatility in the reforming states drops in the post-reform years, though in the case of Utah the reform cannot likely explain the drop because the revenue volatility of its synthetic counterpart behaves similarly in the post-reform period. Though the different economic contexts in which North Carolina and Utah adopted their reforms may explain their different results, differences in their respective policies also cannot be ruled out as explanations.

Though Utah and North Carolina adhered to broadly similar guiding principles in their reform efforts (i.e. lower, flatter tax rates), there are some differences between the two policies that could explain the differing results in the synthetic control models. For the "Total Tax Revenue" models, the differences are more obvious. North Carolina made significant changes to their corporate income tax system, primarily by lowering their rates, while Utah made no changes to their corporate tax rates. Corporate income taxes have long been found to be relatively income elastic (Groves and Kahn 1952), so a lessening dependence on corporate tax revenue (other things equal) would be expected to result in a lower overall level of revenue volatility. The second major difference lies in each state's treatment of the sales tax. North Carolina largely left the sales tax alone, maintaining the pre-reform statewide rate while eliminating some minor exemptions and preferential rates (Binker 2013). Utah, on the other hand, lowered its statewide rate from 4.75 to 4.65 percent and its rate on food to 1.75 percent. Food is a relatively income inelastic good because its consumption changes relatively little in proportion to changes in income, so a shrinking reliance on revenue generated from food consumption would be likely to result in less stable tax revenues. Given that sales tax revenues

are relatively income inelastic (compared to income taxes) and that North Carolina kept their reliance on sales tax revenue stable (other things equal) while Utah lessened their reliance on sales taxes, it is probable that Utah's policies resulted in higher overall revenue volatility, relative to that of North Carolina.

The differences between the reforms of North Carolina and Utah that could explain the different results in the "Individual Income Tax" models are more subtle than the differences between each state's treatment of sales taxes and corporate income taxes and largely lie in their respective reforms of deductions, credits, and exemptions. In North Carolina, the reform eliminated a number of exemptions and deductions in order to preserve a degree of revenue neutrality and maintain a broader, more stable tax base. Though they also raised the standard deduction for individuals, Utah arguably preserved these policies to a such a greater extent that they could have counteracted other volatility mitigating aspects of their policy. As a result of their reform, Utah maintained a progressive tax credit that gradually phases out over certain income thresholds which depend on filing status. Such credits are inherently different from deductions because they lower tax liability, as opposed to taxable income, by the amount of the credit and thus may have a more substantial effect on revenue collection than that of deductions, depending on the size of the credit. Determining the exact effect of North Carolina's treatment of deductions, credits and exemptions on subsequent income tax revenue volatility relative to that of Utah's reform would require further research, but Cornia, Johnson, and Nelson (2017) established through simulations using individual tax return data that the system of tax credits implemented by Utah caused higher revenue volatility than would have been the case had the state eliminated all deductions, credits, and exemptions.

Based on these results, future research of tax revenue volatility should further study the effects of cases tax reform (whether at the local or state-level) in order to determine the likely causal mechanisms that determine shifts in subsequent revenue volatility. In North Carolina, the 2013 reform broadly appears to have caused a more stable revenue stream for the state. However, in Utah, the causal effect of the 2007 reform on subsequent revenue volatility is less clear. The results presented here provide visual evidence only, though statistical evidence is certainly obtainable. A fixed effects regression model utilizing the volatility measures of each state's revenue source (i.e. income tax revenue, total tax revenue, etc.) and its corresponding synthetic control would produce numerical treatment effects with standard errors which would determine the statistical significance (or insignificance) of the models just presented.

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Appendix A: North Carolina and Utah Revenues Plotted Against Linear Time Trend

The graphs below plot the values of each of the revenue sources used in the five synthetic control models in the body of the paper. All graphs plot revenue figures from 2000 to 2017 in real, 2012 dollars. Each graph also contains a line which plots a linear time trend in order to compare predicted revenues with actual revenues. The purpose of this is to give context to the volatility measures presented in the paper, which are calculated as the difference between predicted and actual revenues as a percentage of total actual revenues.

North Carolina

Figure A.1

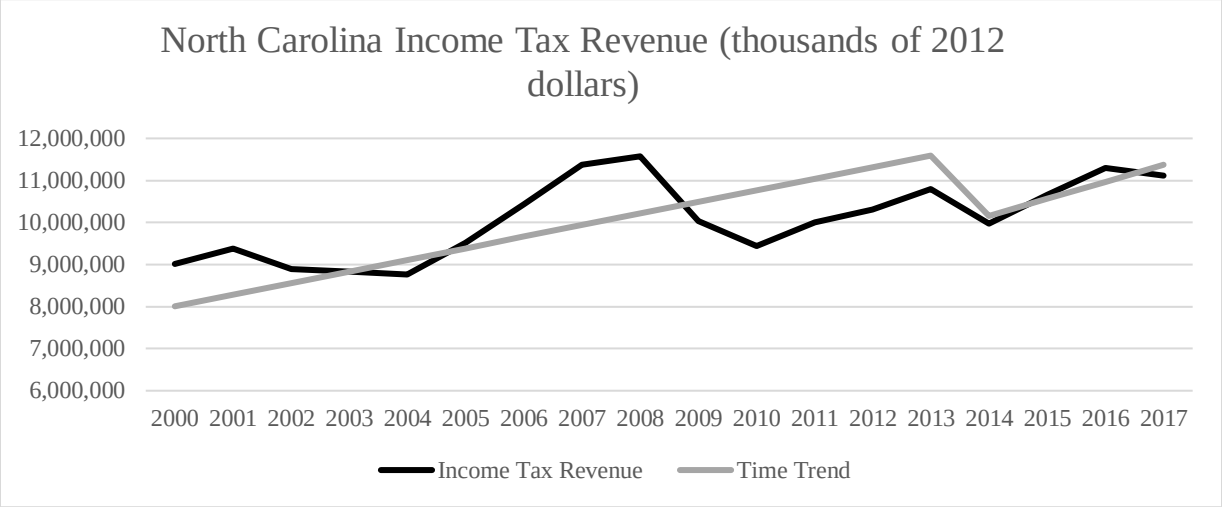


Figure A.2

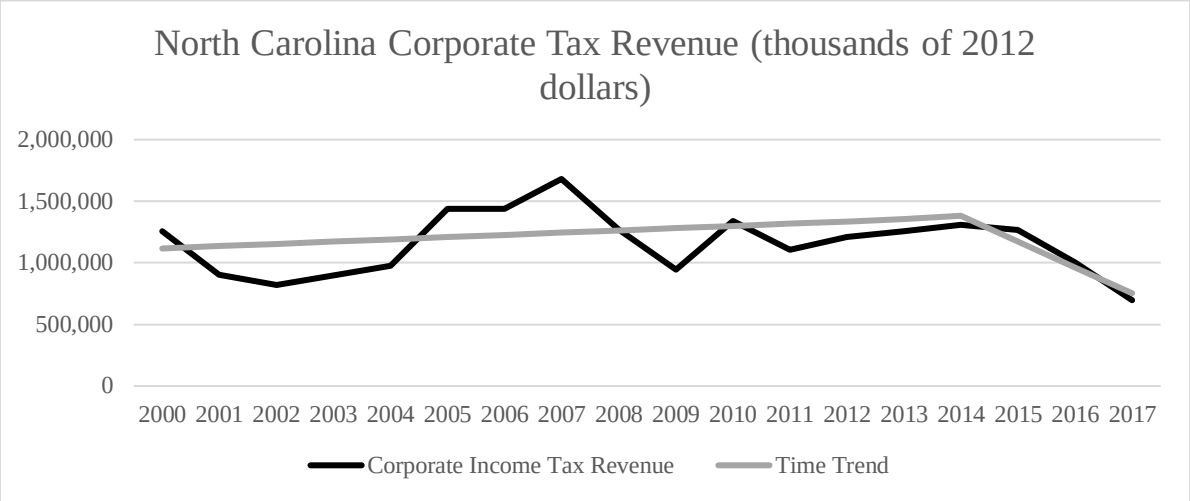
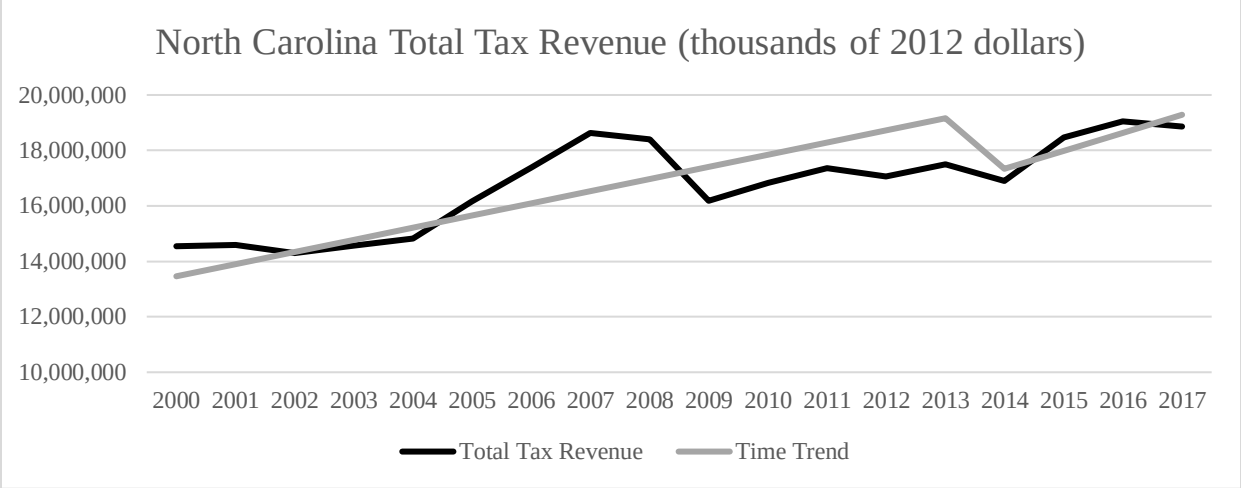


Figure A.3



Utah

Figure A.4

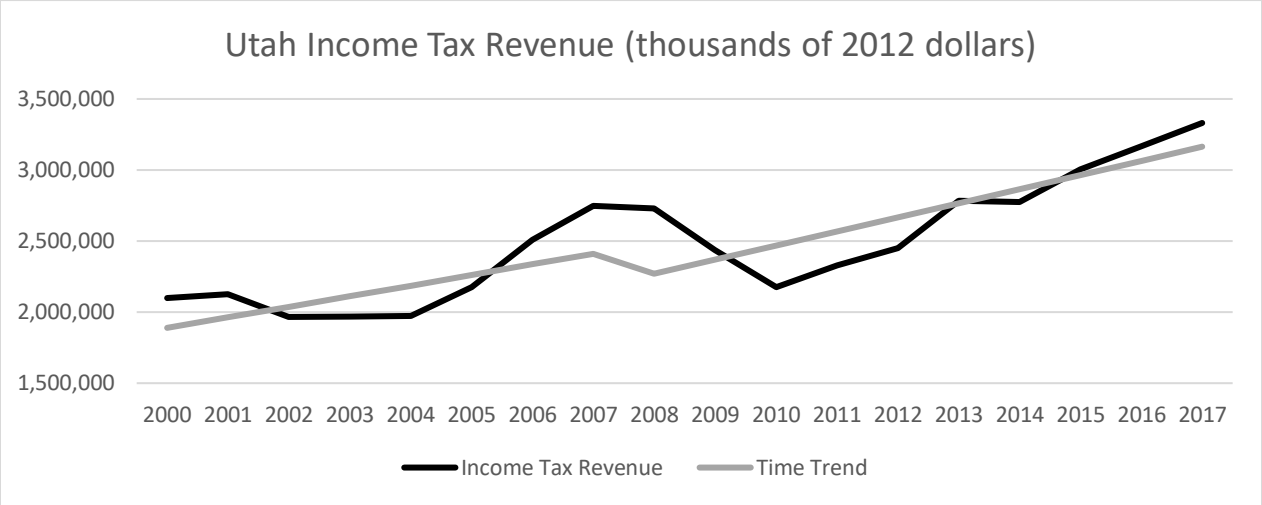


Figure A.5