THE PERFORMANCE OF STATE TAX PORTFOLIOS DURING AND AFTER THE GREAT RECESSION

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State tax revenues continue, since the Great Recession, to experience elevated volatility relative to previous decades. The elevated tax revenue volatility is due to both economic uncertainty and the riskiness of the tax portfolios state governments are holding. Since the Great Recession, 18 states have increased the riskiness of their tax portfolio. However, many of these states were constrained to accept additional volatility in exchange for additional tax revenues. The mean-volatility constraint state governments face depends on numerous tax system characteristics. For example, states that tax groceries under the sales tax base and have less progressive income taxes are able to increase revenues and accept less volatility than states that exempt groceries from their sales tax base and have a progressive income tax.

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JEL Classification: H21, H7, R58

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I. INTRODUCTION

One of the striking features of the Great Recession is the volatility that state tax revenues experienced. Specifically, growth rates in tax revenues went from tracking gross domestic product (GDP) growth in the 1980s and 1990s to experiencing aggregate drops of 20 percent in the Great Recession that GDP did not experience. The large drops in tax revenues during the Great Recession caused many states to make substantial cuts to expenditures including K–12 education, which is a large state expenditure that is not procyclical in nature. This paper extends a growing literature on tax revenue volatility by examining how tax revenue volatility has changed since the Great Recession and how different tax system characteristics affect state governments' mean-volatility tradeoff.

A simple examination of tax revenues since the Great Recession demonstrates that tax revenues continue to experience elevated volatility relative to previous decades. Tax revenue volatility is a function of both economic uncertainty and the tax portfolio a state government holds. A state's tax portfolio consists of each of the tax bases a state relies on, which can be thought of as an asset in its tax portfolio. A state can change the mean and volatility of its tax revenues by changing its tax rates, similar to portfolio weights. This paper focuses on the part of the observed volatility due to changes in the riskiness of the tax portfolios states hold.[1]

Since the Great Recession, 18 states have increased the riskiness of their tax portfolio. Some of these states are constrained to accept more volatility in exchange for higher tax revenues, similar to a traditional risk-return tradeoff in finance. This constraint is formalized by a state's minimum volatility frontier, which defines the minimum variance possible for a given level of expected tax revenues. Some states accept unnecessary levels of risk by choosing tax

[1] Modeling tax revenues as returns from a tax portfolio follows a long literature starting with Groves and Kahn (1952). A longer discussion of this literature follows the introduction.

portfolios that are not on their minimum volatility frontier. This paper estimates the level and changes of unnecessary risk each state undertakes using the volatility index created in Seegert (2015).

The minimum volatility frontier defines the mean-volatility tradeoff that state governments face. This tradeoff depends on tax system characteristics such as what is included in a state's sales tax base and how progressive a state's income tax is. To study the impact of different tax system characteristics on a state's minimum volatility frontier, this paper estimates the slope of the minimum volatility frontier for each state for the years 1990–2011. The paper then regresses the slope of the minimum volatility frontier on a series of tax system characteristics including: whether the state exempts groceries, clothing, and soda from their sales tax base, the progressivity of a state's income tax, the capital gains tax rate in the state, and the level of income inequality in the state.

The results suggest that states could loosen their mean-volatility constraint by changing some of their tax system characteristics. Specifically, states that include groceries and clothing in their sales tax base and have less progressive income taxes can accept less volatility for a given increase in revenues. The benefits of loosening the mean-volatility constraint need to be compared with the costs of lower progressivity, possibly higher deadweight loss, and other political economy costs.

This paper builds upon insights from Groves and Kahn (1952). The literature built on this work has focused on the income elasticities and stability of state and local taxes.[2] Fox and Campbell (1984) and Otsuka and Braun (1999) looked at how the stability changed over time and with the business cycle. Dye and McGuire (1991) separate tax revenues into revenues from

[2] This literature has noted that the elasticities change over time (Groves and Kahn, 1952), and with the business cycle (Fox and Campbell, 1984; Otsuka and Braun, 1999).

sales taxes and income taxes to determine which tax base is less volatile. Several papers, including Dye and McGuire (1991), find that differences in tax system characteristics across states can make either the income tax or sales tax more volatile (Sobel and Holcombe, 1996; Bruce, Fox, and Tuttle, 2006). Following this literature, this paper looks at the impact of different tax system characteristics on the mean-volatility tradeoff states experience.

The tax portfolio analysis in this paper builds on insights from Giertz (2006) and Seegert (2015). Giertz (2006) uses an efficient frontier analysis to assess the benefits of the property tax and finds that the property tax base experienced a high growth rate, low standard deviation of growth rates, and the growth rates were negatively correlated with the growth rates of the other tax bases. Together these three characteristics make the property tax a "superior asset," that comprises a significant portion of every portfolio mix on the efficient frontier. The following analysis ignores the property tax, the focus of Giertz (2006), because of data limitations on property tax rates across states, but complements this research by producing tax portfolios to measure the efficiency of state tax policy with respect to tax revenue volatility. Specifically, this paper uses the volatility index created in Seegert (2015) to determine the level of unnecessary risk state governments are undertaking after the Great Recession. This paper extends the work of Seegert (2015) by investigating how the mean-volatility tradeoff depends on different tax system characteristics.

II. DATA

This section describes the data used to estimate the riskiness of state tax portfolios, state-level minimum variance frontiers, and possible tax system variables that affect the mean-volatility tradeoff that state governments face. To estimate the riskiness of state tax portfolios, I collect data on U.S. state government tax revenues, tax rates, and economic conditions for the years 1970–2012. Tax revenues include personal income, sales (both general and selective), and corporate income. State-level revenues are used because the local data is unavailable for 2013, however, the results are robust to using state and local revenues up to 2012. Tax rates are the statutory rates imposed by the state and include the top and bottom income tax rate, the sales tax rate, and the corporate income tax rate. Tax revenue and tax rate data come from the Book of States and are cross-checked with the Tax Foundation and the Advisory Commission on Intergovernmental Relations biannual report *Significant Features in Fiscal Federalism*. State-level economic conditions such as state-level GDP (broken into industries) and personal income come from the U.S. Bureau of Economic Analysis' National Income and Product Accounts.

Figure 1 provides a first visualization of this data, depicting the log of deviations of aggregate U.S. state tax revenue and GDP from a flexible time trend, including a lag. The variability of GDP and tax revenue is similar from 1970 to 1995. After 1995, tax revenue became more variable relative to GDP and this elevated variability continues throughout the sample, ending in 2013. The empirical analysis defines the volatility of a variable x_t as,

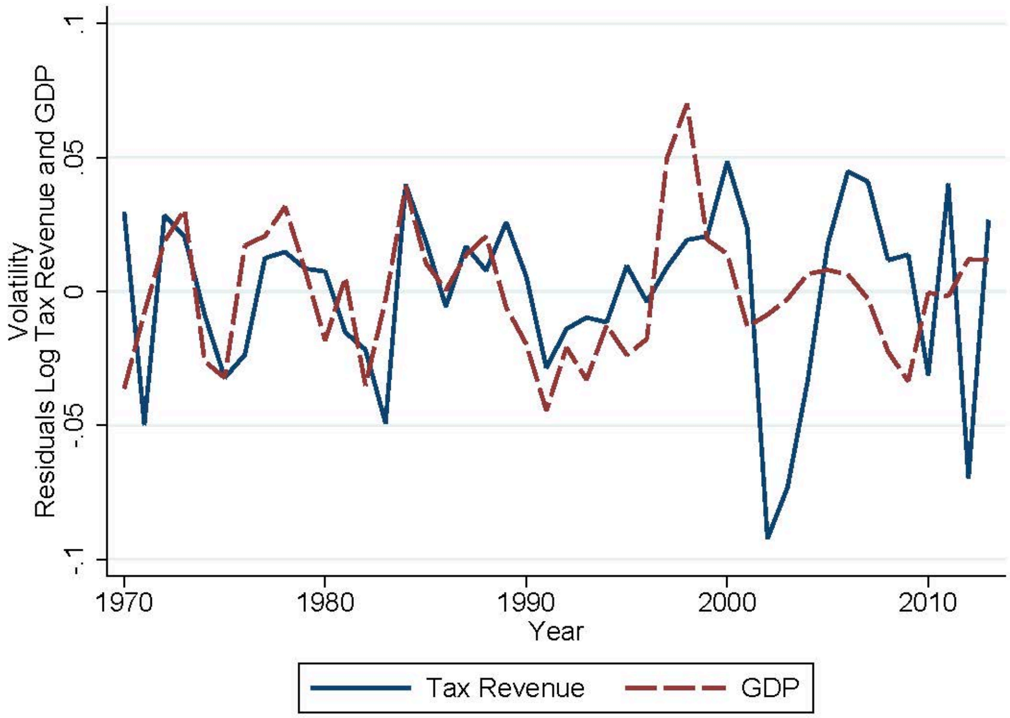
$$Volatility = \log(|x_t - \overline{x}_t|)$$

where $\overline{x}_t$ is a flexible time trend including a lag to account for autocorrelation. Volatility captures a measure similar to the standard deviation of year-over-year variability, abstracting from differences in time trends across states.[3]

[3] For example, tax revenue has an increasing trend over time. The variance of tax revenue, therefore, captures both the year-over-year variability and how much tax revenues have increased over time. To abstract from the general time trend, previous studies have used a similar detrending method (Seegert, 2012) or have used the variance over four years surrounding a given year (Poterba, 1994).

Figure 1

Deviations in Log Tax Revenues and Log GDP



I collect data on the sales tax base, income tax base, treatment of capital gains, income inequality, and a series of state-level variables to test which tax system characteristics affect a state's mean-volatility tradeoff. For example, sales tax bases differ across the U.S. states depending on what items are included. The following paragraphs describe the tax system characteristics, where the data for these characteristics are collected from, and how the characteristics are predicted to affect a state's mean-volatility tradeoff.

The items most commonly exempt from sales taxation are clothing and groceries, which sometimes includes soda and sometimes does not. Theory predicts that states that exempt goods with low elasticities, such as groceries and clothing, will have to accept more volatility for a given increase in revenues (flatter minimum volatility frontier). In contrast, states that exempt goods with higher elasticities from sales taxation, such as soda, will be able to collect more revenue for a given level of volatility (steeper minimum volatility frontier). Data on whether a state exempts groceries, soda, and clothing are collected from the Advisory Commission on Intergovernmental Relations biannual report *Significant Features in Fiscal Federalism* and the Tax Foundation[4]

States can make their income taxes more or less progressive by adjusting the marginal tax rates, number of brackets, and standard deduction. Theory predicts that states with a more progressive income tax will have to accept more volatility for a given increase in revenues (flatter minimum volatility frontier). This paper uses the Theil index as the baseline measure of the progressivity of a state's income tax.[5] The Theil index takes the weighted sum of the log of the ratio of after-tax to before-tax shares of income for each income group. The Theil index is calculated using simulations from NBER's Taxsim program for incomes $5,000, $10,000, $20,000, $25,000, $30,000, $35,000, $40,000, $50,000, $100,000, and $200,000. Appendix A discusses other measures of progressivity and demonstrates the results are robust to these other measures. The baseline estimates use an indicator variable equal to one if the income tax progressivity in the state-year observation is above the median. The indicator variable is used for ease of comparison with the sales tax measures that are also indicator variables. The indicator variable also alleviates some concerns over the use of a specific measure of progressivity. The results are robust to using the continuous variable instead of the indicator variable.

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[4] Tax Foundation's "State Corporate Income Tax Rates 2000-2014," "State Sales, Gasoline, Cigarette, and Alchohol Tax Rates by State, 2000-2014," and "State Individual Tax Rates, 2000-2014."

[5] The Theil index of progressivity was introduced by Theil (1988) and builds upon the Theil index of income inequality introduced in Theil (1967).

Capital gains are treated differently across the U.S. states. Nine states do not have an income tax and do not tax long-term capital gains (Alaska, Florida, Nevada, New Hampshire, South Dakota, Tennessee, Texas, Washington, Wyoming). The remaining 41 states do tax capital gains but some, like Arkansas, Montana, South Carolina, and Wisconsin, have lower tax rates on long-term capital gains than on other income.[6] Theory predicts that states that have higher capital gains tax rates will have to accept more volatility for a given increase in revenues (flatter minimum volatility frontier). The capital gains tax rate for each state in each year is calculated using NBER's Taxsim program with a long-term capital gain realization of $50,000.[7]

The tax revenue volatility a state experiences may depend on the underlying income inequality that exists in the state. Theory predicts that states with higher income inequality will have to accept more volatility for a given increase in revenues (flatter minimum volatility frontier). This paper uses the Theil index as the baseline measure of income inequality within a state. The index is collected from Frank (2009) who calculates the index using individual tax filing data available from the Internal Revenue Service. The Theil index is the maximum possible entropy of the data minus the observed entropy, used in information theory as a measure of redundancy. The results are robust to using other measures of income inequality such as a Gini coefficient, or the income shares of the top 10 percent and 1 percent, which Frank (2009) also calculates.

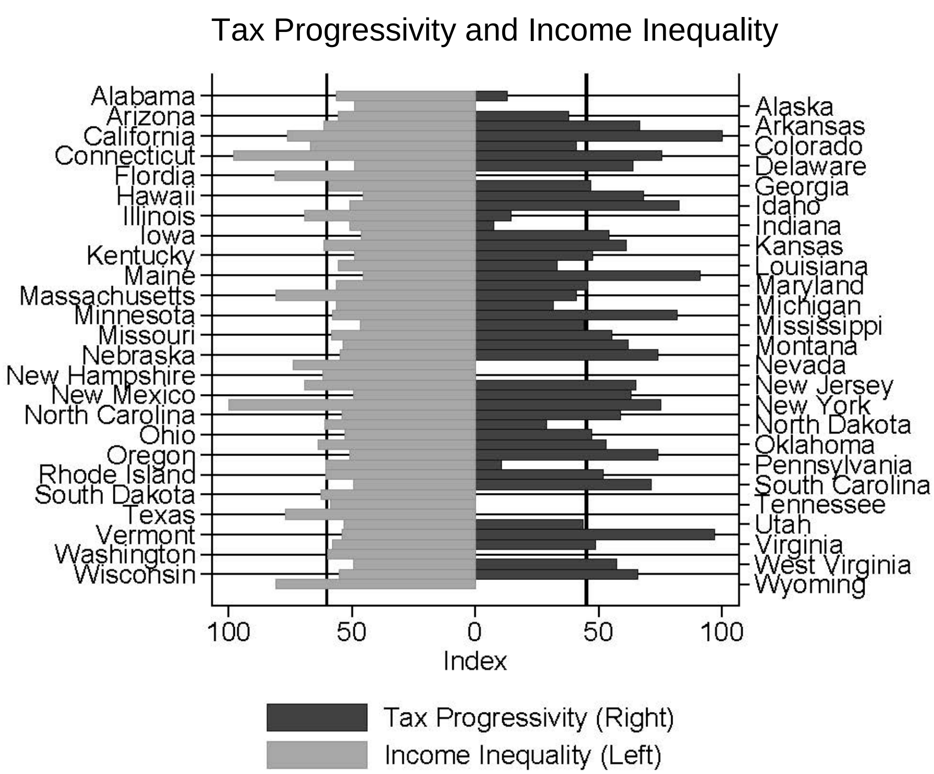
To control for other variation across states a series of state-level variables are collected. These include land area, fertility, personal income, population, and GDP broken into industries. Population, GDP, and personal income are collected from the U.S. Bureau of Economic

[6] Tennessee and New Hampshire do not tax capital gains but do tax interest and dividends.
[7] The results are robust to using other values of capital gain realization.

Analysis. Fertility is collected from the Centers for Disease Control and Prevention's National Vital Statistics System, and land area is collected from the U.S. Census Bureau.

Figure 2 graphs the Theil index of tax progressivity and income inequality for each state in the year 2011. The vertical black lines indicate the mean index level. California has the most progressive income tax followed by Vermont and Maine. Indiana, Pennsylvania, and Alabama have the least progressive income taxes. The highest levels of income inequality exist in New York, Connecticut, and Florida while the lowest levels of income inequality exist in Maine, Hawaii, and Iowa.

Figure 2



III.

III. EMPIRICAL SPECIFICATION

This section describes the two-stage procedure used to estimate the mean and volatility of different tax portfolios, holding fixed economic uncertainty. Mean and volatility of different tax portfolios are used to estimate a minimum volatility frontier for each state that can be used to estimate: (1) a volatility index and; (2) the relationship between tax system characteristics and the tradeoff between volatility and expected revenues a state experiences. The contribution from these estimates is twofold. The first contribution is to update our knowledge of state tax revenue volatility since the Great Recession and determine whether tax policy changes have caused states to accept more or less unnecessary risk, holding constant the economic uncertainty. The second contribution is to determine how different tax system characteristics, such as exempting groceries from the sales tax, affect the tradeoff between volatility and expected revenues.

The first stage estimates the relationships between tax rates and the mean and volatility of tax revenues controlling for economic conditions. The second stage uses the first stage estimates to simulate, for a given set of tax rates, the volatility and mean revenue collection a state would have experienced over the last forty years, given the actual economic conditions the state experienced. The second stage estimates are used to estimate a minimum volatility frontier and a volatility index for each state.

A. Stage 1 Mean and Volatility Functions

The goal of the first stage is to estimate state-specific relationships between tax portfolios, given by the tax rates, and the mean and volatility of tax revenues. This is done in two steps. The first step estimates the inverse probability weights used in the weighted least squares estimation in step two. Briefly, the weights determine the probability that an observation in year t and state k could have been observed in the focal state i using predicted values from a logit model. The logit model's dependent variable is a state dummy, equal to one for the focal state, and is related to the share of GDP in each industry.[8] The weighted least squares estimates give more weight to state-year observations that look similar, in terms of the economy, to the focal state. For example, Minnesota has a large weight when Wisconsin is the focal state and a small weight when Connecticut is the focal state.

The second step of the first stage estimates the relationships between tax rates and the mean and volatility of tax revenues using weighted least squares. These relationships are estimated for each tax base *j* (sales, income, and corporate) in each state *i* using data from years *t* ranging from 1963–2012. The relationships are estimated with the log of tax revenue and tax revenue volatility as the dependent variables and the tax rates $T_{i,t}$, various economic variables $X_{i,t}$, and the interaction of the set of tax rates and economic variables as the independent variables,

$$\log(TR_{j,i,t}) = \beta_0 + T_{i,t}\,\beta_T + X_{i,t}\beta_x + T_{i,t}X_{i,t}\,\beta_I + u_{j,i,t}$$

$$V_{j,i,t} = \delta_0 + T_{i,t}\,\delta_T + X_{i,t}\delta_x + T_{i,t}X_{i,t}\,\delta_I + v_{j,i,t}$$

where the error terms are given by $u_{j,i,t}$ and $v_{j,i,t}$. The set of tax rates includes the top and bottom income tax rate, the sales tax rate, and the corporate income tax rate and each of these tax rates squared. The economic variables include state GDP, personal income, and population.[9] The results are robust to using only data from the focal state, which can be thought of as setting the weights equal to one if the observation is from the focal state and zero otherwise.

B. Stage 2 Simulations

Stage 2 estimates each state's minimum volatility frontier using a two-step process. First, nearly 200,000 tax portfolios, characterized by their mean and volatility, are simulated using the

[8] The results are robust to using additional variables in the logit model including tax rates, personal income, population, and land area.
[9] The results are robust to excluding population and using per capita tax revenue and GDP. Controlling for population allows a more flexible model than using per capita variables.

estimates from stage 1 and the actual economic conditions the state experienced from 1963–2013.[10] Each tax portfolio consists of a sales, corporate, and top and bottom income tax rate. In the simulation, each of these tax rates takes on 21 different values between zero and the larger of either four or 115 percent of the largest tax rate the specific state has levied. Each value of a given tax rate is then paired with every value of each of the other three tax rates, creating nearly 200,000 different simulated tax portfolios, for each state.

Second, the minimum volatility frontier is estimated as the upper convex hull of the simulated points in volatility and mean revenue space. This process is repeated to produce state-specific minimum volatility frontiers. A similar process is used to estimate the mean and volatility of the tax portfolios states held between 1963–2013, characterized by the actual tax rates they levied.

C. Volatility Index

The simulation's estimates are used to calculate three measures that summarize the mean-volatility tradeoff governments face. Figure 3 depicts these measures on a graph with a minimum volatility frontier and four possible portfolios in volatility-mean space. First, the riskiness of a tax portfolio can be summarized by its volatility given by the horizontal axis. In terms of volatility, portfolios *C* and *D* are riskier than portfolio *A* because they are further to the right. Second, the riskiness of a tax portfolio can be summarized by the volatility of a tax portfolio relative to its mean, formally the coefficient of variation. In terms of the coefficient of volatility portfolio *D* remains riskier than *A*, but *C* is now less risky because the ratio of portfolio *C*'s volatility to its mean is smaller than the same ratio for portfolio *A.* Finally, the volatility index developed in Seegert (2015) is calculated to measure the unnecessary risk associated with a tax

[10] The analysis is partial equilibrium in nature because it abstracts from any general equilibrium effects of different tax rates on the economic conditions.

portfolio. In Figure 3 the volatility index for portfolio *A* is given by the percent change in mean tax revenues between portfolios *A* and *B*.

Formally, the volatility index is given by the percent difference in the coefficient of variation between a portfolio *A*, with mean μ_A and volatility σ_A, and a portfolio on the minimum volatility frontier with the same level of volatility,

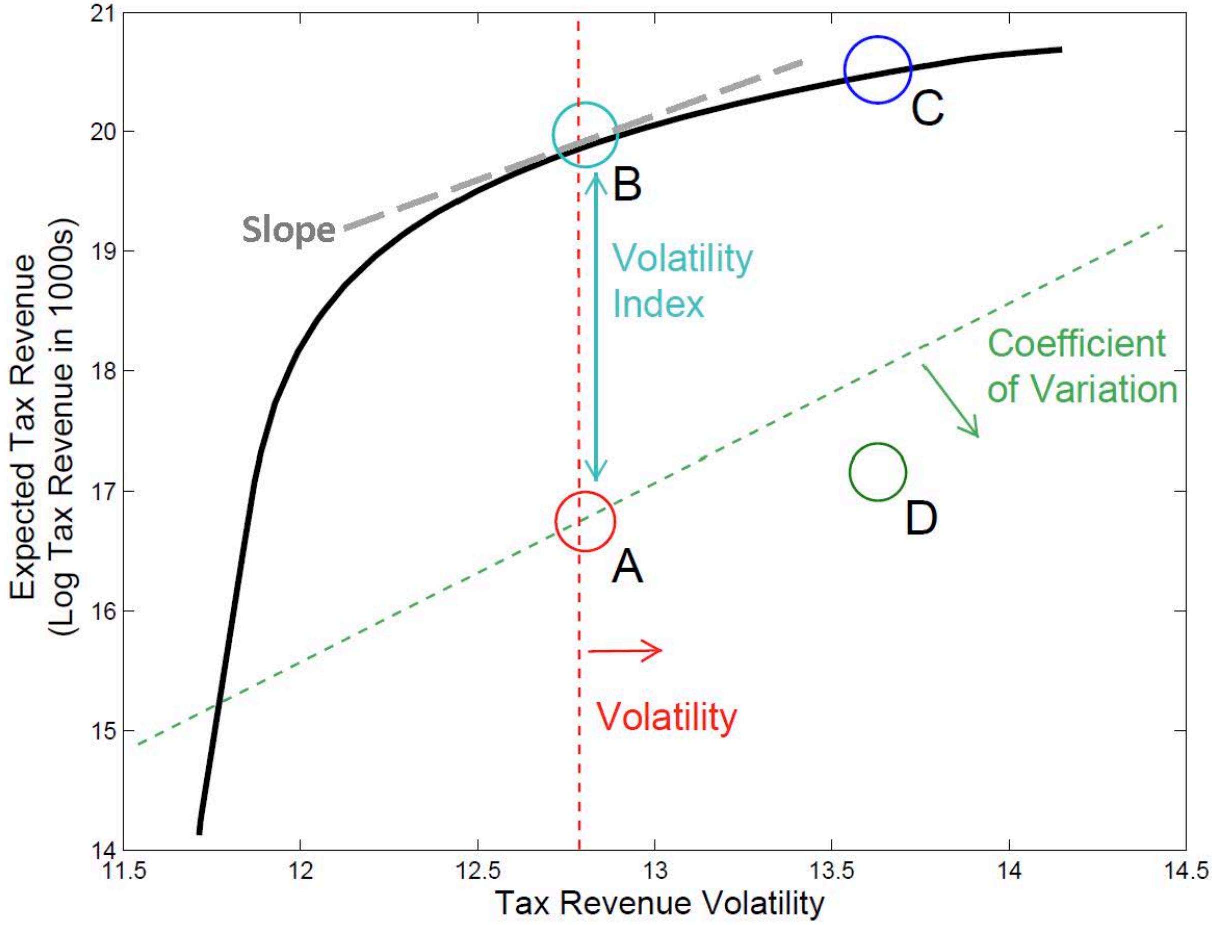
$$\frac{Volatility\ Index}{100} = \frac{\frac{\sigma_A}{\mu_A} - \frac{\sigma_{MV}}{\mu_{MV}}}{\frac{\sigma_A}{\mu_A}} = 1 - \frac{\sigma\mu_A}{\mu_{MV}}$$

where μ_{MV} is the expected tax revenue on the minimum-variance frontier for the level of volatility σ_{MV} = σ_A.

The volatility index is bounded between zero and 100. A portfolio with a volatility index of zero indicates that the portfolio is on the minimum volatility frontier, which can be seen by reducing the volatility index to one minus the ratio of the mean of the focal portfolio and the mean of the portfolio on the minimum volatility frontier. The volatility index can be interpreted as the cost of unnecessary risk measured as the percent of tax revenues lost by being off of the minimum volatility frontier.

Figure 3

Minimum Volatility Frontier and Volatility Index



D. Determinants of the Tradeoff Between Volatility and Mean Revenue

This section considers the different conditions that may force a state to accept more volatility. Formally, we test the explanatory power of characteristics such as whether a state taxes groceries or not on the slope of a state's minimum volatility frontier. This section extends previous work that estimates minimum volatility frontiers as "black boxes" to help understand what causes the heterogeneity across states, building on insights from previous work on tax base variability.[11] The slope of the minimum volatility frontier at the volatility level of a given portfolio provides the constraint a state faces in terms of the tradeoff between volatility and expected revenues. A smaller (flatter) slope indicates that a state has to accept more volatility for a given increase in revenues. The slope differs across states for various reasons, including differences in sales and income tax bases.

The minimum volatility frontier is characterized by the function $M_{i,t} = g_{0,i} + g_{1,i}V_{i,t} + \left(\frac{1}{2}\right) g_{1,i}V_{i,t}^2$. The relevant slope of the minimum volatility frontier varies with time (and state) depending on the specific tax portfolio a state holds. The slope at time *t* is determined in two steps. First, the volatility $V_{i,t}$ of the tax portfolio state *i* is holding at time *t* is determined. Second, the slope of the minimum volatility frontier at $V_{i,t}$ is determined by substituting the variance into the derivative of the function that characterizes the minimum volatility frontier $S_{i,t} = g_{1,i} + g_{2,i}V_{i,t}$. For example, Figure 3 depicts the slope associated with portfolio *A*. The slope is calculated for every state for the years 1990– 2011.

The relationship between the slope of the minimum volatility frontier and different tax system characteristics is estimated by,

$$S_{i,t} = \gamma_0 + \gamma_1 d_{i,t}^{Groceries} + \gamma_2 d_{i,t}^{Clothing} + \gamma_3 d_{i,t}^{Soda} + \gamma_4 d_{i,t}^{Progressive} + \gamma_5 CG_{i,t} + \gamma_6 IN_{i,t} + w_{i,t}$$

where $w_{i,t}$ is the error term. The sales tax characteristics $d_{i,t}^{Groceries}$, $d_{i,t}^{Clothing}$, $d_{i,t}^{Soda}$ are indicator variables equal to one if the state at time *t* exempts groceries, clothing, and soda from their sales tax base. The income tax characteristic $d_{i,t}^{Progressive}$ is an indicator variable equal to one if the state-year observation has a Theil index of income tax progressivity above the median in the sample. Finally, the capital gains tax rate $CG_{i,t}$ and the Theil index of income inequality

[11] Dye and McGuire (1991) and Fox and Campbell (1984) investigate how different characteristics affect tax revenue volatility.

$IN_{i,t}$ are included as additional characteristics. As a summary of the previous discussion, the theory predicts that all coefficients will be negative except for the soda exemption.

IV. RESULTS

A. Volatility Index

Figure 4 reports the volatility index for each state in 2013 and the percent change in the coefficient of variation between 2007 and 2013. On average, states increased the riskiness in their tax portfolio by one percent, depicted by the solid vertical line (on the left) in Figure 4. Between 2007 and 2013, Maine, Utah, and Rhode Island, increased the riskiness of their tax portfolio the most and Delaware, Ohio, and Kentucky decreased the riskiness of their tax portfolio the most.

The average volatility index is three, meaning that the cost of unnecessary risk in state tax portfolios is 3 percent of current tax revenues. States with a volatility index less than one, such as Georgia, Virginia, and Connecticut, are not taking on much unnecessary risk. In contrast, Michigan and Alaska have volatility indexes greater than 10, indicating a large amount of unnecessary risk. The correlation between the volatility index and the change in the coefficient of variation is slightly negatively correlated. The negative correlation suggests that the states that have increased the riskiness of their tax portfolios are not necessarily the states that are undertaking unnecessary risk.

Figure 4

Volatility Index and Coefficient of Variation

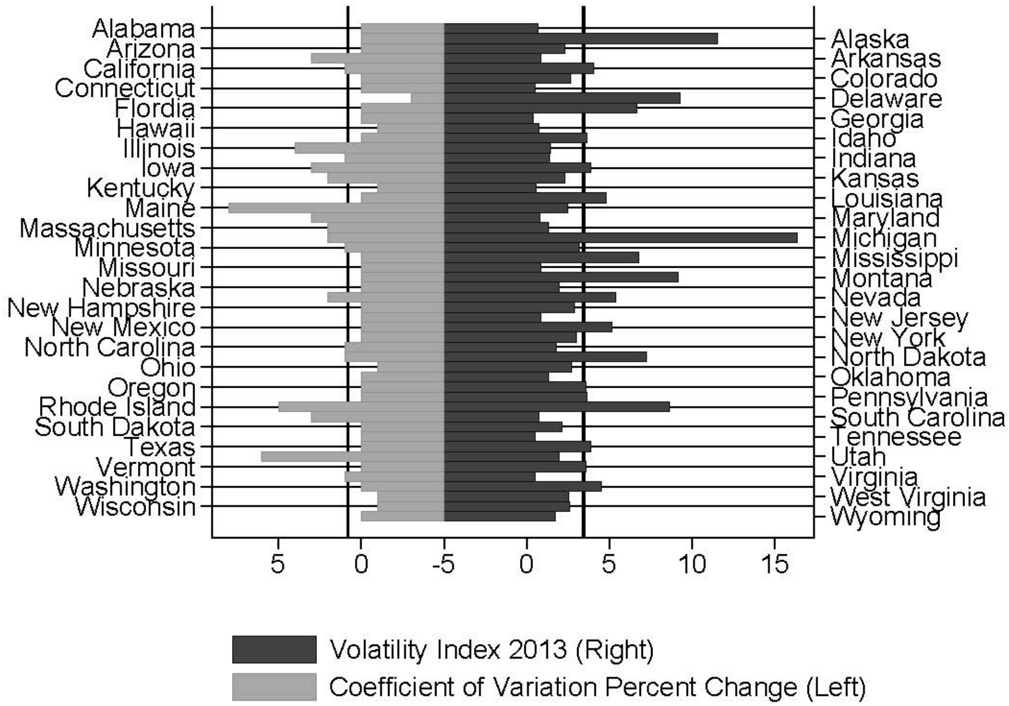


Figure 5 reports how states changed the riskiness of their tax portfolios between 2007 and 2013. States that chose riskier tax portfolios are shaded dark gray, states that chose safer tax portfolios are shaded light gray, and states that made little or no change are shaded white. Since the Great Recession, 18 of the 23 states that have changed their tax portfolio increased the riskiness of their portfolio, measured in terms of the coefficient of variation.

Figure 5

Changes in Volatility 2007 to 2013 Measured as the Coefficient of Variation

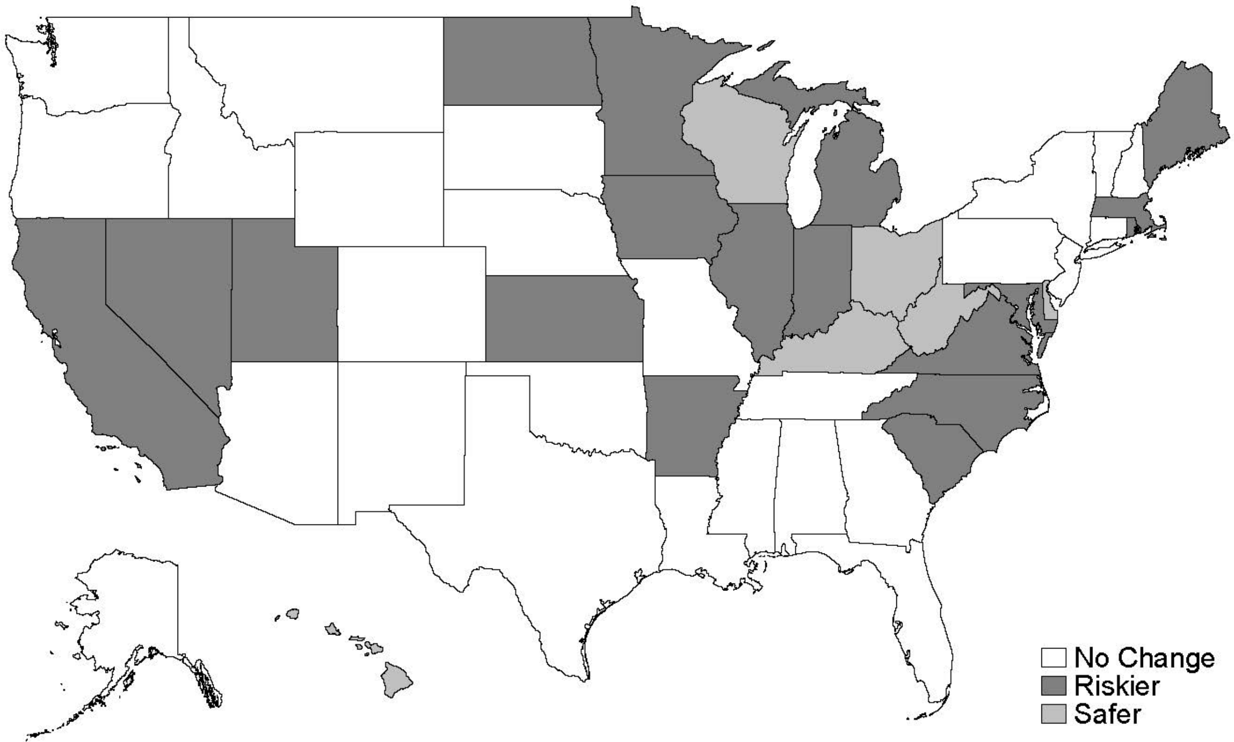


Figure 6 reports how states changed the level of unnecessary risk associated with their tax portfolios between 2007 and 2013. States that increased their volatility index undertook more unnecessary risk in 2013 and are shaded dark gray. States that decreased their volatility index decreased their unnecessary risk and are shaded light gray and states that had little or no change are shaded white. Thirty-two states changed the level of unnecessary risk of their tax portfolios. Of these, 15 states increased the level of unnecessary risk, and 17 states decreased the level of unnecessary risk.

Figure 6

Changes in Volatility Index 2007 to 2013

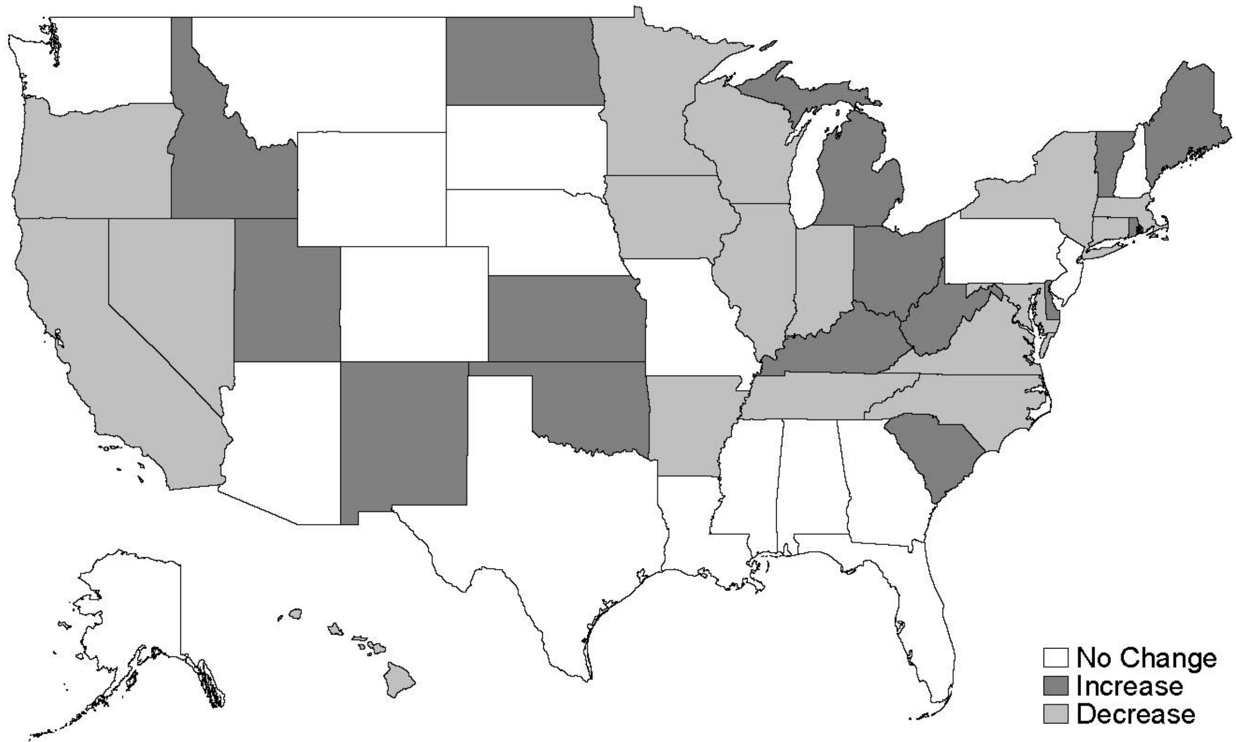


Figure 5 demonstrates that state governments have continued to increase the level of riskiness of their tax portfolios. However, Figure 6 shows that some of the increase in riskiness is due to the fact that states are forced to accept more risk as they demand higher revenues. If in the future states demand higher tax revenues, then these findings suggest that states will have to accept more volatility. This mean-volatility tradeoff in tax revenue leads to two types of policy recommendations. First, as states are constrained to increase the riskiness of their portfolio, it will become more important to decrease the unnecessary risk associated with their portfolios. Second, states should consider policies that dampen the impact of tax revenue volatility. For example, reconsidering balanced budget rules and saving more in rainy day funds. In addition, states may want to consider changing the characteristics of their tax bases to make them less volatile. The following section reports how different tax system characteristics affect states' mean-volatility tradeoff.

B. Tradeoff Between Volatility and Mean Revenue

Table 1 reports how the slope of the minimum volatility frontier changes with tax system characteristics. A negative coefficient implies that the slope of the minimum volatility frontier is flatter for states with those characteristics, causing them to be constrained to accept more volatility for a given increase in mean tax revenues. Column 1 gives the coefficients for the sales tax base characteristics of whether the state-year observation exempts groceries, clothing, and soda. All of the sales tax base characteristics have the predicted sign, are statistically significant at the 1 percent level, and are robust to all specifications in Table 1

Column 2 of Table 1 reports the sales tax base characteristics and whether the income tax in the state-year is progressive, measured by the Theil index.[12] The coefficient on the income tax progressivity dummy has the predicted sign, is statistically significant at the 1 percent level, and robust to all specifications in Table 1. The magnitude of the coefficient on the income tax progressivity dummy suggests it has a larger effect on the mean-volatility tradeoff than exempting clothing from the sales tax but a smaller effect than exempting groceries.

Column 3 of Table 1 reports the sales and income tax base characteristics with state controls for land area and fertility. The results are robust to including these state controls and other state controls such as GDP, personal income, and population, which are reported in Appendix A. Columns 4 and 5 report the coefficients on the capital gains tax rate and income inequality. The coefficient on the capital gains tax rate does not have the predicted sign and is

[12] The results are robust to using alternative measures of income tax progressivity. For more details see Appendix A.

not statistically significant at the 10 percent level. The coefficient of income inequality does have the predicted sign and is statistically significant at the 5 percent level.

Taken together, the results in Table 1 suggest that states can loosen their mean-volatility constraint by changing the characteristics of their tax bases. Specifically, including groceries and clothing in the sales tax base and decreasing the progressivity of the income tax base can loosen the mean-volatility constraint. However, there are other tradeoffs involved with making these tax base changes, such as decreasing the progressivity of the state's tax system.

TABLE 1

Volatility and Expected Tax Revenue Tradeoff

	1	2	3	4	5
Groceries Exempt	9.913***	10.170***	9.903***	9.899***	9.085***
	(1.79)	(1.83)	(1.79)	(1.79)	(1.60)
Clothing Exempt	4.537***	2.857***	2.328***	2.222***	2.309***
	(0.27)	(0.61)	(0.72)	(0.75)	(0.75)
Soda Exempt	8.077***	7.670***	7.036***	7.003***	6.887***
	(0.56)	(0.61)	(0.68)	(0.69)	(0.72)
Income Tax Progressivity		6.015***	6.633***	7.026***	7.211***
		(1.45)	(1.56)	(1.65)	(1.70)
Capital Gains Tax Rate				3.054	1.488
				(2.12)	(2.21)
Income Inequality					–8.003**
					(3.37)
State Controls			X	X	X
Adj. R-Square	0.043	0.059	0.07	0.071	0.073
Observations	1,100	1,100	1,100	1,100	1,100

Notes: The dependent variable in this table is the simulated slope of the minimum volatility frontier (Δ expected revenues/Δ volatility) for each state for the years 1990–2011. Columns 3–5 include state control variables fertility and land area. Table A1 demonstrates the results are robust to including additional state control variables including GDP, personal income, population, and GDP broken into industries. This table uses an indicator variable on whether a state's income tax is particularly progressive determined by using NBER's Taxsim program. However, Table A1demonstrates the results are robust to other measures. Income inequality is measured as the Theil index but is robust to using the Gini coefficient instead. Standard errors are reported in parentheses and are robust to heteroskedasticity. Statistical significance at the 1 percent level is denoted by ***, the 5 percent level by **, and the 10 percent by *.

V. CONCLUSION

This paper examines how U.S. state tax revenue volatility has changed since the Great Recession and how different tax system characteristics affect state governments' mean-volatility tradeoff. Since the Great Recession, U.S. state tax revenue volatility has remained elevated compared with previous decades. A contributing factor to the elevated volatility is the increase in riskiness of state tax portfolios. Specifically, from 2007 to 2013, 18 states increased the riskiness of their tax portfolio and only five decreased the riskiness of their tax portfolio.

Many states that have increased the riskiness of their tax portfolio have done so in exchange for more tax revenues. States are constrained to choose tax portfolios that are below their minimum volatility frontiers, which define the minimum volatility a state can accept for a given amount of tax revenues. To determine whether states are increasing their tax portfolio riskiness because of this constraint or because they are accepting unnecessary risk, this paper estimates the volatility index, developed in Seegert (2015). The volatility index characterizes the costs to governments from accepting unnecessary levels of risk from choosing tax portfolios not on their minimum volatility frontier. This paper finds that roughly half of the states that have changed their tax portfolio since the Great Recession have decreased their level of unnecessary risk.

The minimum volatility frontier a state is constrained by depends on the underlying tax bases in the state and tax system characteristics the state is able to change. This paper finds that the minimum volatility frontier depends on tax system characteristics including whether the state includes groceries, clothing, and soda in their sales tax base and the progressivity of their income tax. This paper also finds supportive evidence that the level of income inequality within a state affects a state's minimum volatility frontier and finds no evidence that the capital gains tax rate affects the minimum volatility frontier. These findings suggest that states could loosen their mean-volatility constraint by taxing groceries and clothing and having a less progressive income tax.

The persistence of the elevated volatility in tax revenues and the negative welfare effects associated with it suggest tax revenue volatility will continue to be an important topic for research. Further research is needed to understand the tradeoffs states face between loosening their mean-volatility constraint by decreasing the progressivity of their income tax and the benefits of redistribution. Further research is also needed to understand how states can hedge risk with different tax bases. Specifically, property taxes could be an important asset for state governments because the property tax base is less correlated with movements in the economy.

Tax revenue volatility is going to continue to be an important topic as state governments balance increasing tax revenues to fund education, roads, and health care with increasing volatility that make it difficult to provide stable funds to these essential programs.

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APPENDIX A: ROBUSTNESS

This appendix reports several additional specifications as robustness to the estimates in Table 1. Table A1 reports seven additional specifications. Columns 1–4 report the estimates from Table 1 with enhanced state controls that include land area, fertility, GDP, personal income, population, and GDP broken into industries. The estimates in these specifications all have the same sign and similar magnitudes of the estimates in Table 1. However, the coefficient estimate on the clothing exemption and income inequality are no longer statistically significant.

The baseline measure of the progressivity of the income tax is the Theil index but the results are robust to other measures including a Gini coefficient, number of income tax brackets, or the ratio of the change in the effective tax rate to the change in income. The number of income tax brackets a state has is collected from the Advisory Commission on Intergovernmental Relations biannual report “Significant Features in Fiscal Federalism” and the Tax Foundation. The Gini coefficient is calculated using simulations from NBER’s Taxsim program for income levels $5,000, $10,000, $20,000, $25,000, $30,000, $35,000, $40,000, $50,000, $100,000, and $200,000.

The ratio of the change in marginal tax to the change in income provides an intuitive measure of income tax progressivity based on effective tax rates. To calculate this measure, the effective tax rate for income levels $5,000, $10,000, $20,000, $25,000, $30,000, $35,000, $40,000, $50,000, $100,000, and $200,000 are simulated for each state using NBER’s Taxsim program. Then the ratio of the change in the effective tax rate to the change in income is calculated by regressing the marginal tax rate on the set of income levels used in the simulation.

A steeper slope represents a tax schedule that has its effective tax rates increase faster as income increases than a tax schedule with a flatter slope. For example, a flat tax with the same marginal tax rate for all income levels has a slope of zero, and is not progressive.

Columns 5–7 of Table A1 report specifications using the ratio of the change in the effective tax rate to the change in income. The estimates in these specifications have the same sign and similar magnitudes as the estimates in Table 1. The only difference is that the coefficient of whether clothing is exempt is no longer statistically significant. The results are also robust to using the number of income tax brackets a state has or a Gini coefficient as measures of progressivity. The estimates are also robust to using a continuous measure of income tax progressivity instead of using a dummy variable that separates states-year observations above and below the median income tax progressivity level.

Table A1

Volatility and Expected Tax Revenue Tradeoff: Additional Specifications

	Additional State Controls				Alternative Progressivity		
	1	2	3	4	5	6	7
Groceries Exempt	8.317***	8.645***	8.552***	8.276***	9.013***	8.983***	7.856***
	(1.89)	(1.87)	(1.87)	(1.88)	(1.62)	(1.62)	(1.69)
Clothing Exempt	–2.556	–0.192	–0.275	–0.633	–2.741	–2.707	–2.772
	(2.84)	(2.84)	(2.84)	(2.85)	(2.64)	(2.64)	(2.63)
Soda Exempt	6.563***	6.190***	6.101***	6.396***	6.754***	6.732***	6.533***
	(2.01)	(1.98)	(1.99)	(2.00)	(1.83)	(1.83)	(1.83)
Income Tax Progressivity		8.074***	8.385***	8.649***			
		(1.51)	(1.53)	(1.55)			
Capital Gains Tax Rate			3.098	1.881		2.094	0.076
			(2.82)	(2.97)		(2.23)	(2.39)
Income Inequality				–7.956			10.490**
				(6.18)			(4.46)
Alt. Income Tax Progressivity					6.737***	6.898***	7.481***
					–1.393	–1.404	–1.422
State Controls	X	X	X	X	X	X	X
Enhanced State Controls	X	X	X	X			
Adj. R-Square	0.051	0.075	0.075	0.076	0.07	0.07	0.074
Observations	1,099	1,099	1,099	1,099	1,100	1,100	1,100

Notes: The dependent variable in this table is the simulated slope of the minimum volatility frontier for each state for the years 1990–2011. Enhanced state controls include area, fertility, GDP, personal income, population, and GDP broken into industries. The alternative measure of progressivity is the slope of the linear fit line of the simulated marginal tax rates for income levels between $5,000 and $200,000. Standard errors are reported in parenthesis and are robust to heteroskedasticity. Statistical significance at the 1 percent level is denoted by ***, the 5 percent level by **, and the 10 percent by *.