Joint Discussion Paper
Series in Economics

by the Universities of

Aachen · Gießen · Göttingen
Kassel · Marburg · Siegen

ISSN 1867-3678

No. 42-2011

Bernd Hayo and Matthias Uhl

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Coordination: Bernd Hayo • Philipps-University Marburg
Faculty of Business Administration and Economics • Universitätsstraße 24, D-35032 Marburg
Tel: +49-6421-2823091, Fax: +49-6421-2823088, e-mail: hayo@wiwi.uni-marburg.de

Regional Effects of Federal Tax Shocks*

Bernd Hayo and Matthias Uhl

March 28, 2012

Philipps-University Marburg

Corresponding author:

Bernd Hayo
Faculty of Business Administration and Economics
Philipps-University Marburg
D-35032 Marburg
Germany
Phone: +49-6421-2823091
Email: hayo@wiwi.uni-marburg.de

* We thank Kerstin MaritFriebel, Florian Neumeier, Matthias Neuenkirch, and Britta Niehof for their helpful comments. All remaining shortcomings are ours.

Regional Effects of Federal Tax Shocks

Abstract This paper studies regional output asymmetries following U.S. federal tax shocks. We estimate a vector autoregressive model for each U.S. state, utilizing the exogenous tax shock series recently proposed by Romer and Romer (2010) and find considerable variations: estimated output multipliers lie between –0.2 in Utah and –3.3 in Hawaii. Statistically, the difference between state and national output effect is significant in about half the U.S. states. Analyzing the determinants of differences in the magnitude of regional tax multipliers suggests that industry composition of output and sociodemographic characteristics help explain the observed asymmetry across U.S. states in the transmission of federal tax policy.

Keywords Fiscal Policy · Tax Policy · Narrative Approach · U.S. States · Regional Effects · Asymmetries in Fiscal Policy Transmission

JEL Classification E32 · E62 · H20 · R10 · R11

1 Introduction

Policymakers frequently attempt to influence economic activity by means of fiscal policy instruments. Accordingly, the macroeconomic effects of such policies are studied intensively. Important contributions by Ramey and Shapiro (1998), Fatás and Mihov (2001), Blanchard and Perotti (2002), Mountford and Uhlig (2009), and Romer and Romer (2010, R&R henceforth) conclude that increases in government spending or decreases in taxes promote short-term economic activity.[1] These econometric studies on the effectiveness of fiscal policy overwhelmingly focus on aggregate, nationwide effects. Commonly, empirical models include expenditure and tax indicators of federal or general government and investigate the consequences of shocks in these series for national output. But if economic effects differ across regions, then national averages give only an incomplete picture of the consequences of federal fiscal policy action. Knowledge about the income multiplier at the regional level is important for at least three reasons. First, it is relevant to U.S. citizens, as their employment and income situation might be affected quite differently depending on their place of residence. Second, state policymakers and administrative staff are interested in improving their forecasts about the output effect of federal tax shocks on their home region and, perhaps, implementing offsetting policies. Third, a better understanding of the regional effects of U.S. federal fiscal policy shocks will enable policy coordination between the federal and state levels, thereby potentially generating welfare gains.

In this paper, we focus on legislated federal tax changes as an exogenous fiscal policy instrument and contribute to the analysis of the fiscal policy transmission mechanism in two ways. In a first step, we apply the exogenous tax shock series recently proposed by R&R (2010) to infer the consequences of federal tax shocks at the U.S. state level. To date, the literature only hints at asymmetries in the fiscal policy transmission mechanism across states. To the best of our knowledge, our study is the first systematic analysis of state-level output effects of U.S. federal tax policy. In addition, we test whether estimated regional asymmetries are statistically significant.

Our results indicate that output effects of federal tax shocks are asymmetric across many U.S. states, although there is a group of states for which output changes are statistically

[1] Methodological differences have a noteworthy influence on the estimated size of fiscal multipliers and the effects on other important macroeconomic variables, such as wages and consumption. See Fontana (2009), Ramey (2011b), and Hebous (2011) for recent surveys of the literature on fiscal policy effects.

equal to the national average. Following a tax increase of 1 percentage point of personal income, the peak reduction in state personal income over a period of 20 quarters varies between 0.2 percent in Utah and 3.3 percent in Hawaii, while the national peak output reduction is 1.4 percent. In 26 out of 51 states, there is evidence that the state output multiplier deviates statistically significantly from the national average.[2]

In a second step, we explore the influence of potentially important determinants of such regional asymmetries across U.S. states by utilizing our set of estimated state output effects. Specifically, we regress peak state-level output effects on four groups of explanatory variables, controlling for regional effects, output composition, economic variables, and demographic factors. Our analysis suggests that only states' industry composition of output and sociodemographic characteristics affect the size of the state income multiplier.

The paper is organized as follows. Section 2 outlines the background of this study and Section 3 briefly discusses methodology and data. Section 4 presents the benchmark results and discusses possible extensions to our preferred specification. In Section 5, determinants of the estimated state income effects of federal tax policy shocks are explored. Section 6 concludes.

2 Background

Vector autoregressions (VARs), pioneered by Sims (1980), are now a standard way of drawing inferences about the macroeconomic effects of fiscal policy. Policy analysis in VAR models requires the identification of exogenous policy shocks (innovations). Fatás and Mihov (2001) and Blanchard and Perotti (2002) achieve this identification by making direct assumptions about the relationship between reduced-form and structural innovations, whereas Mountford and Uhlig (2009) apply sign restrictions. A methodological alternative is the so-called narrative approach, which bases identification on information from outside the VAR model. Ramey and Shapiro (1998), Eichenbaum and Fisher (2005), and Ramey (2011a) study the macroeconomic consequences of exogenous military buildups. In a particularly influential study, R&R (2010) identify size, timing, and motivation of legislated tax shocks by using information from official sources, such as presidential speeches and congressional

[2] For practical purposes, we do not differentiate between states and the District of Colombia.

reports. Classifying as "exogenous" only those tax policies undertaken to raise long-term growth or in reaction to inherited budget deficits, the authors arrive at a tax shock series that is independent of current macroeconomic disturbances and hence allows consistent estimation of tax policy effects. Basing identification on the narrative approach has the advantage that no *a priori* assumptions, which are typically untestable, have to be made about either the covariance structure of the residuals or the direction of the effects of the shocks. This advantage is of special relevance in our framework, as the addition of a regional dimension would tremendously complicate identification, requiring many "incredible restrictions" (Sims, 1980). In our empirical investigation of state-level effects of U.S. federal tax shocks, we follow the narrative approach; specifically, we include the R&R (2010) tax shock series in VAR models estimated at the state level.[3]

Economic theory has not reached consensus as to the transmission channels of fiscal policy shocks, particularly at the state level. Nevertheless, general economic reasoning suggests several potential reasons for regional asymmetry in federal fiscal policy effects. First, the output composition of state personal income could matter. Industries differ in terms of labor and capital intensity of the production process and, given the unequal geographic distribution of industries, so do states.[4] As some industries might react more strongly to economic shocks than others, either because their business is more cyclically sensitive or because consumer spending on their products is more sensitive to changes in disposable income, this can help explain variation in regional reaction to federal fiscal shocks. Federal fiscal policy might also affect interest rates (e.g., Aisen and Hauner, 2008; Caselli et al., 2007; Dai and Philippon, 2005; Tanzi and Fanizza, 1995) and exchange rates (e.g., Kim and Roubini, 2008; Sachs and Wyplosz, 1984). As different industries are affected asymmetrically by such shocks, this could in turn lead to asymmetric reactions to federal tax shocks.

Moreover, fiscal policy shocks may affect states differently depending on structural parameters of the transmission mechanism, such as the intertemporal elasticity of

[3] The R&R (2010) identification strategy is well established in studying the United States (Favero and Giavazi, forthcoming; Mertens and Ravn, forthcoming; Perotti, 2011), but is also applied to other countries (United Kingdom: Cloyne, 2011; Germany: Hayo and Uhl, 2011).

[4] The R&R series measures tax shocks on the aggregate level. In reality, policymakers control a wide range of potential tax instruments and specific tax measures are likely designed to affect certain sectors of the economy. In general, the composition of tax shocks is likely to be important for their sectoral effects. However, our data are informative only as to the average historic effects of tax policies.

substitution, the marginal propensity to consume, or the elasticity of employment with regard to output shocks. Most taxes are paid by individuals and, therefore, differences in the socioeconomic composition of the population could induce differences in the effects of fiscal policy. For examples, states are characterized by different age structures and different income distributions, which influence the sensitivity of individual income to tax changes. In addition, the policy reaction of state governments toward federal tax shocks might vary across states, leading, in turn, to different real effects. For instance, Taylor and Yücel (1996) argue that states showing stronger reliance on taxes that are not deductible against federal income taxes are affected differently by changes in federal taxes.

The literature on regional effects of national fiscal policy is small. Owyang and Zubairy (2009) study state-level effects of U.S. federal spending shocks using VAR modeling. Although the authors conclude that the magnitude and timing of response vary across states, they do not test for the statistical significance of these differences. Taylor and Yücel (1996) use VAR modeling to assess the sensitivity of employment at the industry level in the four largest states—California, Florida, New York, and Texas—to monetary and fiscal policy shocks and conclude that the national estimate is only an imperfect predictor of regional employment responses.

Our research is also related to studies of national spending multipliers based on state-level data.[5] Fishback and Kachanovskaya (2010) study fiscal policy effects during the period 1930 to 1940. Although the core subject of their paper is average effects, the authors provide individual state-level estimates for the effects of a one dollar increase in per capita grants. When concentrating on the 33 states for which the authors deem their estimates reliable, the implicit income multiplier varies between –1.27 in Kansas and 2.21 in New Jersey. Suáraz Serrato and Wingender (2011) use measurement errors in U.S. Census population estimates as an instrument for federal government spending. The authors estimate a distribution of county-level multipliers using instrumental variable quantile regression and conclude that fiscal multipliers are larger in counties with lower income growth, varying from 2 to almost 0. Finally, our study is somewhat related to the literature on U.S. regional business cycles (e.g., Blanchard and Katz, 1992; Hess and Shin, 1998; Owyang et al., 2005; Owyang et al., 2009; Carlino and Sill, 2001). Studying whether federal

[5] See Ramey (2011b) for a discussion of this literature.

tax shocks affect U.S. states asymmetrically yields insights into regional growth differentials and business cycles.

3 Methodology and Data

We study the effects of federal tax shocks on U.S. states in the framework of vector autoregressions. Our baseline specification is given in Equation (1):

$$(1) \qquad \mathbf{y}_t = \mathbf{c}_t + \mathbf{A}(L)\mathbf{y}_t + \mathbf{B}(L)x_t + \mathbf{u}_t$$

where $\mathbf{y}_t$ is the vector of endogenous variables, $\mathbf{c}_t$ a vector of exogenous controls, $\mathbf{x}_t$ is the R&R exogenous tax shock series as percent of personal income excluding retroactive components, and $\mathbf{u}_t$ is the vector of reduced-form errors.[6] All data are quarterly and the sample period is 1950-I to 2007-IV. In the baseline case, $\mathbf{c}_t$ is simply a constant.[7] In the national VAR, we include general government expenditures and taxes, the rate of inflation, a short-term interest rate, and national personal income as endogenous variables. For conclusions about the regional impact of federal tax shocks, we add the ratio of state personal income to national personal income and estimate the model separately for 51 U.S. states.[8] Employing this ratio allows statistically testing for differences in the estimated federal-level and state-level tax multipliers.

To address concerns related to the nonstationarity of some of the time series, the model is estimated in first differences.[9] **A**(L) and **B**(L) are lag-polynomials of length 4 and 8, respectively.[10] All variables, except the interest rate and the inflation rate, are logarithmic transformations of real per capita values. As state level population data are available only

[6] The tax shock series is expressed as percent of personal income in order to enhance compatibility with the state-level data. Using the original R&R tax shock series, which is expressed in relation to GDP, leads to very similar results, as does employing the R&R exogenous tax shock series with retroactive components. All omitted results are available on request.

[7] Adding as exogenous controls Bretton Woods dummies, the Hoover and Perez (1994) oil shock dummy, the Ramey Shapiro dummy for military buildups, the R&R dummy variable for shifts to anti-inflationary monetary policy, and the log of price of crude petroleum (domestic production) does not affect the result.

[8] One might be concerned about the lack of additional regional variables, but limitations on degrees of freedom and data availability militate against expanding the system. We experimented with interpolating quarterly data on state revenue and expenditures based on data from the U.S. Census Bureau, Annual Survey of State Government Finances, and Census of Governments. Results show no notable changes. Also note that in a linear regression framework, the R&R tax shock series is unable to statistically significantly predict state taxes in 49 out of 51 states or state expenditures in 50 out of 51 states.

[9] Estimating the model in levels with linear and quadratic trend terms does not change the conclusions qualitatively, although we obtain minor differences in our point estimates.

[10] Neither including 4 nor 12 lags of the exogenous tax shock series change our conclusions qualitatively.

annually, we construct quarterly values by linear interpolation.[11] Our price measure is the annual national GDP deflator.[12] See the Data Appendix for variable definitions and data sources.

The rate of inflation and the Federal Funds rate are included to capture any potential monetary policy reaction in the aftermath of tax shocks.[13] By including a short-term interest rate as a monetary policy indicator, we follow the related VAR literature on the effects of monetary policy (Bernanke and Blinder, 1992). Hayo and Uhl (2011) emphasize the importance of accounting for monetary policy when investigating the effects of fiscal policy.[14] To control for government's role in the economy, we include measures of government expenditures and taxes.

VAR studies on fiscal policy typically use GDP as an output measure. At the U.S. state level, however, GDP data are available only annually. Our preferred alternative is personal income, which is provided on a quarterly basis by the Bureau of Economic Analysis (BEA). Personal income can be derived from GDP by adding net income receipts from the rest of the world plus personal income receipts on assets and personal current transfer receipts and subtracting consumption of fixed capital, corporate profits with inventory valuation, and capital consumption adjustments.[15] Personal income measures income available for (government and private) consumption and is viewed as a good measure of economic well-being. To ensure the robustness of our results, we estimate the national model using personal income and GDP. Figure 1 shows that results are similar.

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[11] Using log-linear interpolations or interpolating linearly between Censuses does not affect the results substantially. Also, results remain unchanged in the absence of per capita adjustments.

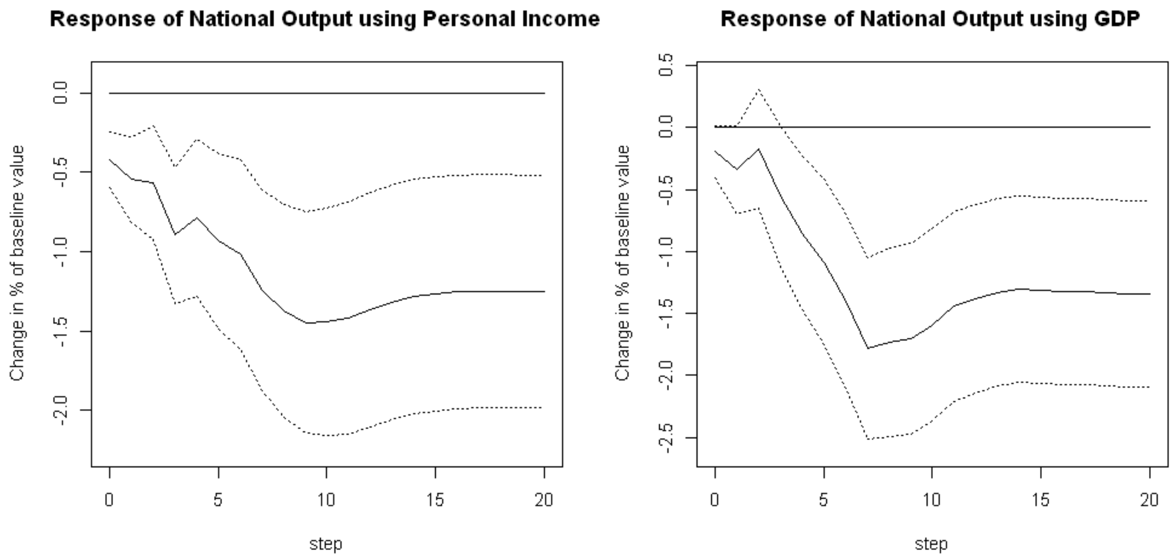
[12] State-level price measures are not available. Using CPI instead of the GDP deflator does not notably change the results.

[13] Using treasury bond rates at 1-, 3-, and 10-year maturity instead of the Federal Funds rate does not notably affect the results. Hence, results are also robust with regard to including interest rates at the longer end of the term structure of interest rates.

[14] Favero and Giavazzi (forthcoming) include average debt servicing costs because of their prior that covering debt dynamics is important. Their own results, however, suggest the contrary, as controlling for debt dynamics has little impact on the actual results.

[15] See BEA Table 1.7.5. Relation of Gross Domestic Product, Gross National Product, Net National Product, National Income, and Personal Income.

Figure 1 National Output Effects of Federal Tax Shocks



Notes: Response of national output to a 1 percent shock in the tax to output ratio. First panel uses personal income, second GDP as output measure. Error bands show one standard error deviations based on a parametric bootstrap with 10,000 repetitions.

Based on our estimation of Equation (1), we compute the response of the endogenous variables to an increase in federal taxes equal to 1 percent of personal income. Error bands are constructed by drawing 10,000 repetitions of the coefficient vector from a multivariate normal distribution with expected value equal to the estimated parameter values and covariance matrix equal to the estimated covariance matrix. Thus, error bands show one standard error deviations of the resulting impulse responses. Similar error bands are common in the literature (see R&R, 2010; Favero and Giavazzi, forthcoming; Mertens and Ravn, forthcoming). As the model is estimated in first differences, we accumulate the impulse responses once to obtain effects on the level of the variables. Regional output responses are constructed by adding the response of national output and the response of the ratio of respective state to national output.[16]

A key question of our study is whether federal tax shocks have asymmetric output effects across U.S. states. As the model is estimated in first differences, it contains the regional growth differential. Accumulated once, the response of the regional output differential can

[16] Given that the model is estimated in first differences of logarithms, it contains the national growth rate and the regional growth rate differential. The state effect is the national effect plus the response of the state growth differential. We also estimate Equation (1) with personal income of state i, i = 1, …, 51 and personal income of the rest of the nation included separately, which generates direct estimates of state and national output multipliers. While the results are similar, our specification has the important advantage of providing a direct test of the statistical significance of the estimated difference between state and national output response.

be interpreted as the difference in the output multiplier of the respective state relative to the national one. Standard VAR testing procedures now can be applied to test for the significance of this difference. However, we propose basing the tests on the twice-accumulated responses, as the once-accumulated responses have the drawback of showing only one point in the transmission of the federal tax shock. Accumulating the responses a second time gives the integral below the curves and hence allows testing for the statistical significance of the estimated difference between the full impulse response functions. Economically, the twice-accumulated responses can be interpreted as total output loss after a tax shock and, hence, have a useful and intuitive economic interpretation.

4 Estimation Results

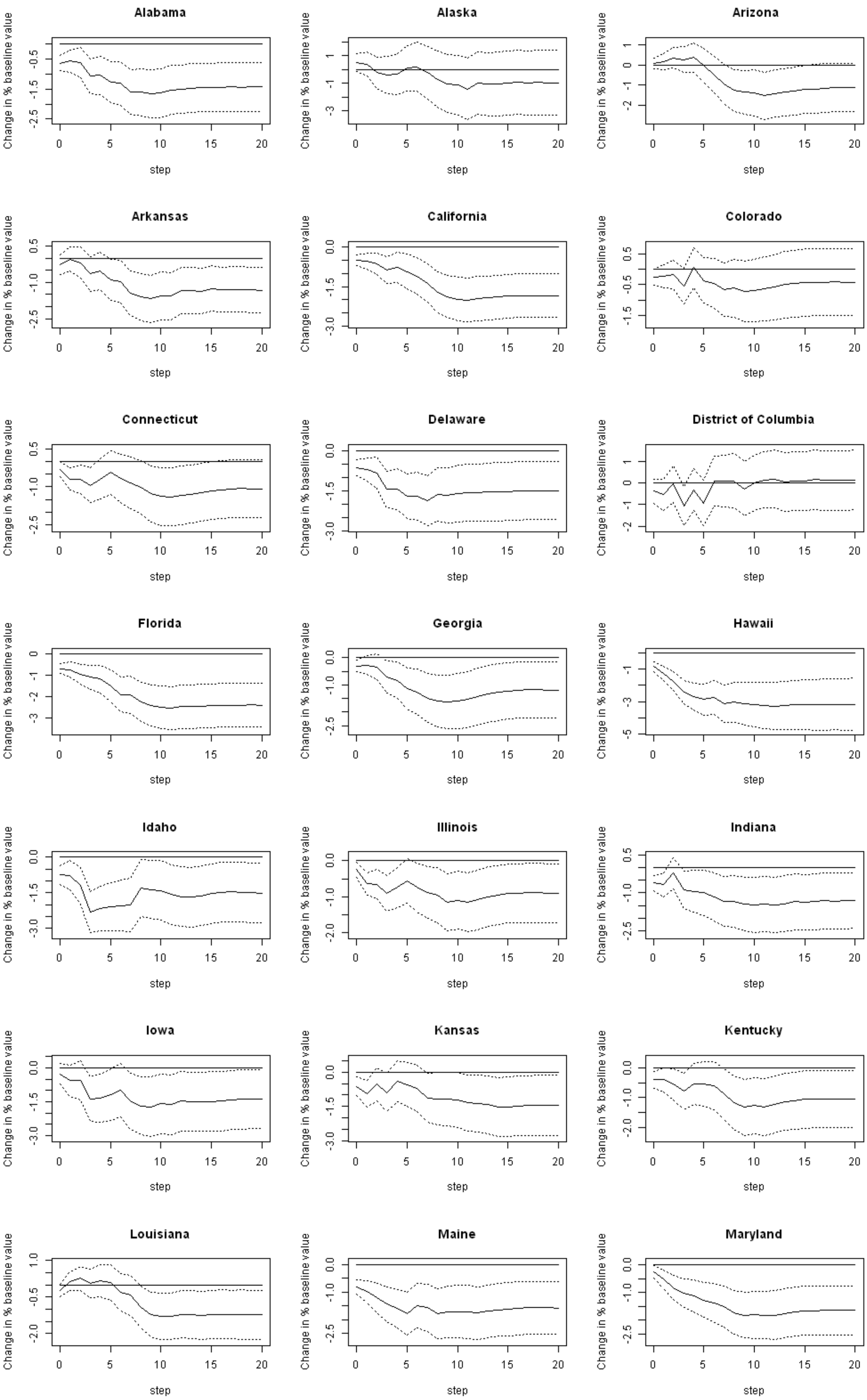
4.1 The State-Level Effect of Federal Tax Shocks

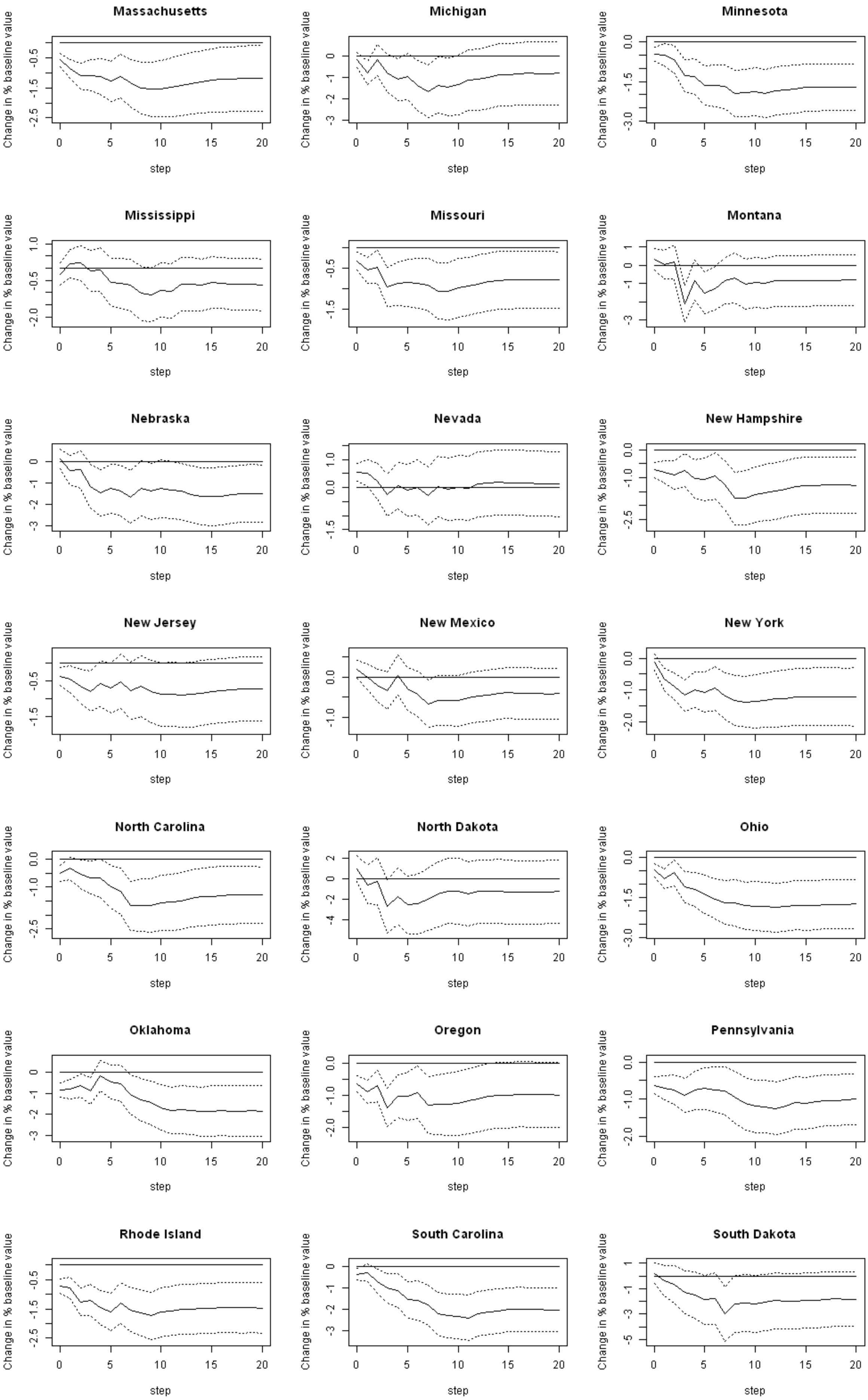
Figure 2 shows the estimates of the state output responses to a federal tax increase equal to 1 percent of personal income. These are constructed as the sum of the responses of national output and the difference between state and national output.[17] Visual inspection of the set of 51 state response functions suggests remarkable differences across states. In some states, there is no evidence of statistically significant effects, particularly Alaska, Colorado, the District of Colombia, Michigan, Mississippi, Montana, Nevada, New Jersey, New Mexico, North Dakota, South Dakota, Utah, West Virginia, and Wyoming. In most cases, however, state-level output decreases statistically significantly following the tax increase.

Further, the impulse response functions appear to be different with respect to timing and size of effects. Regarding timing, for example, in Florida, federal tax increases reduce output as soon as the first quarter, whereas output in Arkansas does not react to the tax shock until after the first six quarters. Regarding the size of the output effect in this example, it is about –1.5 in Arkansas and –2.5 in Florida. Hence, state output effects vary with respect to their statistical significance, their timing, and their magnitude.

[17] The estimate of the national output response in each state-level VAR is remarkably close to the one in the five-variable national VAR. Hence, the inclusion of state output variables does not affect the estimate of the national output response and differences between state and national output found in any of the 51 state-level VAR models are not due to variations in the estimate of the national output effect, but instead reflect genuine regional asymmetries.

Figure 2 Regional Output Effects of Federal Tax Shocks

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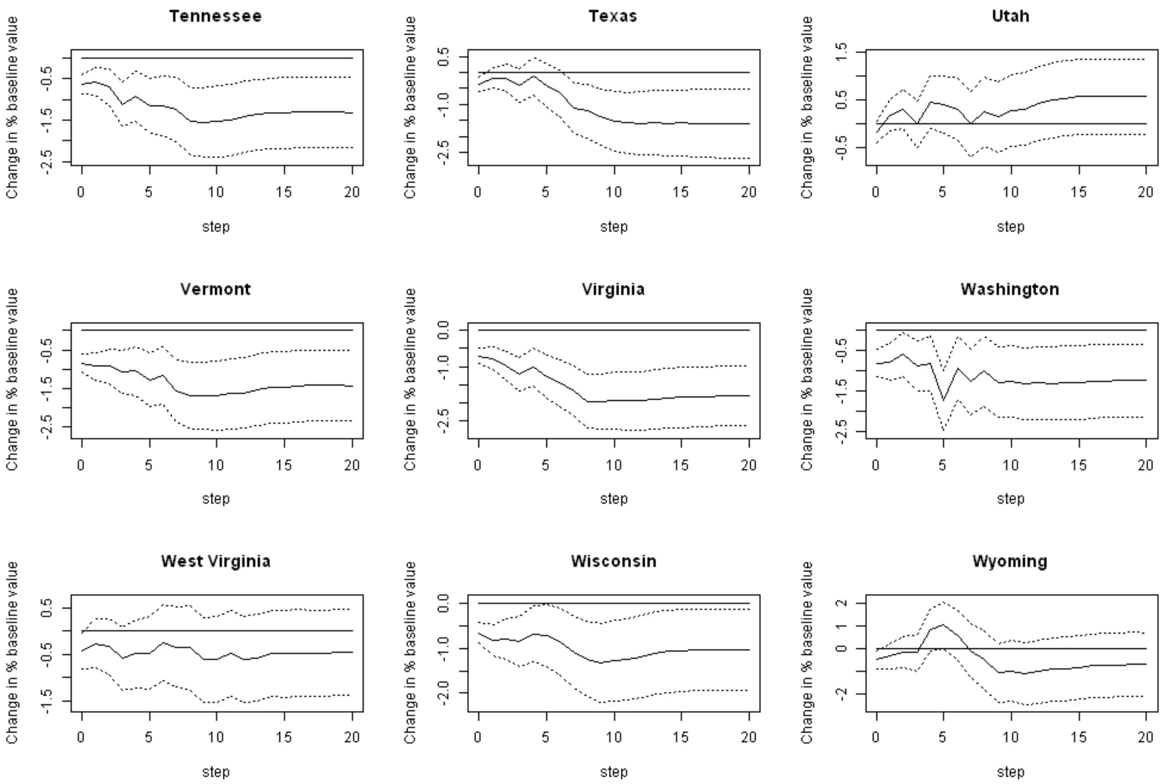


Notes: Figure shows impulse responses of respective state output to a 1 percent increase in the national-tax-to-personal-income ratio. Responses constructed as the sum of response of national output and difference between state and national output. Error bands are one standard error deviations based on a parametric bootstrap procedure with 10,000 repetitions.

Table 1 provides a numerical overview of the regional output effects. It shows the peak output effect together with the effect at 4, 8, 12, 16, and 20 quarters after the tax increase. The peak output effect ranges from –0.2 in Utah to –3.3 in Hawaii, with the standard deviation of peak state output multipliers being 0.6. As the average peak state output effect is close to the national estimate, the standard deviation can be interpreted as the average deviation of the peak state output effect from the peak national output effect.[18]

Figure 3 is a histogram of peak state-level output multipliers. Note, first, that state-level multipliers are distributed relatively symmetrically around the national multiplier. Second, although there are substantial deviations from the national average in both directions, a large group of states have a reaction close to the national average.

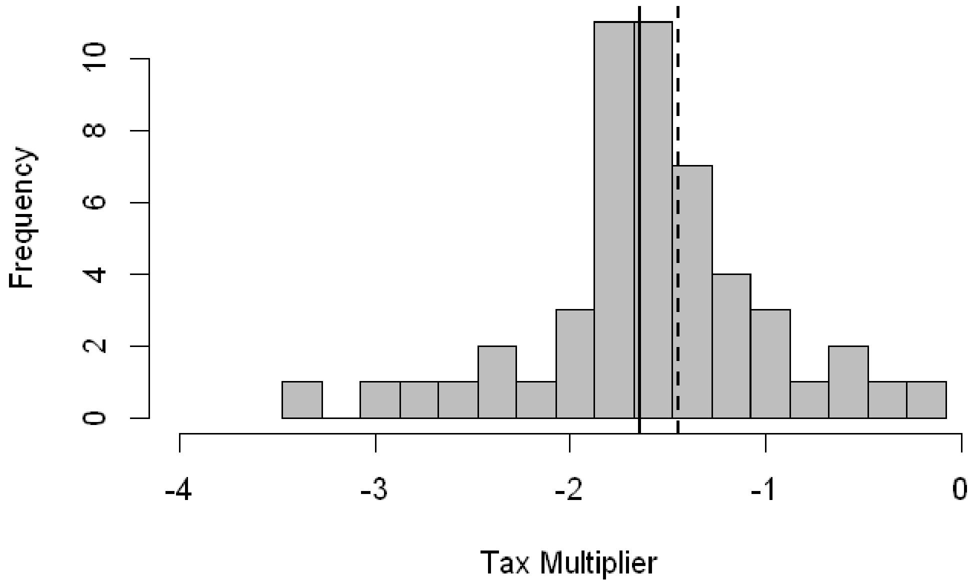
[18] The average of the peak output effects is –1.6, in contrast to the –1.4 estimated at the national level. It is also close to the national average for the output effects at quarters 4, 8, 12, 16, and 20.

Table 1 Output Effects of Federal Legislated Tax Shocks Across U.S. States

Geographic Unit	Peak	4	8	12	16	20
United States	-1.4 **	-0.8 *	-1.4 **	-1.4 *	-1.3 *	-1.3 *
Alabama	-1.7 **	-1 *	-1.6 **	-1.5 *	-1.4 *	-1.4 *
Alaska	-1.4	-0.3	-0.7	-1	-0.9	-1
Arizona	-1.5 *	0.4	-1.3 *	-1.4 *	-1.2 *	-1.1
Arkansas	-1.7 *	-0.5	-1.6 *	-1.3 *	-1.3 *	-1.3 *
California	-2 **	-0.8 *	-1.7 **	-2 **	-1.8 **	-1.8 **
Colorado	-0.7	0	-0.6	-0.6	-0.4	-0.4
Connecticut	-1.4 *	-0.7	-1	-1.3 *	-1.1	-1.1
Delaware	-1.9 **	-1.4 *	-1.6 *	-1.6 *	-1.5 *	-1.5 *
District of Columbia	-1.1 *	-0.3	0.1	0.2	0.1	0.1
Florida	-2.5 **	-1.2 *	-2.3 **	-2.5 **	-2.4 **	-2.4 **
Georgia	-1.6 *	-0.8 *	-1.6 *	-1.4 *	-1.2 *	-1.2 *
Hawaii	-3.3 **	-2.7 **	-3 **	-3.3 **	-3.2 **	-3.2 *
Idaho	-2.3 **	-2.2 **	-1.3 *	-1.7 *	-1.5 *	-1.5 *
Illinois	-1.2 *	-0.7 *	-1 *	-1.1 *	-0.9 *	-0.9 *
Indiana	-1.5 *	-0.9 *	-1.3 *	-1.5 *	-1.3 *	-1.3 *
Iowa	-1.7 *	-1.3 *	-1.7 *	-1.5 *	-1.5 *	-1.4 *
Kansas	-1.5 *	-0.4	-1.2 *	-1.4 *	-1.5 *	-1.5 *
Kentucky	-1.3 *	-0.6	-1.2 *	-1.2 *	-1.1 *	-1 *
Louisiana	-1.3 *	0.2	-0.9 *	-1.2 *	-1.2 *	-1.2 *
Maine	-1.8 **	-1.6 **	-1.8 *	-1.8 *	-1.6 *	-1.6 *
Maryland	-1.8 **	-1.1 *	-1.7 **	-1.8 **	-1.7 *	-1.6 *
Massachusetts	-1.6 *	-1.1 *	-1.5 *	-1.4 *	-1.2 *	-1.2 *
Michigan	-1.6 *	-1.1 *	-1.4 *	-1.1	-0.8	-0.8
Minnesota	-2 **	-1.3 *	-2 **	-1.9 **	-1.7 *	-1.7 *
Mississippi	-1.1	-0.1	-1	-0.7	-0.6	-0.7
Missouri	-1.1 *	-0.9 *	-1.1 *	-0.9 *	-0.8 *	-0.8 *
Montana	-2.1 **	-0.8	-0.7	-0.9	-0.8	-0.8
Nebraska	-1.7 *	-1.4 *	-1.3	-1.4 *	-1.6 *	-1.5 *
Nevada	-0.3	0.1	0	0.1	0.2	0.1
New Hampshire	-1.7 *	-1 *	-1.7 *	-1.5 *	-1.3 *	-1.3 *
New Jersey	-0.9 *	-0.6	-0.7	-0.9 *	-0.8	-0.7
New Mexico	-0.7 *	0	-0.6	-0.5	-0.4	-0.4
New York	-1.4 *	-1 *	-1.3 *	-1.3 *	-1.2 *	-1.2 *
North Carolina	-1.7 *	-0.7	-1.6 *	-1.5 *	-1.3 *	-1.3 *
North Dakota	-2.7 *	-1.7	-1.5	-1.2	-1.3	-1.2
Ohio	-1.9 **	-1.2 *	-1.7 *	-1.9 **	-1.8 *	-1.7 *
Oklahoma	-1.9 *	-0.1	-1.3 *	-1.8 *	-1.8 *	-1.8 *
Oregon	-1.4 **	-1 *	-1.3 *	-1.1 *	-1	-1
Pennsylvania	-1.2 *	-0.8 *	-0.9 *	-1.2 *	-1.1 *	-1 *
Rhode Island	-1.7 **	-1.5 **	-1.6 **	-1.5 *	-1.5 *	-1.5 *
South Carolina	-2.4 **	-1.1 *	-2.2 **	-2.2 **	-2 *	-2 *
South Dakota	-3 *	-1.5	-2.2	-1.9	-1.9	-1.8
Tennessee	-1.6 *	-0.9 *	-1.5 *	-1.4 *	-1.3 *	-1.3 *
Texas	-1.6 *	-0.1	-1.2 *	-1.6 *	-1.6 *	-1.6 *
Utah	-0.2	0.5	0.3	0.4	0.6	0.6
Vermont	-1.7 *	-1.1 *	-1.7 **	-1.6 *	-1.4 *	-1.4 *
Virginia	-2 **	-1 *	-1.9 **	-1.9 **	-1.8 **	-1.8 **
Washington	-1.7 **	-0.8 *	-1 *	-1.3 *	-1.3 *	-1.2 *
West Virginia	-0.6	-0.5	-0.4	-0.6	-0.5	-0.5
Wisconsin	-1.3 *	-0.7 *	-1.2 *	-1.2 *	-1 *	-1 *
Wyoming	-1.1	0.8	-0.5	-1	-0.7	-0.7
Max	-0.2	0.8	0.3	0.4	0.6	0.6
Min	-3.3	-2.7	-3	-3.3	-3.2	-3.2
SD	0.6	0.65	0.61	0.62	0.63	0.62

Notes: Table shows output changes in percent following a tax increase equal to 1 percent of personal income. The state-level effect is computed as the sum of national effect and difference between state and national effect. ** indicates significance at two standard error deviations, * significance at one standard error deviations. Standard errors based on parametric bootstrap with 10,000 repetitions. Max is the maximum, Min the minimum, and SD the standard deviation across geographic entities (except the national estimate) in that row.

Figure 3 Histogram of Peak Output Effects at the State Level



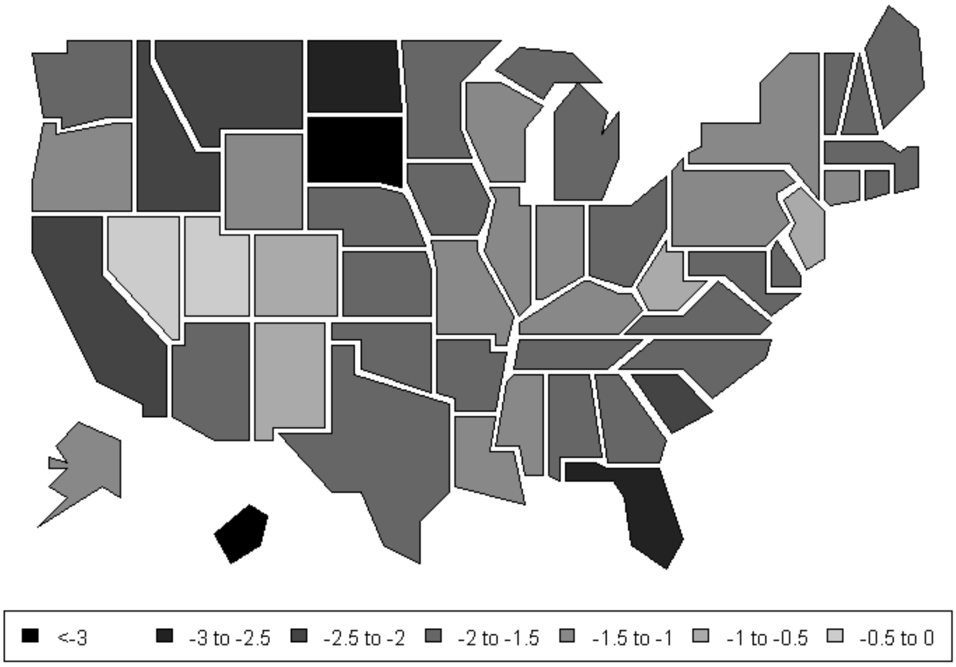
Notes: Figure shows histogram of peak state-level tax multipliers across 50 U.S. states and the District of Colombia. Dashed line shows national effect. Solid line shows median and average of state-level multipliers, which are almost identical.

For instance, Table 1 shows that the responses in Arkansas, Connecticut, Georgia, Indiana, and Kansas are very similar to the national effect. Roughly two thirds of the states display peak output multipliers close to the national average. Figure 4 maps the geographical distribution of state-level multipliers. There is very little evidence of regional clustering; indeed, output effects seem to vary across states independently of their geographic location.

To this point, there appears to be economically meaningful dispersion of federal tax-induced output effects across states. However, given the estimation uncertainty, it is important to corroborate this finding with statistical testing. Our preferred measure of the difference between state and national output responses is the twice-accumulated response function of the output differential after the tax shock, which is equivalent to testing whether the areas below the two impulse-response functions are equal.

Table 2 shows the significance tests for the twice-accumulated response function at different lengths. We also show the test for the statistical significance of the once-accumulated response function at the quarter, when the state-level output effect peaks.

Figure 4 Geographical Distribution of Peak State Output Effects



Notes: Figure shows peak state-level multiplier of a tax increase equal to 1 percent of personal income. This is a visibility-based map with states in their approximate geographical position and smaller states made larger and larger states made smaller. Alaska and Hawaii are shown in the lower left corner instead of in their actual geographic position. Credit for map creation goes to Mark Monmonier of Syracuse University's Maxwell School of Citizenship and Public Affairs.

When counting all states for which at least one of these tests rejects the null hypothesis, we find statistically significant deviations of state from national output in 26 out of 51 states, namely, Arizona, California, Colorado, Delaware, Florida, Hawaii, Idaho, Illinois, Louisiana, Maine, Massachusetts, Minnesota, Mississippi, Montana, Nevada, New Jersey, New Mexico, North Carolina, Rhode Island, South Carolina, Texas, Utah, Virginia, Washington, West Virginia, and Wyoming. Focusing on the peak effect test, 16 states show statistically significant responses. At quarters 4, 8, 12, 16, and 20, we find significant asymmetries in 17, 17, 11, 10, and 11 states, respectively. Note that the timing of effects differs across states; thus, in some cases we find asymmetric responses following directly after the tax shock, but not at the end of the forecast horizon, and vice versa. This is the case, for example, in Arizona, Minnesota, and Delaware. In fact, the shorter the forecast horizon, the stronger the evidence of asymmetries. A potential economic explanation is that movements in capital and labor over time tend to compensate asymmetric movements in output and thereby help restore equilibrium across regions. To summarize, we find evidence of statistically meaningful asymmetries in the response of output across U.S. states.

Table 2 Differences in Output Effects Across U.S. States

Geographic Unit	Peak	1:4	1:8	1:12	1:16	1:20
Alabama	-0.2	-0.7	-2	-2.7	-3.2	-3.9
Alaska	0	3.2	7.2	8.2	9.2	10.3
Arizona	-0.1	4.3 **	5.8 *	5.9	6.1	6.7
Arkansas	-0.3	1.1	0.4	-0.3	-0.6	-1.2
California	-0.5 *	-0.1	-0.5	-2.2	-3.9	-5.7
Colorado	0.7	2.1 *	4.6 *	7.6 *	10.8 *	14 *
Connecticut	0	-0.3	0.9	0.9	0.9	1.1
Delaware	-0.6	-1.8 *	-4.2 *	-5	-6	-7.1
District of Columbia	-0.2	0.8	4.6	10	15	20.1
Florida	-1.1 *	-1.5 *	-4.6 *	-8.9 *	-13.4 *	-17.9 *
Georgia	-0.3	0.3	-1.1	-2	-2.5	-3
Hawaii	-1.9 *	-5.9 **	-13 **	-20 *	-27.6 *	-35.1 *
Idaho	-1.4 *	-3.8 *	-6.5 *	-7	-8.5	-9.6
Illinois	0.4 *	0.2	1.9 *	3.5 *	5.3 *	7.1 *
Indiana	0.1	0	0	0.5	1.2	2
Iowa	-0.3	-1	-1.9	-2.7	-3.5	-4.2
Kansas	-0.2	-0.5	0.3	0.9	0.4	-0.1
Kentucky	0.1	0.5	1.9	2.5	3.2	4.1
Louisiana	0	3.4 *	6.3 *	6.6	6.1	5.4
Maine	-0.8 *	-2.8 *	-4.8 *	-6	-7.3	-8.6
Maryland	-0.4	-0.1	-1.1	-2.4	-3.6	-4.8
Massachusetts	-0.1	-1.6 *	-2.3	-2.5	-2.4	-2.1
Michigan	-0.3	0.3	-0.2	0.9	3.1	5.4
Minnesota	-0.6 *	-0.9	-3.3 *	-5.2 *	-7.1	-8.9
Mississippi	0.3	3.2 *	4.7	6.8	9.3	11.4
Missouri	0.3	-0.1	0.6	2.1	3.5	4.9
Montana	-1.1 *	1.1	1.5	3.5	5.3	7
Nebraska	-0.4	-0.1	-1.1	-0.8	-2	-2.9
Nevada	1 *	4.5 **	8.9 *	14.7 *	20.5 *	26.1 *
New Hampshire	-0.3	-0.9	-1.3	-2	-2.2	-2.4
New Jersey	0.5 *	0	1.6	3.8	5.7	7.8 *
New Mexico	0.6	2.9 *	5.5 *	9 *	12.5 *	15.9 *
New York	0.1	-0.7	-0.5	-0.1	0.2	0.4
North Carolina	-0.5 *	0.4	-0.8	-1.5	-1.9	-2.3
North Dakota	-1.7	-0.7	-4.2	-3.3	-2.7	-2.4
Ohio	-0.2	-0.5	-1.7	-2.4	-3	-3.6
Oklahoma	-0.6	0	1.3	0.3	-1.9	-4.3
Oregon	-0.3	-0.8	-0.2	0.9	2.1	3.3
Pennsylvania	0.2	-0.9	-0.1	0.7	1.5	2.2
Rhode Island	-0.3	-2.2 *	-3.7 *	-4.5	-5.2	-6
South Carolina	-1 *	-0.5	-3.2	-6.7 *	-9.8 *	-12.9 *
South Dakota	-1.8	-0.4	-4.6	-7.4	-10.2	-12.5
Tennessee	0	-0.3	-0.5	-0.4	0	0.3
Texas	-0.2	1.9 *	3.1	3	2.3	1.5
Utah	0.3 *	4.1 **	9.7 **	16.6 **	24 **	31.4 **
Vermont	-0.3	-1.6 *	-2.7	-3.7	-4.6	-5.3
Virginia	-0.6 *	-1.8 *	-3.9 *	-6.1 *	-8.5 *	-10.8 *
Washington	-0.9 *	-0.9	-1.7	-1.3	-1.5	-1.6
West Virginia	0.9 *	1.5	5.1 *	8.9 *	12.6 *	16.2 *
Wisconsin	0.1	-0.6	0.1	0.7	1.6	2.6
Wyoming	0.2	2.7	8 *	9.1	9.8	10.9

Notes: Table shows difference between effect on state and national output. ** indicates significance at two standard error deviations, * significance at one standard error deviations. Standard errors based on parametric bootstrap with 10,000 repetitions. Peak gives the difference between state and national effect at the peak state output effect. 1:x, x = 4, 8, 12, 16, 20 is the integral below the response function of the difference between state and national output up to step x.

4.2 Extensions

The estimates presented in Section 4.1 are the ones we most favor. As mentioned, they are robust to many minor alterations in the specification. In addition, we consider some extensions to Equation (1). Perotti (2011) argues that discretionary components of taxation should be allowed to have different impacts than automatic responses of taxes. As a solution, he suggests an IV estimation strategy of the VAR model. Due to multicollinearity, this strategy is not feasible when including both taxes and lags of the tax shock variable. We work around this restriction by estimating a total of three variations of the specification in Equation (1). First, we remove taxes, which yields one of the models estimated in Perotti (2011). Second, we additionally remove government expenditure. Third, we reduce the lag length of the exogenous tax shock series to zero, which produces the model in Favero and Giavazzi (forthcoming). We then add lags 0 to 4 of the residuals from an IV regression of taxes on contemporaneous values of all other variables included in the VAR. We follow Perotti (2011) in using lags 0 to 4 of the exogenous tax shock series as well as lags 1 to 4 of the other variables as instruments.

Tables A1 and A2 in the Appendix present the results of the extended specification, focusing on peak effects. To facilitate the comparison, our benchmark results from Table 1 are given in Column 2. The third column, labeled "WT," shows the outcome when taxes are excluded from the model. The fifth column, labeled "WGT," shows the results of excluding both taxes and expenditures. The columns labeled IV show the IV estimation results of the model from the corresponding left-side column. Taken together, these alterations do not matter much. Point estimates and error bands are similar to our benchmark model, except that in the model without government variables we discover additional evidence for asymmetries. The column labeled "FG" shows the results of Favero and Giavazzi's (forthcoming) specification with zero lags of the exogenous variable. Peak state-level multipliers are now much lower, but using the Perotti (2011) estimation strategy delivers results similar to those of our benchmark case. In fact, our finding corresponds to Perotti's (2011) conclusion that Favero and Giavazzi (forthcoming) underestimate the size of the multipliers and that applying his approach will yield much greater multipliers.

Finally, we split the sample in two parts, 1950-I to 1979-IV and 1980-I to 2007-IV, and reestimate our benchmark model. First, the standard deviation of peak multipliers has increased substantially in both subperiods, most likely indicating increased statistical uncertainty brought about by halving the number of observations. Our results indicate the well-known subsample instability of estimates when working with the R&R (2010) exogenous tax shock series (see, e.g., Favero and Giavazzi, forthcoming), as multipliers in the earlier sample are much higher than in the later sample.[19] Nevertheless, even though there are substantial deviations from the benchmark results in the more recent period, the main conclusions of our paper hold quite well. There are, however, some sign changes, most noteworthy in California, Delaware, Florida, Mississippi, and Tennessee.

5 What Drives Differences in Tax Multipliers?

The analysis conducted in the previous section delivers a set of 51 state-level tax multipliers. This section contains an explorative analysis of the determinants of the estimated regional asymmetries of federal tax shocks. Our cross-sectional investigation is based on Equation (2).

(2) $$\mathrm{TM}_i = \alpha + \boldsymbol{\beta}\mathbf{x}_i + \varepsilon_i ,$$

where TM is the peak state-level output multiplier of federal tax changes in state i (i = 1, …, 51), $\mathbf{x}_i$ is a vector of explanatory factors, and ε_i an error term. We estimate the model by ordinary least squares (OLS) and employ general-to-specific modeling to arrive at a more concise but still data-admissible model (Hendry, 2000). Given the exploratory nature of our analysis, our initial set of explanatory variables is relatively large in comparison to the available number of observations. Moreover, at least some of the variables in $\mathbf{x}_i$ are expected to show high degrees of collinearity. The general-to-specific modeling approach increases estimation efficiency by reducing the number of variables based on a consistent testing-down path.

In creating the cross-sectional dataset, our explanatory variables are computed as averages over time for each U.S. state. We classify them into four categories: (i) regional effects, (ii) output composition, (iii) economic variables, and (iv) demographic factors. The Appendix contains a detailed description of these variables.

[19] Explaining the decline in fiscal multiplier across subsamples remains an interesting avenue for future research. Potential explanations include the increased openness of the U.S. economy in the second half of the sample. Also, monetary policy has been more stability oriented since the late 1970s.

Capturing regional effects, vector $\mathbf{x}_i$ contains a constant and a set of regional dummies that are based on the BEA classification of economic regions.[20] Second, output composition is measured by shares for each SIC industry in percent of total personal income. Earnings are defined as wage and salary disbursements and supplements to wages and salaries plus proprietors' income. The SIC industries considered are farming, agricultural, forestry and fishing, mining, construction, manufacturing, transportation, wholesale trade, retail trade, finance, insurance and real estate, services, and government and government enterprises. Finally, we add the shares of aggregate state income derived from dividends, interest, and rents, as well as transfers as percent of total personal income. Third, for our economic variables we employ indicators of states' employment and capital intensity. Employment intensity is captured by average wage and salary disbursements in percent of personal income. Capital intensity is based on estimates provided by Yamarik (forthcoming), which we standardize by personal income. We also control for average personal income per capita and the average unemployment rate. As a proxy for the states' fiscal capacity, we compute total state tax revenue as percent of personal income and use the gini coefficient as an indicator of income inequality. The fourth group of variables contains two demographic indicators—the average median age and average dependency ratio, which is defined as the share of people younger than 18 or older than 64 in percent of total population.

Table 3 contains the estimation results of a regression explaining the estimated regional income multipliers of federal tax shocks by these four groups of variables. Most of the models do not deviate significantly from classical OLS assumptions, but Models 2 and 4 show evidence of nonnormality. In Model 1, we include only regional effects. Neither individually nor jointly do we find a significant impact of regional effects, which supports the finding from the descriptive analysis in Figure 4. Model 2 studies the impact of industry composition on regional asymmetries. We find a significant joint influence of this group of variables, as well as individually significant coefficients for transportation, services, and government. This group of variables explains more than 50 percent of the variation in regional multipliers. The group of economic variables is included in Model 3; they are jointly significant and we find significant individual effects for the unemployment rate, state tax revenues, and capital

[20] The seven BEA regions are New England, Mideast, Great Lakes, Southeast, Plains, Southwest, Rocky Mountains, and Far West. Each of these regions is a simple aggregate of U.S. states; see http://www.bea.gov/regional/docs/regions.cfm.

intensity. Model 4 focuses on the demographic factors. Neither of the two variables are either jointly or individually significant, and the coefficient of determination is low.

However, a separate analysis of these groups does not allow discovering their joint effects and is likely subject to biased estimates. Thus, Model 5, the general unrestricted model, contains all the variables in one regression and explains almost 75 percent of the variation in regional multipliers. However, the model is overparameterized and although the variables are jointly significant, there is only one individually significant coefficient—for the share of transportation sector. Applying the consistent general-to-specific modeling approach yields the reduced Model 6. This is a statistically valid description of the data-generating process and much more efficiently estimated than the general model. It still explains over 60 percent of variation in the dependent variable. Diagnostic testing does not indicate problems of nonnormality or heteroscedasticity. The testing-down restriction shows that the omitted variables have no significant predictive power.

Note that none of the economic variables survived the testing-down process. Thus, results from Model 3 are spurious and suggest that different economic situations of U.S. states are related to industry composition. At the same time, demographic factors, insignificant in Model 4, are now significant.[21]

[21]We experimented with ordered probit models, where the dependent variable is coded as 0: insignificant responses based on all tests given in Table 2, as 1: peak tax multiplier larger than average, and –1: peak tax multiplier smaller than average. Comparing the outcome of the ordered probit models with Table 3, we find robust results. First, in the case of "industry composition," all variables except the share of farm income remain significant and have identical signs. Second, when using the explanatory variables from the reduced model, all variables, except median age and the share of farm income, remain significant with identical signs.

Table 3 Determinants of Tax Multipliers (51 Cases)

	Model 1: Regional Variables		Model 2: Industry Composition		Model 3: Economic Variables		Model 4: Demographic Variables		Model 5: Unrestricted Model		Model 6: Reduced Model	
	Coefficient	t-prob	Coefficient	t-prob	Coefficient	t-prob	Coefficient	t-prob	Coefficient	t-prob	Coefficient	t-prob
Constant	-1.081 *	0.086	-1.624	0.355	-1.016	0.539	3.21774	0.2440	21.817	0.152		
New England	-0.570	0.396							-5.742	0.333		
Mideast	-0.364	0.591							-6.128	0.309		
Southeast	-0.542	0.402							-5.719	0.345		
Great Lakes	-0.414	0.542							-6.511	0.272		
Plains	-0.869	0.193							-5.999	0.312		
Rocky Mountain	-0.196	0.773							-6.026	0.302		
Southwest	-0.338	0.626							-5.313	0.363		
Far West	-0.603	0.369							-6.258	0.275		
Dividends, Interest, and Rents			-0.052	0.271					0.009	0.924		
Transfers			-0.016	0.773					-0.110	0.512		
Farming			-0.054	0.134					-0.035	0.629	-0.104 ***	0.000
Agricultural, Forestry, and Fishing			0.127	0.783					0.441	0.512		
Mining			0.086	0.113					0.101	0.579		
Construction			-0.080	0.597					-0.098	0.700		
Manufacturing			0.017	0.316					0.035	0.791		
Transportation			0.218 *	0.056					0.525 **	0.025	0.212 ***	0.000
Wholesale Trade			-0.054	0.688					-0.171	0.409		
Retail Trade			-0.030	0.862					-0.397	0.349	-0.332 ***	0.004
Finance, Insurance, and Real Estate			-0.055	0.545					0.050	0.802	-0.160 ***	0.006
Services			0.083 ***	0.003					0.120	0.389	0.096 ***	0.000
Government			-0.039 ***	0.007					-0.071	0.616	-0.040 ***	0.000
Per Capita Personal Income					0.000	0.505			0.000	0.636		
Unemployment Rate					0.238 ***	0.005			0.282	0.250		
State Tax Revenues					-0.150 **	0.075			0.031	0.789		
Gini Coefficient					-6.432	0.147			-14.905	0.213		
Capital Intensity					0.007 *	0.087			-0.017	0.187		
Employment Intensity					0.015	0.159			-0.041	0.778		
Dependency Ratio							-0.049	0.279	-0.029	0.810	0.091 ***	0.005
Median Age							-0.087	0.108	-0.174	0.201	-0.108 ***	0.001
R^2	0.11		0.56		0.28		0.07		0.76		0.62	
Adjusted-R^2	-0.06		0.41		0.18		0.03		0.43		0.56	
F-Test	F(8,42) = 0.666	0.718	F(13,37) = 3.655 ***	0.001	F(6,44) = 2.847 **	0.02	F(2,48) = 1.658	0.201	F(29,21) = 2.322 **	0.025	F(8,43) = 110.68 ***	0.000
Normality	Chi²(2) = 3.832	0.147	Chi²(2) = 7.036 **	0.03	Chi²(2) = 2.09	0.352	Chi²(2) = 5.473 *	0.065	Chi²(2) = 2.478	0.29	Chi²(2) = 1.221	0.543
Heteroscedasticity	n.a.		F(26,24) = 1.053	0.452	F(12,38) = 0.549	0.868	F(4,46) = 0.748	0.564	n.a.		F(16,34) = 1.207	0.312
Testing-down	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	F(22,21) = 0.568	0.902

Notes: F-test is the test of the joint significance of all regressors (except the constant). n.a. means not applicable. Normality is the Jarque-Bera test. Heteroscedasticity is the White-test (without cross-products). The reduced model is the result of applying the testing-down restriction to the unrestricted model. * significant at 10%, ** significant at 5%, *** significant at 1%. In Model 6, R^2 is based on the squared multivariate correlation coefficient.

Thus, results in Model 6 indicate that industry composition of personal income as well as the sociodemographic composition of the population help explain asymmetries in regional multipliers. In addition to being significant statistically, these variables have notable economic effects. An increase in the median age of the total population of one year increases the state-level multiplier by 0.11. As the median age in the United States is typically below 35 in most states, this might simply reflect the fact that both income and the tax burden increase with age. An increase in the dependency ratio of 1 percentage point decreases the state-level multiplier by 0.09. Again, this estimate is economically meaningful and has a plausible interpretation: people younger than 18 or older than 65 are less likely to depend on economic activity for their livelihood; hence, states characterized by a larger dependency ratio might show less reaction to economic shocks.

The bulk of significant effects in Model 6 are related to the industry composition of personal income. A 1 percentage point increase in the share of farm income increases the multiplier by 0.1. Farmers thus appear to have stronger reactions to tax shocks than the average producer. A 1 percentage point increase in the share of income from transportation decreases the size of the multiplier by 0.21. An increase in the share of income from retail trade increases the multiplier by 0.33, which is the largest single effect found in our analysis. Thus, consumers facing higher taxes appear to react to an increase in federal taxes by decreasing their household's shopping expenditure, and thus states in which retail sales are a large part of the economy are particularly hard hit by federal tax shocks.

A 1 percentage point increase in the share of income from finance, insurance, and real estate increases the multiplier by 0.16. This sector seems especially prone to fluctuations and hence might be affected relatively strongly by an economic shock. The opposite appears to be true for the service sector, where a 1 percentage point increase in the share of income derived from services lowers the output effect by 0.1. Also, incomes in the service sector might be low, implying that the service sector is less affected by the aggregate tax shock. Also, the service sector might offer more opportunity for tax evasion. A 1 percentage point increase in the share of income from government increases the regional multiplier by 0.04, which is relatively modest. This effect could be explained by government's greater insulation from business cycle fluctuations.

6 Conclusion

This paper studies regional asymmetry in output effects of U.S. federal tax shocks. Econometrically, we estimate separate vector autoregressive models for each U.S. state and utilize the exogenous tax shock series recently proposed by Romer and Romer (2010) to infer the regional consequences of federal tax changes. In our benchmark model, which contains general government expenditures and taxes, the Federal Funds rate, the log-difference of the GDP price deflator, national output, and the log-difference of state and national output, we find that state-level peak output multipliers vary between –0.2 in Utah and –3.3 in Hawaii. In as many as 26 states, we find statistically significant differences between regional and national output responses, which we interpret as evidence that the transmission of federal tax policy shocks is asymmetric across U.S. states. These results are remarkably robust to variation in the specification and suggest that state-level output effects of fiscal policy can be quite different from the effects observed at the national level.

Analyzing the determinants of the size of state-level tax multipliers suggests that the industry composition of output as well as demographic characteristics of the states matter. Tax multipliers are larger the higher the median age of the state's population and the greater its share of income from farming, retail trade, finance, insurance and real estate, and government. Tax multipliers are smaller the larger the dependency ratio in a state, as well as the larger its share of income from transportation and services. The greatest economic impact on the size of the multiplier is related to the share of a state's income derived from the retail sales sector. This suggests that federal tax shocks have a substantial impact on household consumption behavior.

Thus, estimates of the average tax multiplier provide an incomplete picture of the effects of federal tax changes, leading to several implications for policy making. First, the well-being and employment prospects of individual households are affected by federal tax actions in a way that goes beyond the macroeconomic effects given by estimates of the national multiplier. Moreover, this is affected by a state's demographic factors and industry structure, which are unlikely to change over the short to medium run.

Second, the federal government needs to acknowledge that its legislated tax changes do not have a neutral effect across U.S. states and therefore can aggravate regional economic differences. Thus, it could be argued that disadvantaged states should be compensated, which could be achieved, for instance, by implementing a vertical or horizontal fiscal insurance mechanism as implemented in other countries comprised of federal states, such as Canada or Germany.

Third, state governments may want to consider offsetting federal tax shocks to avoid additional fluctuation in state income. However, doing so would require precise estimates of the respective income multipliers related to regional changes in fiscal policy, which opens up an interesting avenue for further research.

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Appendix

Data Description

The exogenous tax shock series is taken from the website accompanying the R&R (2010) paper, http://www.aeaweb.org/articles.php?doi=10.1257/aer.100.3.763. The GDP deflator, 2005 = 100, seasonally adjusted, is from BEA Table 1.1.4. CPI, 2005 = 100, seasonally adjusted, is from the Bureau of Labor Statistics (BLS), Series CU.S.R0000SA0. Inflation is computed as quarterly log-difference of the price level. Our main measure of the interest rate is the effective Federal Funds rate, computed as arithmetic averages of monthly averages. For the sake of robustness, we employ three alternative measures of interest rates: 1-, 3-, and 1-year Treasury constant maturity rates. For 1- and 3-year bonds, the values until 1953-II are based on the 3-month auction high bill rate. In case of the 10-year maturity, a composite yield on U.S. Treasury bonds with maturity over 10 years is used for the early years. All interest rate data are from the Board of Governors. Observations of the Federal Funds rate from 1950-I to 1954-II are based on Martens (1958). Population is based on linear interpolations of U.S. Census Bureau annual state-level population estimates.

We define government expenditures as the sum of government consumption expenditures, current transfer payment, and gross government investment. Revenues are the sum of current tax receipts, contributions for government social insurance, and current transfer receipts. Data for general and federal government are from BEA Tables 3.1 and 3.2, seasonally adjusted, and transformed to logarithms, real, and per capita terms as needed. Personal income data are from BEA Table SQ1, seasonally adjusted, and transformed to logarithms, real, and per capita terms as needed.

We further apply a set of exogenous controls. The Bretton Woods Dummy is 1 until the "Nixon Shock" in 1971-III. From Hoover and Perez (1994), we take oil price shock dummies. The Ramey Shapiro dummy for military buildups is based on Ramey and Shapiro (1998) and extended in Ramey (2011a) to cover the military buildup following 9/11. From the R&R (2010) dataset, we take a dummy variable for shifts to anti-inflationary monetary policy. Finally, we take the price of crude petroleum based on BLS WPU0561.

Data on the composition of state-level personal income are from BEA Table SA05. We compute average shares on personal income over the time period 1958 to 2001. Average real personal income per capita is computed over 1950 to 2007 and obtained from BEA

Table SA1-3. Price adjustment is based on the GDP deflator. The unemployment rate is the average over 1976 to 2007 and comes from BLS Local Area Unemployment Statistic. Median age is the average of the Censuses 1980, 1990, and 2000, as provided by the U.S. Census Bureau. The dependency ratio is defined as share of population younger than 18 or older than 64. It is computed as averages of the Censuses 1970, 1980, 1990, and 2000, as provided by the U.S. Census Bureau. Total state tax revenue in percent of personal income, average over 1950 to 2007, is based on U.S. Census Bureau State Government Finances. Yamarik (forthcoming) provides state capital estimates for 1990, 2000, and 2007. We take averages of values standardized by personal income. To proxy employment intensity, state wage and salary disbursements are expressed in percent of personal income. Averages are computed for 1958−2001; data source is BEA Table SA07. Regional dummies are based on the BEA definition of economic regions, see http://www.bea.gov/regional/docs/regions.cfm.

Table A1 Peak Effects in Extended Model

Geographic Unit	Bench	WT	IV	WG	IV	FG	IV	I	II
United States	-1.4**	-1.4 *	-1.4 **	-1.6 **	-1.5 **	-0.4 *	-1 *	-2.8 **	-1.4 *
Alabama	-1.7**	-1.6 **	-1.7 **	-1.8 **	-1.7 **	-0.7 **	-1.3 **	-3.2 **	-1.6 *
Alaska	-1.4	-1.2	-0.8	-2	-1.5	0.5	-0.8	-0.9	-1.6 *
Arizona	-1.5*	-1.5 *	-1.5 *	-1.8 *	-1.7 *	0	0	-0.9	-2.1 *
Arkansas	-1.7*	-1.7 *	-1.7 *	-1.6 *	-1.6 *	-0.4 *	-0.9 *	-4.5 **	-1.3 *
California	-2**	-2 **	-1.9 **	-2.1 **	-1.9 **	-0.6 *	-1 *	-2.4 **	-2.6 *
Colorado	-0.7	-0.7	-0.7 *	-1.3 *	-1.2 *	-0.2	-0.8 *	-2.4 *	-0.4 *
Connecticut	-1.4*	-1.4 *	-1.2 *	-1.6 *	-1.6 *	-0.3	-1.2 *	-3.2 *	-2.4 *
Delaware	-1.9**	-1.9 *	-1.8 **	-2 **	-2 **	-0.9 **	-1.6 **	-3.3 *	-1.9 *
DC	-1.1*	-1.1 *	-1.3 *	-1.1 *	-1.3 *	-0.2	-1.2 *	-3 *	-1.6 *
Florida	-2.5**	-2.5 **	-2.2 **	-2.4 **	-2.2 **	-0.8 *	-1.6 **	-3.5 *	-2.4 *
Georgia	-1.6*	-1.6 *	-1.6 *	-1.9 *	-1.8 *	-0.3 *	-1.3 *	-3.8 **	-0.5
Hawaii	-3.3**	-3.4 **	-3.3 **	-3.4 *	-3.2 **	-1.5 **	-3.6 **	-2.5	-5.4 *
Idaho	-2.3**	-2.3 **	-2.5 **	-2.4 **	-2.5 **	-0.9 *	-2.5 **	-5.3 **	-1
Illinois	-1.2*	-1.2 *	-1.1 *	-1.4 *	-1.4 **	-0.4 *	-0.9 *	-3 **	-0.4 *
Indiana	-1.5*	-1.4 *	-1.6 *	-1.7 *	-1.8 *	-0.7 *	-1.3 *	-4 **	-0.2
Iowa	-1.7*	-1.7 *	-1.6 *	-1.9 *	-1.7 *	-0.3	-1.5 *	-5.5 **	-1.1 *
Kansas	-1.5*	-1.5 *	-1.4 *	-1	-1.1 *	-0.6 *	-1 *	-3.9 *	-0.1
Kentucky	-1.3*	-1.3 *	-1.2 *	-1.5 *	-1.6 *	-0.4 *	-1 *	-2.7 **	-0.8
Louisiana	-1.3*	-1.2 *	-1.2 *	-1.2 *	-1.3 *	-0.2	-0.4	-3.2 **	-0.9
Maine	-1.8**	-1.8 *	-1.9 **	-2.1 **	-2.1 **	-1.1 **	-1.6 **	-3.1 **	-1.7
Maryland	-1.8**	-1.8 **	-1.7 **	-2 **	-1.8 **	-0.4	-1.5 **	-2.5 *	-2.3 **
Massachusetts	-1.6*	-1.5 *	-1.4 *	-1.8 *	-1.6 **	-0.6 **	-1.3 **	-2.6 **	-1.9
Michigan	-1.6*	-1.6 *	-1.7 *	-1.8 *	-1.8 *	-0.4	-1.3 *	-4.5 **	-0.3
Minnesota	-2**	-2 **	-1.9 **	-2.3 **	-2 **	-0.5 *	-1.5 **	-4.2 **	-1.5 *
Mississippi	-1.1	-1	-0.8	-1.1	-0.9	-0.3	-0.4	-4.6 **	-0.4
Missouri	-1.1*	-1.1 *	-1.1 *	-1.1 *	-1.2 *	-0.4 *	-1 *	-3.2 **	-0.3
Montana	-2.1**	-2.1 **	-2.2 **	-2.1 **	-2.2 **	-0.1	-2.2 **	-6.3 **	-1.5 *
Nebraska	-1.7*	-1.6 *	-1.5 *	-1.6 *	-1.5 *	-0.1	-1.5 *	-5.7 **	-0.7
Nevada	-0.3	-0.4	-0.3	-0.2	-0.2	0.5 *	-0.3	-1.7 *	-0.3
New Hampshire	-1.7*	-1.8 *	-1.8 *	-2 **	-2 **	-0.8 **	-1.3 *	-3.1 **	-2.1 *
New Jersey	-0.9*	-0.9	-0.8 *	-1.1 *	-1 *	-0.4 *	-0.8 *	-2.1 *	-1.4
New Mexico	-0.7*	-0.7 *	-0.6 *	-0.8 *	-0.7 *	0.2	-0.5 *	-1.8 **	-0.7 *
New York	-1.4*	-1.4 *	-1.2 **	-1.5 *	-1.3 *	-0.2	-1.2 **	-2 *	-3 *
North Carolina	-1.7*	-1.7 *	-1.6 *	-2 **	-1.9 **	-0.6 *	-1 *	-3.2 **	-1.1
North Dakota	-2.7*	-2.5	-2.8	-2.7	-3.2 *	0.1	-2.1	-12.3 **	-0.9
Ohio	-1.9**	-1.7 *	-1.9 **	-2 **	-2.1 **	-0.5 *	-1.5 **	-3.5 **	-0.3
Oklahoma	-1.9*	-1.8 *	-1.7 *	-1.6 *	-1.8 *	-0.8 *	-1.1 *	-3.2 *	-1.4 *
Oregon	-1.4**	-1.3 **	-1.3 **	-1.4 *	-1.5 *	-0.7 **	-1.4 **	-3.1 **	-0.6 *
Pennsylvania	-1.2*	-1.2 *	-1.2 *	-1.4 *	-1.3 **	-0.6 **	-1.1 **	-3.1 **	-0.9
Rhode Island	-1.7**	-1.8 **	-1.7 **	-1.8 **	-1.8 **	-0.9 **	-1.6 **	-3.5 **	-2.4 *
South Carolina	-2.4**	-2.4 **	-2.2 **	-2.5 **	-2.3 **	-0.4 *	-1.7 **	-4.8 **	-1.3
South Dakota	-3*	-2.9 *	-2.4 *	-3.4 *	-2.3 *	-0.4	-1.8 *	-8.5 *	-1.1
Tennessee	-1.6*	-1.5 *	-1.5 *	-1.7 *	-1.7 **	-0.7 **	-1.2 *	-3.6 **	-0.4 *
Texas	-1.6*	-1.6 *	-1.5 *	-2 *	-1.9 *	-0.4	-0.6 *	-3 **	-1
Utah	-0.2	-0.1	-0.2	-0.2	-0.4	-0.2	-0.2	-0.9 *	-0.4
Vermont	-1.7*	-1.7 **	-1.6 *	-2 **	-1.9 **	-0.9 **	-1.3 *	-3.9 **	-1.9 *
Virginia	-2**	-2 **	-1.9 **	-2.1 **	-2 **	-0.9 **	-1.4 **	-2.2 *	-2.2 *
Washington	-1.7**	-1.8 **	-1.8 **	-1.7 **	-1.8 **	-0.7 *	-1.1 *	-4.2 **	-1.2 *
West Virginia	-0.6	-0.6	-0.6	-0.8	-0.8	-0.5 *	-0.7	-2.4 *	-0.3
Wisconsin	-1.3*	-1.3 *	-1.3 *	-1.5 *	-1.4 *	-0.7 *	-0.9 *	-3.7 **	-0.5 *
Wyoming	-1.1	-1	-0.8	-1.8 *	-1.7 *	-0.4	-0.6	-2.5 *	-1.7
Max	-0.2	-0.2	-0.9	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2
Min	-3.3	-3.3	-12.3	-5.4	-3	-3.4	-3.3	-3.4	-3.2
SD	0.6	0.6	1.85	0.95	0.56	0.6	0.6	0.62	0.56

*Notes: Table show peak multipliers following a tax increase equal to 1 percent of personal income. Bench is the benchmark model. WT is model without taxes; WTG is model without government. FG means Favero and Giavazzi (forthcoming) specification. IV implies IV estimation, as in Perotti (2011), of the respective column on the left side. I and II are the subsamples 1950-I to 1979-IV and 1980-I to 2007-IV, respectively. ** indicates significance at two standard error deviations, * significance at one standard error deviations.*

Table A2 Accumulated Differences Across Regions in Extensions

Geographic Unit	Bench	WT	IV	WGT	IV	FG	IV	I	II
Alabama	-3.9	-3.7	-5.3	-3.5	-3.7	-5.6 *	-5.1	8.7	-8.6
Alaska	10.3	12.5	14.3	2.2	5.4	22.2 *	17.1	52.1	-5.5
Arizona	6.7	5.9	6.6	3.4	4.1	10.7 *	18.5 *	36.7 *	-5.8
Arkansas	-1.2	-1.1	-1.8	1.5	1.1	1.5	3.3	-8.7	2.6
California	-5.7	-6.1	-5.4	-4.6	-4.1	-0.7	0.2	9	-14.4 *
Colorado	14*	14.2 *	14.1 *	7	7	6.2	17.3 *	15.4	12.4
Connecticut	1.1	0.5	1.7	-0.7	-1.1	1.8	-1.5	0.8	-14.8
Delaware	-7.1	-6.3	-6.8	-8.1	-9.2	-8.5 *	-8.9	3.6	-17.7 *
DC	20.1	21.6	20.5	21.3	19.4	5	10	33.3	-6
Florida	-17.9*	-17.7 *	-15.3 *	-14 *	-13.1 *	-6.3 *	-10.6 *	-11.2	-19 *
Georgia	-3	-3	-3.4	-5.2	-4.9	1.8	-2.9	-17.3 *	12.4
Hawaii	-35.1*	-37 *	-35.1 *	-34.1 *	-32.7 *	-23.2 *	-41 *	6.9	-76.6 *
Idaho	-9.6	-10.2	-6.9	-8.4	-7.6	-7.7	-15 *	-29.6	0.7
Illinois	7.1*	7.1 *	7.3 *	5.5 *	5.4 *	2.7	4	0.1	13.5 **
Indiana	2	2.2	-0.3	1.1	-0.6	-3.5	-1.7	-7.4	23.9 *
Iowa	-4.2	-3.7	-3.3	-5	-4.3	3.5	-4.5	-16.4	10.6
Kansas	-0.1	0.4	0.4	8.7	7.4	-2.5	0.6	-15.2	26.2 *
Kentucky	4.1	3.7	4.1	2.9	1.4	2.5	2.7	5.3	10.4
Louisiana	5.4	6.2	4.7	8.8	4.6	6.9	11.8 *	-6.1	11.9
Maine	-8.6	-9.5	-9.3	-10.3	-9	-9.8 *	-11.1 *	-1	-14.4
Maryland	-4.8	-5.6	-4.5	-6.7	-5.5	3.4	-5.6	9.4	-18.2 *
Massachusetts	-2.1	-2.7	-0.6	-5.5	-3.9	-2.7	-4.1	1.4	-10.6
Michigan	5.4	5.4	3.2	4	2.3	4	-1.3	-13.4	20.8 *
Minnesota	-8.9	-8.9	-8.7	-11.7 *	-10.8 *	-1.3	-5.9	-6.9	-0.9
Mississippi	11.4	11.7	12.6	13.1	13.1	8.5 *	15.8 *	-10.5	23.7 *
Missouri	4.9	4.8	4.5	6	5.8	1.9	1.8	1.8	15.1 *
Montana	7	8.5	9.3	5.3	5	11.9 *	6.1	-19.9	30 *
Nebraska	-2.9	-1.2	-2.6	3.8	1.9	7.6	-7.4	-19.2	10.3
Nevada	26.1*	25.7 *	26.2 *	32.4 **	32.6 **	25.1 **	20 *	47.3 **	20.3
New Hampshire	-2.4	-3.2	-4	-5.9	-6.4	-4.9	-3.2	-4.1	-13.8
New Jersey	7.8*	7.4	7.9 *	7.6 *	8.1 *	0.4	2.8	10.2	0.2
New Mexico	15.9*	15.8 *	15.9 *	13.4 *	13.5 *	16.1 **	18.1 *	30.9 *	7.7
New York	0.4	0.6	2.4	-0.6	0.7	6.2 *	-0.6	11.8	-23 *
North Carolina	-2.3	-2.5	-2	-5.9	-5.9	-2.4	1	-6.3	4
North Dakota	-2.4	6.4	-4.6	-5.2	-13	19.6	-5	-55	55.7 *
Ohio	-3.6	-3.4	-3.1	-4.5	-2.9	-1.7	-3.5	-6	15.3 *
Oklahoma	-4.3	-3.9	-4	0.4	-1.7	-8.2 *	3.2	-4.1	-2.6
Oregon	3.3	3.6	2.8	4	2.7	-1.4	-0.9	-5.3	22 *
Pennsylvania	2.2	2	1.8	1.6	1.8	-5.2 *	-2.4	-2.5	6.2
Rhode Island	-6	-6.7	-6.1	-5.1	-5.3	-7.9 *	-9.9 *	-8.2	-23.8 *
South Carolina	-12.9*	-13.5 *	-12.3 *	-13.6 *	-12.3 *	1.8	-9.6 *	-32.4 *	1.9
South Dakota	-12.5	-10.7	-9.1	-26.3	-13.8	5.4	-11.2	-16.4	10.2
Tennessee	0.3	0.3	0.3	0.5	-0.1	-2.9	-1.5	-12.4 *	22.2 *
Texas	1.5	1	1.5	0.2	0.7	-0.7	9.2	-4.6	9.6
Utah	31.4**	31.8 **	31.1 **	26.9 **	24 **	7.5 *	27.4 **	53 **	15.6
Vermont	-5.3	-5.5	-5.1	-9.3 *	-8.7 *	-8.8 *	-5.7	-15.4	-11
Virginia	-10.8*	-11.3 *	-10.7 *	-9.4 *	-9.4 *	-5.9 *	-8.4 *	1.8	-19.2 **
Washington	-1.6	-1.5	-1.1	2.5	2.5	-3.7	-2.5	-20.5 *	12
West Virginia	16.2*	16.1 *	15.7 *	14.6 *	14.8 *	-0.1	11	25.3	34.2 *
Wisconsin	2.6	2.5	2	0.9	0.8	-5.2 *	1	-11.1 *	24.2 **
Wyoming	10.9	10.4	12.4	-1.3	0.5	-2.1	25.6 *	14.7	8.8

Notes: Table shows accumulated difference between state and national response after 20 quarters. See notes to Table A1.