CROSS-STATES HETEROGENEITIES IN THE TRANSMISSION OF THE U.S. NARRATIVE TAX CHANGES

Masud Alam†

Abstract

This paper investigates the assumption of homogeneous effects of federal tax changes across the U.S. states and identifies where and why that assumption may not be valid. More specifically, what determines the transmission mechanism of tax shocks at the state level? How vital are states' fiscal structures, financial conditions, labor market rigidities, and industry mix? Do these economic and structural characteristics drive the transmission mechanism of the tax changes at the state level at different horizons? This study employs a panel factor-augmented vector autoregression (FAVAR) technique to answer these issues. The model identifies tax shocks using sign restrictions with Uhlig's penalty function. The findings show state economies respond homogeneously in terms of employment and price levels; however, do react heterogeneously in terms of real GDP and personal income, and, in most states, these reactions are statistically significant. The heterogeneity in the effects of tax cuts is significantly related to the state's fiscal structure, manufacturing and financial composition, and the labor market's rigidity. The cross-state regression analysis shows that states with higher tax elasticity, higher personal income tax, strict labor market rigidity, and policy uncertainties are relatively less responsive to federal taxes. In contrast, the magnitude of the response in real GDP, personal income, and employment to tax cuts is relatively higher in states with a larger share of finance, manufacturing, lower tax burdens, and flexible credit markets.

Keywords: Narrative tax changes; personal income tax; corporate income tax; FAVAR; state-level; macroeconomic factors; sign restrictions; penalty function.

JEL Codes: C5, E23, E24, E62, H25

---

*I would like to thank Professor Jeremy R. Groves, Carl Campbell, and Ai-ru (Meg) Cheng for supporting my research and the valuable feedback they shared with me.
†PhD candidate, Department of Economics, Northern Illinois University, Email: masud@niu.edu

1 Introduction

This paper investigates the effects of federal tax changes on the U.S. state-level economic activity and examines the assumption of homogeneous effects of federal tax cuts across states and identifies where and why that assumption may not be valid. The study considers exogeneous personal and corporate income tax changes using Romer and Romer's (2009) narrative identification method. Narrative tax shocks are combined with vector autoregressive (VAR) models with aggregate and regional macroeconomic factors to examine the effects of federal tax changes on the state-level real GDP, personal income, employment, and price levels.

The existing literature examining the macroeconomic effects of federal tax changes assume that tax shocks affect all states the same way, which does not seem realistic. The empirical literature on the impact of federal tax changes, pioneered by Romer and Romer (2010), and Mertens and Ravn (2013) use narrative tax shocks to estimate an aggregate tax multiplier. However, this aggregate estimate does not consider the importance of state-level fiscal capacities, industrial mix, financial frictions, and labor market heterogeneities in the transmission of federal tax shocks.

While all states are subject to identical federal tax policy, every state has a unique mix of policy and political ideology impacting output growth, employment, and investment. States are also characterized by different public institutions, economic structures, and levels of regulations controlling public debt. Such diversity and policy complexity across the states' highlights the importance of examining the validity of the homogeneous impact assumption and, if found unwarranted, to uncover what factors within the state economies impacted and how.

In addition to the state heterogeneities, limited information set associated with the small-scale structural VAR models, omitted variable bias, and the recursive identification of policy shocks also lead to forecasts that run contrary to the standard macroeconomic theory, such as price puzzles and delayed exchange rate overshooting. The dynamics of macroeconomic variables across the U.S. states are possibly related to a far wider regional and aggregate policy variables than typically considered in small-scale VAR models. Therefore, the estimation of federal tax policy changes is likely to be biased if the additional regional and aggregate information not included in the VAR system.

The measurement issue of omitted variable bias can be a serious problem when we do not have theoretical criteria about the number and the choice of relevant states and regional variables. Several alternative specification schemes ranging from Bayesian VAR models to sign restrictions, and the penalty function approach are proposed and applied to solve the identification problems (Banbura, Giannone and Reichlin, 2007; Scholl and Uhlig, 2006; Uhlig, 2005). Depending on the choice of a suitable prior and the selection of appropriate a priori signs, the forecast analysis in these methods may also produce mixed success.

Given the disaggregated level focus of this study, a state-specific small-scale structural VAR model may deliver biased estimates (Hansen and Sargent, 1991; Mertens, 2019; Stock and Watson, 2018) that could be solved with additional control variables. This study attempts to solve the identification problem of small-scale structural VAR models by estimating a panel factor augmented vector autoregressive (FAVAR) model across all 50 states. The model extracts U.S. regional and aggregate common macroeconomic factors from an extensive panel data set covering eight Bureau of Economic Analysis (BEA) regions and a panel of 126 output, prices, employment, and monetary and financial variables.

The FAVAR model contains information from a large panel of regional variables and the comovement of the aggregate of macroeconomic variables and confirms that the dynamics of federal and regional variables are adequately controlled through the factors. This specific technique allows this study to deal with dimensionality reduction of the region- or state-specific unobserved influences while mitigating the omitted variable bias in a parsimonious way. As a result, the magnitude and the direction of impulse response functions that the specification delivers through the control of factors ensure that the state-level estimates are likely unbiased and significantly similar to the federal counterparts.

This study adopts the narrative approach (Romer and Romer, 2009) to identify exogenous tax changes relying on the reports published by Congressional Budget Office, the Committee on Ways and Means, Senate and Congressional records, and the Economic Report of the President to classify tax changes that designed to stimulate long-run growth and not directly related to current economic conditions. The narrative dataset of this study includes eleven personal income and nine corporate income tax changes. The FAVAR models identify tax shocks by imposing sign restrictions on the responses of state-level macroeconomic variables with Uhlig's (2005) penalty function. The penalty function warrants that policy shocks are orthogonal to other shocks and deliver a unique solution for the impulse response function (IRFs).

The FAVAR estimates suggest that the magnitude and persistence of GDP, employment, personal income, and price responses are heterogeneous across states, and, in most states, these responses are statistically and economically significant. The impulse response functions (IRFs) support the imposed a priori signs about the theoretical prediction of the New Keynesian model of the unanticipated tax cut shocks. A one percent cut in personal income tax increases real GDP by about 1.2 percent on impact and a maximum of 1.9 percent after four years. A one percent cut in corporate income tax cut raises real GDP on impact by 0.52 percent and by 0.83 percent after two years. Cuts in personal income tax increases real GDP in 33 states, raises personal income in 39 states, and drives the price level up in 46 states. The same unanticipated corporate tax cuts show a significant rise in real GDP and personal income for around 40 states, while price level rises in 48 states with insignificant effects in the remaining states. The direction of state employment response is significantly homogenous in regards to the shock across the U.S. states. However, the magnitude and persistence of employment responses are most considerable in 14 states, with employment rising by a maximum of about 1.6 percent after the personal income tax cut, and 0.8 percent for the corporate tax cut. The impact of either tax cut persists for more than five years.

The study then investigates the importance of state-specific structural characteristics for the transmission mechanism and the heterogeneous responses of federal tax changes. A cross-state regression analysis between state-specific cumulative responses and states' structural characteristics shows that states with a higher financial and manufacturing concentration in their industry share, smaller tax burdens, smaller degree of labor market rigidities and economic policy uncertainty, and a higher capacity of job creation appear to be the more responsive states in real GDP and personal income to the change in either taxes. In contrast, the magnitude of the response in price levels and employment to a corporate tax cut is relatively higher in states with a broader credit channels, a smaller degree of financial friction, and a smaller degree of labor market rigidities. Results further show that the estimated average response is higher for a personal income tax cut than the same amount of cut in personal income tax. These empirical findings are broadly consistent with the recent disaggregated studies of Auerbach (2006); Gravelle (2010); Owyang and Zubairy (2013), and Suarez and Zidar (2016).

The findings of this study contribute to the tax cuts literature of the dynamic factor model, and on the agreement that tax cuts have short to medium-run significant positive effects at a more disaggregated level (Liu and Williams, 2019; Mertens and Montiel Olea, 2018; Zidar, 2017). The magnitude of IRFs is consistent with the aggregate-level analysis of Blanchard and Perotti (2019) and Mertens and Ravn (2013). For example, the maximum per capita GDP response to a personal income tax cut in Mertens and Ravn (2013) is 1.8 percent, while the maximum response of this study is 1.9 percent. Additionally, the transmission mechanism of changes in federal tax policy changes of this study is similar to disaggregated empirical fiscal policy literature (Liu and Williams, 2019; Owyang and Zubairy, 2013), while it also adds new evidence of labor market rigidities, fiscal capacity, and financial frictions on the sources of heterogeneity of state-level estimates.

In theoretical context, the findings of this study are further related to the New-Classical (Kydland and Prescott, 1982; Long and Plosser, 2006; McCallum and Whitaker, 1979) and the Keynesian models (Christiano et al., 2011; Rotemberg, 1987) that theorize the transmission mechanism of federal tax shocks on economic activity. The FAVAR models' findings match the short-term prediction of the expansionary effect of tax cuts on real GDP, employment, and profits through the aggregate demand (AD) and the firm's costs channel. The cross-state regression analysis provides the theoretical insight of microeconomic channels about how the state's financial sectors and fiscal structures interact with the transmission of federal tax changes (Bianchi, 2016; Blinder and Solow, 1973; Christ, 1968; Godley and Lavoie, 2007; Greenwald, Stiglitz, and Weiss, 1984).

The rest of the paper's layout is as follows: a review of related literature, with a specific focus on the narrative tax shocks and the disaggregated effects of tax cuts, is in section 2.2. Section 2.3 provides the specification of the panel FAVAR model and the data. Section 2.4 presents the empirical analysis factor identification, model specification, the dynamic response of the state economy, and the sign restrictions imposed on the response of the state-specific macroeconomic variables. The states' characteristics and heterogeneities in the transmission of tax shocks are in section 2.5. Section 2.6 conducts several robustness analyses of the baseline regression results, while section 2.7 concludes the paper.

2.2 Literature review

Literature examining the effects of tax changes at the state level is relatively limited and generally divided into two competing categories. The first category follows the macroeconomic approach, mostly relying on small-scale SVAR models (Herrera and Rangaraju, 2019; Hooker and Knetter, 1997; Hussain and Malik, 2016; Liu and Williams, 2019; Nekarda and Ramey, 2011; Owyang and Zubairy, 2013).

The main advantage of the structural VAR approach is that it exploits information directly from the time series data, minimizes the risk of measurement errors, and delivers an empirically grounded answer to the research question. The SVAR systems estimate the dynamic impact of policy shocks, where the system automatically allows the data to structure the model. This specification examines the response of variables to a policy shock without using a specified structural model. The SVAR technique, however, requires researchers to impose a priori restrictions on the model parameters and can capture limited information set to modeling the effects of the policy changes, the combination of which often yields counter-intuitive empirical results (Forni et al., 2005; Hansen and Sargent, 1991; Stock and Watson, 2016).

The second, or microeconomic approach (Giroud and Rauh, 2019; Ljungqvist and Smolyansky, 2014; Serrato and Zidar, 2018), mainly focuses cross-states empirics relying heavily on standard economic theory. For example, an individual firm's investment and labor demand response to changes in state taxation, as examine by Giroud and Rauh (2019), estimates corporate tax elasticities and pass-through tax effects using firm-level information.

There are also several cross-state micro-studies for the U.S. which focus on the impact of state-wide tax changes on economic growth: the effect of state and local tax on state's economic growth examines by Helms (1985), Mullen and William (1994) Reed (2008), Holcombe and Lacombe (2004) and Poulson and Kaplan (2008); the nonlinear effects of U.S. state taxes on states economic growth in Bania, Gray and Stone (2007); and more recently, Gale, Krupkin and Rueben, (2015) investigates how state tax policy affects economic growth, employment, and entrepreneurial activity. Zidar (2019) finds the distribution of income across U.S. states strongly correlated with the variation in the response of federal tax cuts, which is similar to the cross-states regression results of this study, where both median income and the state's tax burden have significant effects on state-level tax shock responses. Although there are some exceptions (Herrera and Rangaraju, 2019; Yang, 2005; Gruber and Saez, 2002), a substantial consensus is reached in the literature on the robust relationships between a tax cut and economic growth across U.S. states, supports the New Keynesian prediction of the expansionary effect of tax cuts and the FAVAR results of this study.

This study follows the first approach but differs in methodology and empirical implementation. Like Herrera and Rangaraju (2019), the focus of this study is on the heterogeneity in the response of state macroeconomic activities to federal tax shocks. They examine the response of state-level personal income and employment to a news-based implicit tax shock by using the FAVAR framework. While they use news-based tax foresight as a proxy of a shock to the implicit tax rate and the state-level dynamics of tax revenue shocks, the focus of this study is to identify narrative tax changes as an exogenous policy shock. This study also relies on the FAVAR model but performs a sign restriction with Uhlig's (2005) penalty function to identify tax shocks. In contrast to their zero contemporaneous restriction approach (as in Leeper, Walker, and Yang, 2013) and apply Markov Chain Monte Carlo (MCMC) method to estimate the impulse responses and unobserved factors separately.

The most recent literature closest to this study is Liu and Williams (2019), who investigate the heterogeneous responsiveness of federal tax policy changes at the state level using a small-scale structural VAR model. The findings of their study show the output and employment responses for more than 50 percent of U.S. states are not statistically significant, which poses a question about the limitation of the small-scale SVAR identification strategy. In comparison to their study, the state-level focus of this study is on a broader set of structural characteristics, where the exogenous factors control a broader extent of aggregate and regional variables.

Hussain and Malik (2016) also examine the asymmetric effects of unanticipated tax changes on states' output and they find asymmetric non-linear impulse responses only for personal income tax changes, whereas a considerable symmetry appears in output response to the corporate income tax changes. There is also empirical level analysis on the state-level heterogeneous responses, such as Owyang and Zubairy (2013) who examine military spending shocks on state-level personal income and employment; Nekarda and Ramey (2011) investigate the transmission mechanism of government spending shocks on output, and Serrato and Zidar (2018) are on the importance of state corporate tax structures. While the evidence of heterogeneous responses of output and employment is robust in these kinds of literature, they employ either a low-dimensional VAR or reduced form equation methods. As Stock and Watson (2016) and Forni et al. (2005) pointed out, the low-dimensional VAR models in these kinds of literature face significant challenges, such as identifying exogenous fiscal shocks and omitted variable bias, and limited information or curse of dimensionality. For instance, Owyang and Zubairy (2013) employ a seven-variable VAR model, and Liu and Williams (2019) consider four-variable VARs to study the effects of narrative tax changes.

Therefore, the empirical specification needs to augment the standard VAR model with unobserved aggregate and regional factors. As Mertens (2019) mentions, the highly endogenous nature of federal tax changes implies that the small-scale VAR model with only state-level macroeconomic variables cannot capture sufficient information on the random variation of tax shocks. The information insufficiency could be the potential reason to expect that the estimates are biased, and the confidence intervals are relatively wider than assumed. This study attempts to address this information deficiency problem by estimating a factor-based panel VAR model that incorporates aggregate and regional information as a control variable (Mertens, 2019; Stock and Watson, 2018).

2.3 Econometric model

The panel FAVAR model uses information from the state-, regional-, and federal-level data. The approach accounts for the identification of the federal- and region-specific unobserved influences that reduce omitted variable bias. The state-level analysis includes three sets of information: the first set of information comes from federal-level data, the second set of factors is related to the regional data, which represents the economic characteristics for a specific Bureau of Economic Analysis (BEA) region, and finally, the state-level economic characteristics. There are two reasons to include state and regional-level information: first, estimated factors capture the co-movement of states' economic dynamics, and second, they measure how unobserved regional characteristics influence the heterogeneous response of federal tax changes. This study then estimates a cross-state regression using a broader set of state-level covariates to uncover the determinants of heterogeneous responses.

2.3.1 The FAVAR Model

The empirical approach of this study is a panel FAVAR model that is initially introduced by Geweke (1977) and Sargent and Sims (1977) and later developed by Bai (2003), Bernanke, et al., (2005), and Stock and Watson (2002, 2016). The model assumes that there are two sources of states macroeconomic fluctuations: (i) shocks at the aggregate level which is common to all U.S. states (e.g., federal tax changes, FED monetary policy, and the oil price shocks), and (ii) region-specific idiosyncratic shocks that affect only a state or a BEA region. This set of assumptions is realistic where each state-specific macroeconomic variable depends on several unobserved common factors, regional macroeconomic aggregates, and federal policy changes.

In the empirical implementation, let X_t denote a $S\,x1$ vector of stationary macroeconomic variables (real GDP, personal consumption expenditure, consumer price index, and non-farm employment) at time t $(t = 1,...,T)$ for S states. The F_t^a and F_t^r are the $f\,x1$ vector of unobserved factors capturing the common comovement at the aggregate and regional level. T_t is a vector of narrative tax changes that is considered as an exogenous observable variable, and ω_t is an $S\,x1$ vector follows Gaussian distribution with zero mean disturbances with an $S\,x\,S$ variance-covariance matrix $\Sigma_\omega = diag(\sigma_1^2,...,\sigma_S^2)$. All these σ_S^i's is associated with the state specific macroeconomic series. Following Bernanke, Boivin, and Eliasz (2013), we can incorporate all the information in the following measurement equation that shows state-specific macroeconomic variables, unobserved factors, and common fiscal policy shocks (narrative tax changes) evolve according to the following equation:

$$X_t = \Lambda_F^a F_t^a + \Lambda_F^r F_t^r + \Lambda^T T_t + \omega_t \quad (1)$$

Here Λ_F is a coefficient matrix of factor loadings and Λ^T is coefficient matrix of narrative tax series T_t. It is assumed that the number of unobservable factors is smaller than the number of series at aggregate level $f << N$. Similarly, number of regional factors is also smaller than the number of regional series.

The variance-covariance matrix $\Sigma_\omega = diag(\sigma_1^2,...,\sigma_S^2)$ is a diagonal matrix that implies that comovement between X_t and T_t is arises from the dynamics of the factors. The dynamics of the factors $Z_t = (F'_{a,t}, T'_t)'$ is governed by a VAR process of order L and is given by the following state equation,

$$Z_t = B(Z'_{t-1},...,Z'_{t-L}) + \varepsilon_t \quad (2)$$

With $(f\,x\,k)\,x\,L(f\,x\,k)$ dimensional coefficient matrix B and ε_t are each $f\,x\,k$ dimensional vectors of shocks with ε_t following standard Gaussian distribution with zero mean and the variance-covariance matrix Σ_ε. In equation (1), each state-level macroeconomic variables are directly affected by narrative tax changes and indirectly through the aggregate factors in equation (2). The parameter Λ^F, Λ^T, the coefficient matrix B, and the unobserved dynamic factors F_t in equation (1) and (2) are unknown. As shown by Bai and Ng (2007) and Forni et al. (2009), assuming k and f are known, then a consistent estimation of all unknown parameters in (1) and (2) is estimated using two-step procedure as proposed by Bernanke, Boivin and Eliasz (2013).

2.3.2 Data

The state-level macroeconomic variables used in the panel FAVAR include real GDP, personal income, consumer price index, unemployment rate, and non-farm employment. From 1977 to 2018, the annual frequency of these series come from BEA regional accounts and the St. Louis Federal Reserve. All series are seasonally adjusted, and nominal series of GDP and personal income transformed into the real series using the GDP deflator. Summary statistics for the yearly sample of 1st, median, and 50th states between 1977 and 2018 are shown in Table 2.1 along with their correlation with the U.S. aggregates. The state-level tax data taken from three sources, annual personal and corporate income tax rates for 1977-2018 from the Tax Foundation, calculations by Serrato and Zidar (2016), and the compilation of state and local tax burdens data for 1977 – 2018 are from various Tax Foundation sources.

Table 2.1: Summary statistics of state-level macroeconomic variables

Summary statistics of state-level key macroeconomic variables

Variable	**States**	**Mean**	**Std.dev**	**Max**	**Min**	**CI of mean (95%)**	**Corr with U.S. aggregates**
Real GDP growth	**U.S.**	**2.6**	**1.85**	**7.13**	**-2.54**	**0.59**	**1**
	1st (CA)	3.31	2.6	8.06	-4.01	0.83	0.82
	Median (AL)	2.17	2.26	6.42	-3.93	0.83	0.81
	50th (VT)	2.88	2.80	10.00	-2.71	0.90	0.67
Disp. Pers. Inc	**U.S.**	**5.08**	**1.81**	**8.82**	**-0.30**	**0.63**	**1**
	1st (CA)	5.38	2.17	9.69	-0.15	0.76	0.88
	Median (AL)	4.77	1.89	8.41	0.25	0.66	0.83
	50th (WY)	4.99	3.76	8.43	-4.22	1.31	0.43
Employment	**U.S.**	**1.63**	**1.41**	**4.42**	**-3.11**	**0.45**	**1**
	1st (CA)	1.98	2.06	6.27	-3.95	0.65	0.89
	Median (KY)	1.25	1.50	4.16	-3.22	0.47	0.87
	50th (WY)	1.56	2.74	8.34	-4.66	0.87	0.39
Inflation (% change in CPI)	**U.S.**	**2.92**	**1.51**	**7.63**	**-0.32**	**0.50**	**1**
	1st (CA)	3.42	1.9	10.03	-0.02	0.62	0.74
	Median (CO)	3.20	1.9	9.39	-0.65	0.64	0.74
	50th (AK)	2.81	1.3	5.94	-0.48	0.43	0.95

2.4. Empirical results

2.4.1 Factor estimation

The factor identification method presented in section 2.3.1 extracts the common factors from the panel of aggregate and BEA regional macroeconomic series. Figure 2.1 and 2.2 plot the first factor of the aggregate and regional macroeconomic series and their relationship with the leading U.S. macroeconomic activity index. The factor is accurately tracking the growth and dynamics of U.S. aggregate economic activity. Figure 2.1 and 2.2 show that the aggregate factor entirely consistent with the macroeconomic trend of the Chicago Fed National Activity Index (CFNAI) and the Brave-Butters-Kelley's (Brave, Butters, and Kelley, 2019) Coincident Index. The dynamics of the BEA regional factor also show the similar comovement of aggregate economic expansions and contractions. The expansions at the beginning of 1982, and between 1992 and 2000. The contraction at the beginning of 2002 and during the severe recessions in 1973 and 2007-08.

2.4.2 Model specification

The model's objective is to estimate the response of state-level macroeconomic variables to federal tax changes. State-specific FAVAR model includes an aggregate-level macroeconomic factor, F_a and a regional factor F_r. The regional factors are from the eight BEA regional economic accounts. The regional factor F_r is orthogonal to the F_a. With the estimated factors, narrative tax changes, and state-level variables, the estimation of equation (1) and (2) uses sign restrictions with Uhlig's (2005) penalty function. The advantage of the penalty function is that it implements the unconstrained optimization by quadratic approximation (Powell, 2002). The model estimation algorithm employs the following steps when a given a set of sign restrictions are available and consistent with the economic theory:

(1) Estimate the unrestricted FAVAR in order to get $\hat{B}$ and the variance-covariance matrix $\hat{\Sigma}$

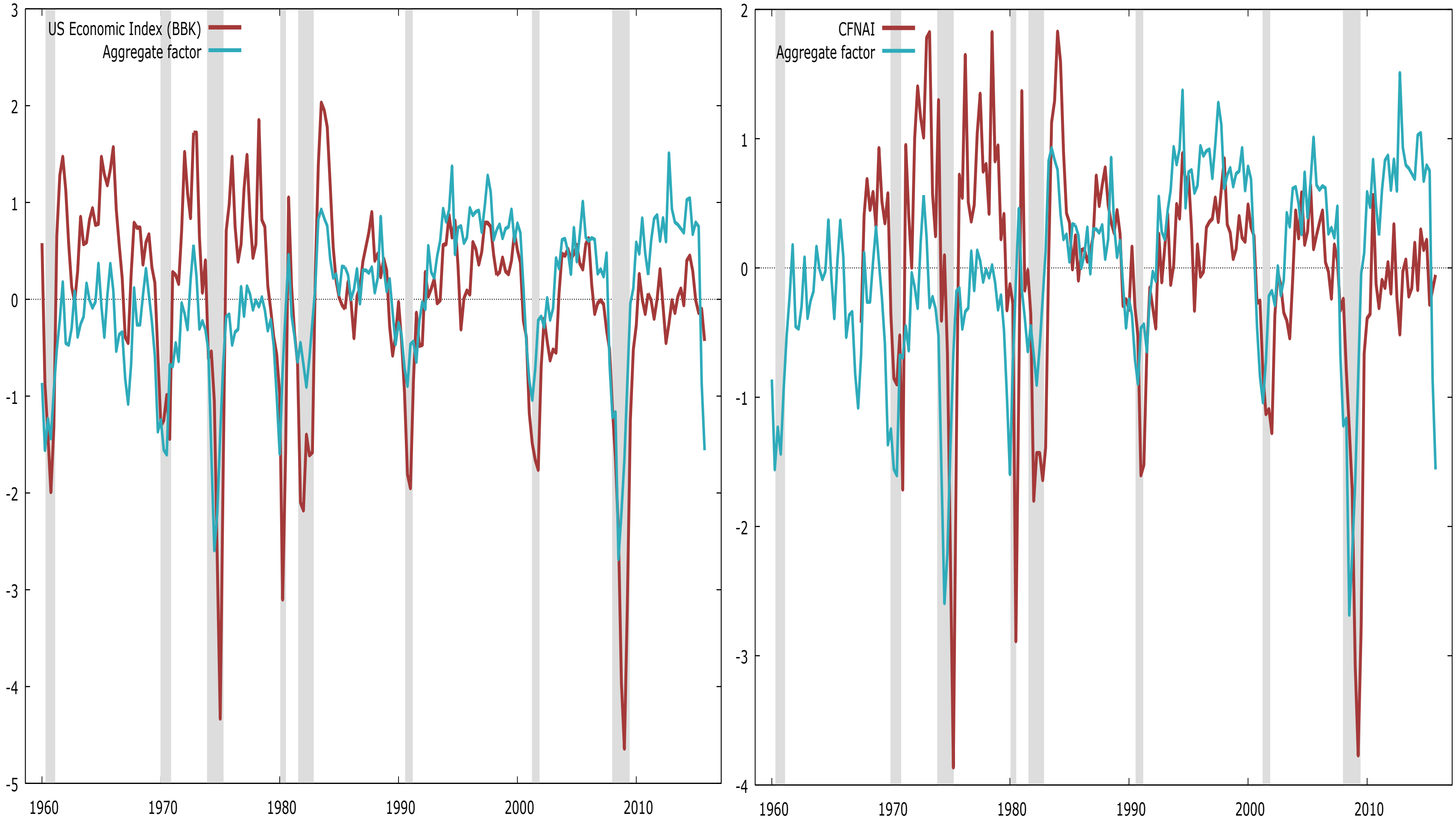

Figure 2.1: First principal component extracted from aggregate macroeconomic series. Graph shows the comovement between first factor and the CFNAI index and the Brave-Butters-Kelley (BBK; 2019) U.S. Coincident Index. The shaded vertical bars indicate official periods of economic recession for the U.S. as announced by the National Bureau of Economic Research.

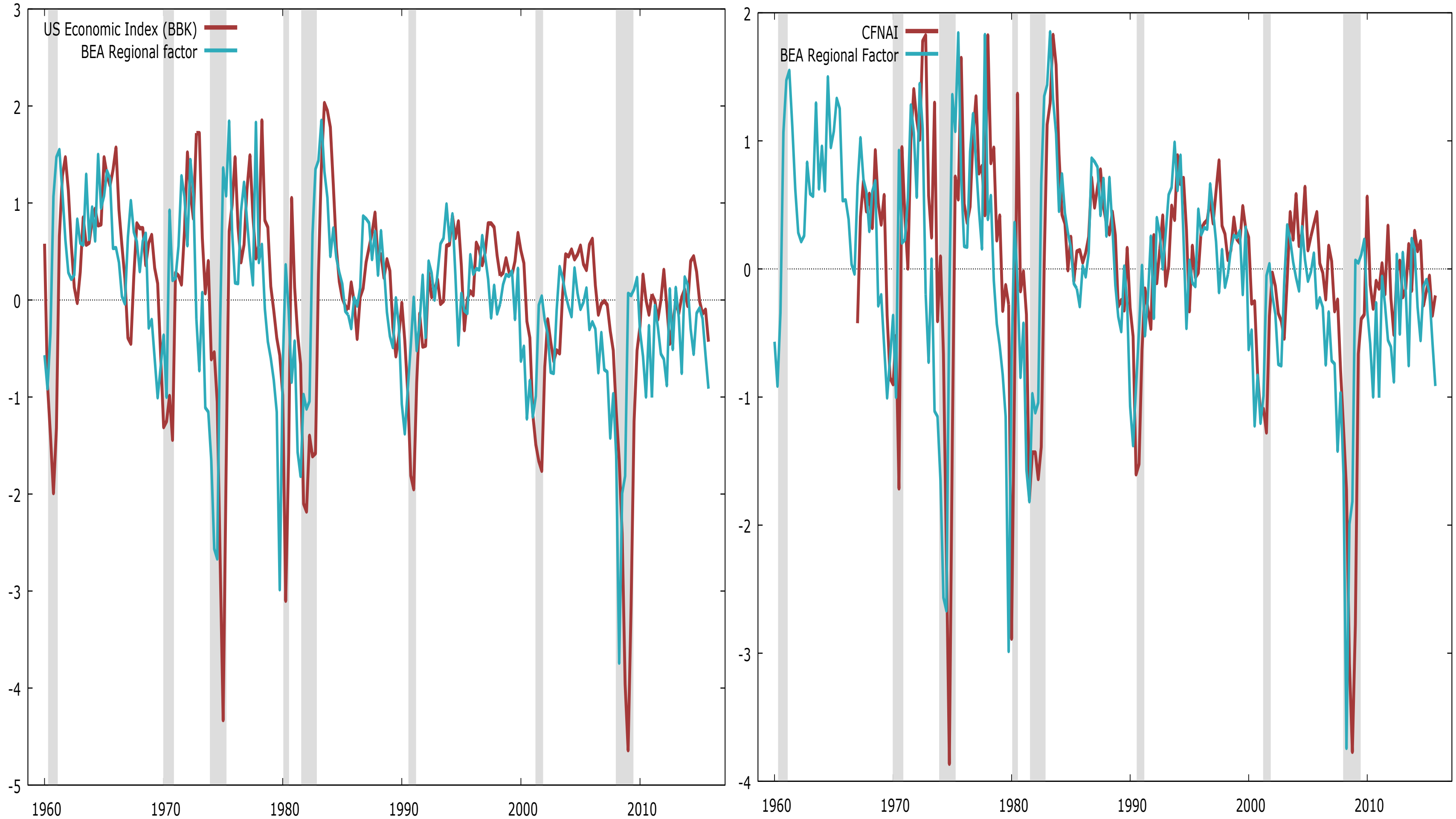

Figure 2.2: First principal component extracted from the BEA regional macroeconomic series. Graph shows the comovement between first factor and the CFNAI index and the Brave-Butters-Kelley (BBK; 2019) U.S. Coincident Index. The shaded vertical bars indicate official periods of economic recession for the U.S. as announced by the National Bureau of Economic Research.

(2) Apply a Cholesky decomposition to the model to orthogonalize narrative tax shocks and extract the orthogonal innovations

(3) Estimate impulse responses of the variable of interest or all the variables in the model

(4) Given $\hat{B}$ and $\hat{\Sigma}$, and impulse responses, an orthogonal impulse vector δ (which is based on the factor rotation) can be drawn using a standard random draw where $\delta = \tilde{B}a$. The n -dimensional vector $\|a\|=1$ comes from $(n-1)x1$ standard normal draw, and $\tilde{B}\tilde{B}' = \Sigma'$

(5) Impulse responses of the variables are multiplied by α and examine if the prior sign restrictions are satisfied. This step identifies an impulse response function which exactly satisfies *a priori* sign restrictions by minimizing penalty function

(6) If *a priori* sign restrictions hold, the model keeps the impulse responses; otherwise, the system drops the draw

Consistent with the standard macroeconomic theory, this study hypothesizes that an unanticipated tax cut shock at the federal level is expansionary and does increase the state's real GDP, personal income, employment, and the price levels for the specific horizons after the shock. Thus, the model specification imposes six restrictions to identify a narrative tax shock. The aggregate and the regional factor variables in the model remain unrestricted (**≅ 0**). Table 2.2 summarizes *a priori* sign restrictions:

Table 2.2: Sign restriction on the variables of the FAVAR model

	Sign restriction							
Variable	**GDP**	**DPI**	**CPI**	**EMP**	**Tax (PI)**	**Tax (CI)**	**Fa**	**Fr**
Personal income tax cut shocks	**> 0**	**> 0**	**> 0**	**> 0**	**> 0**	**≅ 0**	**≅ 0**	**≅ 0**
Corporate income tax cut shocks	**> 0**	**> 0**	**> 0**	**> 0**	**≅ 0**	**> 0**	**≅ 0**	**≅ 0**

≅ 0 indicates no restriction

The model specifies two lags for state's macroeconomic variables X_t , factors F_t , and no lag for narrative tax T_t , no constant, and estimate impulse response functions for 10-year forecasting horizons. The variable includes in the benchmark model are the state-level real GDP, personal income, non-farm employment, consumer price index, aggregate, and regional factor, and the narrative tax changes. The estimation adopts a flat Normal Inverted-Wishart posterior for a joint draw and the model parameters. The MCMC procedure uses 4000 draws from the posterior, maximum 2000 of iterations, and the accepted 1000 draws to generate impulse responses. This study follows the robustness of the identified VAR method suggested by Faust (1998) to test the robustness of the sign restrictions. The procedure examines the impact of tax shocks in two different time horizons, one is from the year one up to the second year of the response, and the second one is up to the tenth year of responses. Impulse response functions conform to the sign restrictions in both horizons. The Median-Target (MT) method proposed by Fry and Pagan (2011) also applies to check the additional validity of the FAVAR model. The MT method identifies how significant the FAVAR parameter and how close the estimated impulse responses to the model median impulse responses.

2.4.3 Dynamic response of the states

For each state, the model estimates the response of GDP, disposable personal income, employment, and price level to a one percent cut in federal personal and corporate income tax. The median estimate of cumulative impulse responses of GDP, employment, personal income, and CPI are summarized in the U.S. map in Figures 2.3 and 2.4 at the 10-year horizon. The visualization of cumulative impulse responses depends on the classification scheme that divides the states into two categories: states above the median and below the median cumulative responses. Darker blue shades denote the states with above the median responses. The states are also ranked based on their cumulative responses over a 10-year horizon. Figures 2.5 and 2.6 show the impulse response function of GDP, personal income, employment, and CPI for 1st, 2nd, 25th, and 50th states. The area in between two blue lines shows the 95% bootstrap confidence intervals. The impulse response function of all 50 states reported in Appendix.

In the responses of real GDP and disposable personal income, the state economies do react heterogeneously in magnitude and directions, and, in most states, these reactions are statistically significant. A one percent cut in personal income tax leads to a rise in GDP for about thirty-three states. The personal income rises in thirty-nine states while decreasing in GDP in fourteen states

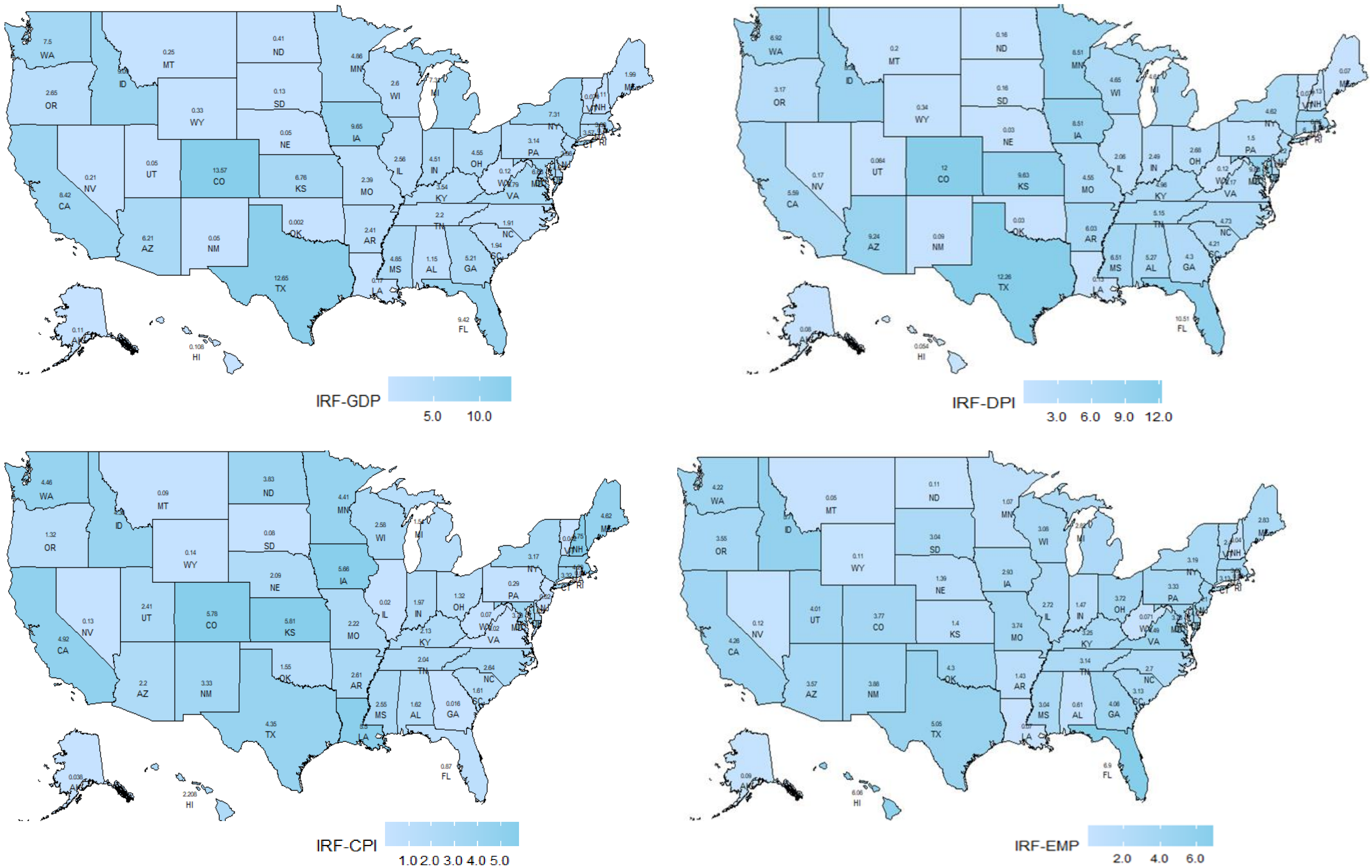

Figure 2.3. Visualization of state's map represents the state level responses of GDP, disposable personal income (DPI), consumer price index (CPI) and employment (EMP) to a one standard deviation cut in federal personal income tax at the 10-year horizon. Horizontal bar under the map presents the range of the magnitude of cumulative responses

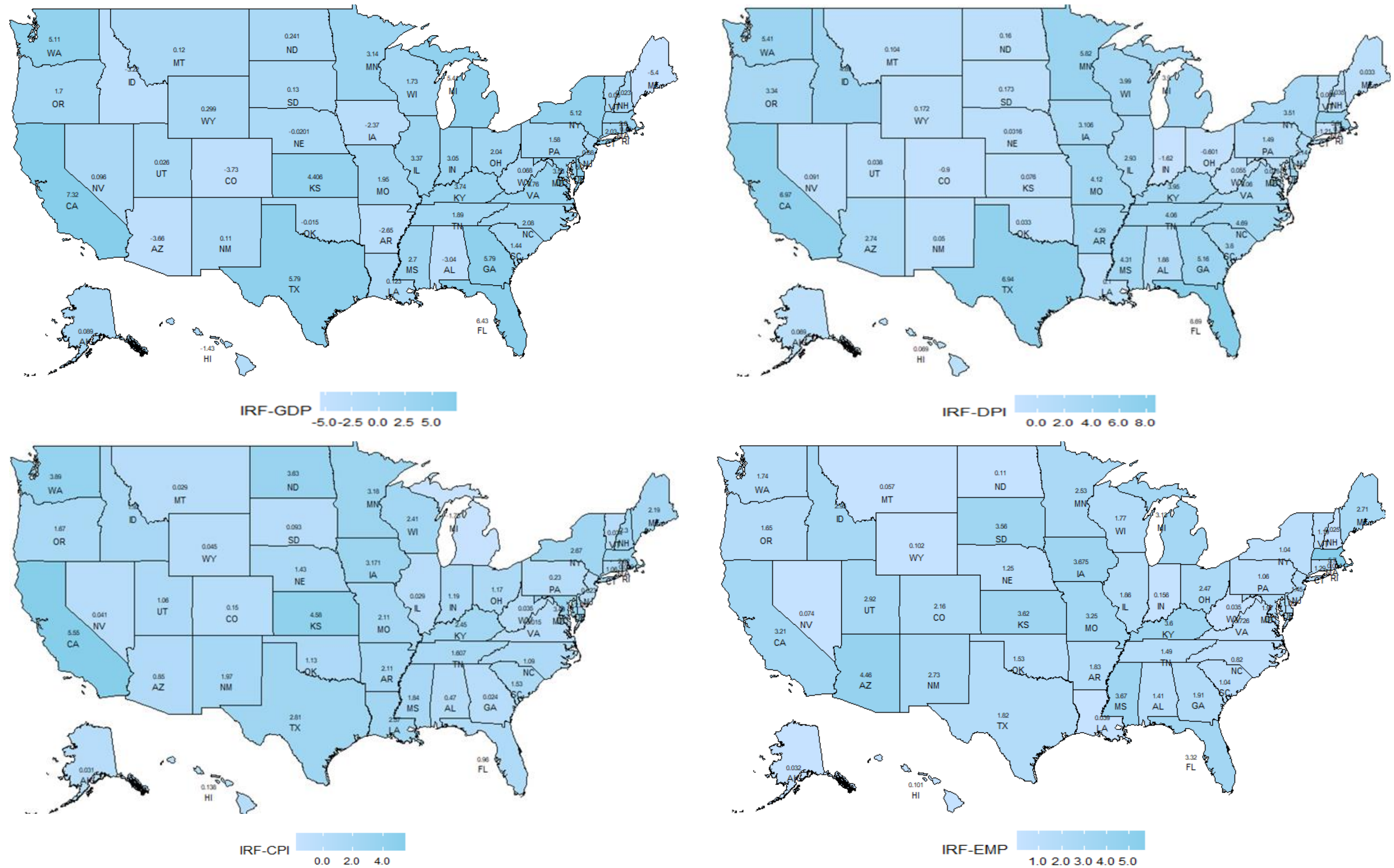

Figure 2.4. Visualization of state's map represents the state level response of GDP, disposable personal income (DPI), consumer price index (CPI) and employment (EMP) to a one standard deviation cut in federal corporate income tax at the 10-year horizon. Horizontal bar under the map presents the range of the magnitude of cumulative response

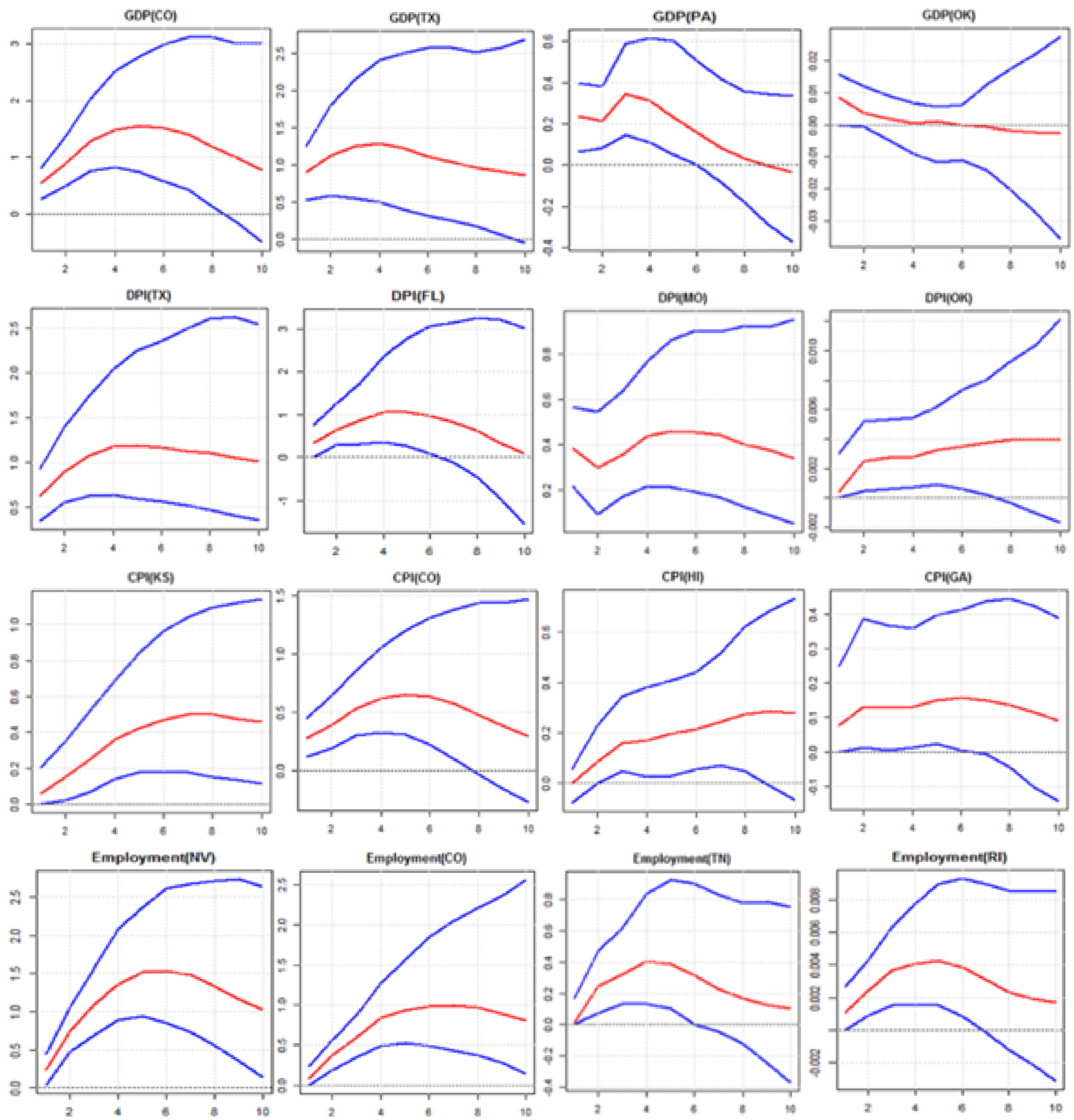

Figure 2.5: Impulses responses of state's GDP, disposable personal income, CPI and employment to a 1 percent cut to the federal personal income tax rate. The responses of 1st, 2nd, 25th and 50th states are presented here where states are ordered by their cumulative impulse responses over a 10-year horizon.

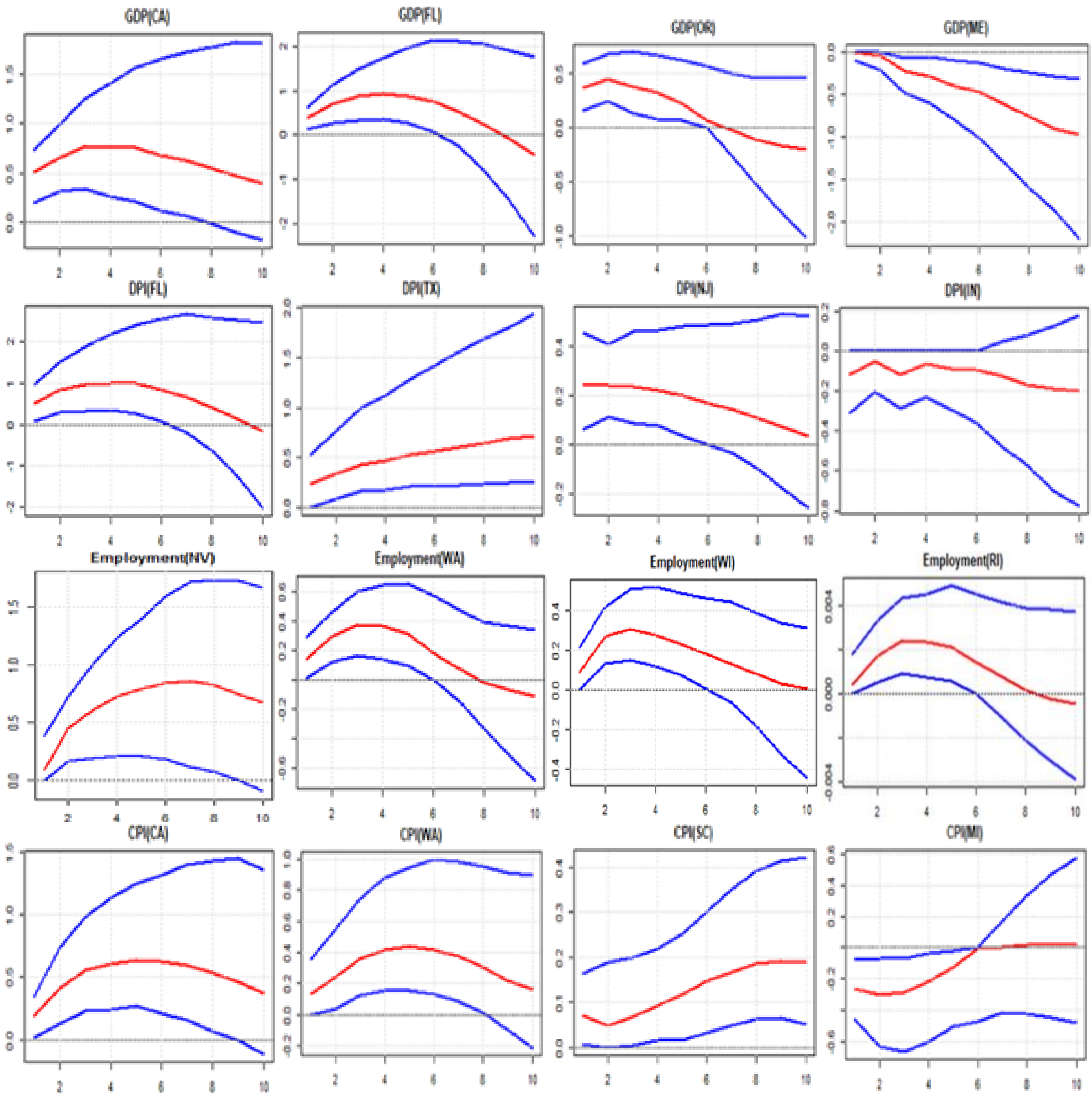

Figure 2.6: Impulses responses of state's GDP, disposable personal income, CPI, and employment to a 1 percent cut to the federal corporate income tax rate. The responses of 1st, 2nd, 25th and 50th states are presented here where states are ordered by their cumulative impulse responses over a 10-year horizon.

and having insignificant effects in the remaining three states. The highest response of real GDP in the first ten states lies within the range from 0.8 percent to 2.2 percent in Texas, Colorado, California, Iowa, Washington, and New York. Like the response of personal income tax cut, thirty-seven states exhibit a positive response in real GDP to a similar cut in federal corporate income tax, with the maximum rise estimated at 1.2 percent. The magnitude of the rise is largest in Florida, Texas, Georgia, California, and Michigan, with real GDP rising by about 0.75 percent to 1.2 percent, which is, on average, slightly lower than the magnitude of response to a personal income tax cut.

The expansionary effects on personal income from a corporate income tax cut also observed for about forty states, with the highest responses range from 0.3 percent to 1.2 percent. Personal income decreases for six states, while four states show insignificant responses. States with the insignificant and lowest response (responses range from -5.4 to -0.015 percent) in real GDP to either personal income or corporate income tax change include Maine, Utah, Nevada, New Mexico, Alabama, Idaho, and Oklahoma.

One of the federal tax cuts' primary objectives is to accelerate nonfarm private, manufacturing, and business sector job growth while federal taxes are only one part of a state economic picture that includes labor costs. In addition to other economic factors, the state's fiscal structures also play an outsized role in how federal tax cuts affect the state's employment growth. Empirical studies, as in Gabe (2003), Moretti and Wilson (2017), and Serrato and Zidar (2018) show that job-creating investment flows from high-tax states to low-tax states.

This study measures employment as the number of newly added jobs at the state's nonfarm business, manufacturing, and private industries. Employment rises in all states, and tax cuts affect states heterogeneously at the 10-year horizons. The highest response to a personal income tax cut in employment lies within the range from 0.6 percent to 1.5 percent in Colorado, Florida, Texas, Arizona, Idaho, South Dakota, Virginia, and Washington. The magnitudes are also heterogeneous across all states, while states with no personal and corporate income taxes or moderate state tax rates show relatively a higher response to either tax changes. States with lower income taxes and states with more financial, manufacturing, and service sectors in their GDP shares, such as Utah, Delaware, South Dakota, Washington, Florida, and Texas exhibit a higher expansion of employment growth. The employment responses to a similar corporate tax cut are relatively lower, where the magnitude lies within the range from 0.2 percent to 0.9 percent. So, a cut in personal income tax produces a higher and prolonged impact in employment growth than the cut in corporate income taxes. These results are relatively similar to those of Romer and Romer (2009) and Marten and Ravn (2013), particularly, in the direction of the impulse response functions. However, the magnitude and the persistence of the impulse response functions appear to be quite different for most of the states.

Consistent with the prediction of standard Keynesian models, a cut in either taxes significantly increase the consumer price index for almost all states except for Delaware and South Carolina. The magnitude of the cumulative response of the price level to a personal income tax cut range between 0.02 and 5.8 percent. The highest responsive states are California, Washington, Kansas, Colorado, Minnesota, New Hampshire, and New York, where the cumulative responses are on average lies between 2.30 percent and 5.8 percent. In contrast, a few states like Alabama, Montana, Virginia, Arkansas, and Georgia are less responsive, with maximum cumulative impulse responses accounted for 0.96 percent at the 10-year horizon.

In addition to cumulative impulse response functions, the model also estimates the contribution of the tax shocks to the variance decomposition of GDP, personal income, employment, and price levels. Tables 2.3 and 2.4 show substantial heterogeneity in the percentage of variance decomposition. Taking the proportion of GDP variation as an example, personal income tax shocks explain the maximum amount of variation about 58 percent of GDP for Nevada, while the variation is only 2.32 percent for North Carolina. For employment and price levels, personal income tax shocks also explain a significant amount of variation, on average, from 17 percent up to 27 percent for Texas, Michigan, Nevada, Minnesota, Utah, Georgia, and South Dakota. Relative to personal income tax shocks, corporate income tax shocks on average accounted for a smaller portion of the variance. As shown in Table 2.3 and 2.4, above the mean amount of the variation of shocks for both real GDP and personal income lies in between 18 percent and 37 percent for Washington, South Dakota, Nevada, Florida, Delaware, and California.

Table2.3: Forecast Error Variance Decomposition (Real GDP)

	PIT Shock Horizon (in year)			CIT Shock Horizon (in year)		
	1	5	10	1	5	10
AK	0.52	6.44	8.30	1.08	4.63	5.69
AL	12.45	13.45	14.11	32.63	16.81	12.71
AR	22.93	17.59	16.10	1.45	7.08	9.96
AZ	54.64	31.97	22.88	7.81	10.39	10.28
CA	43.10	29.16	23.19	37.50	23.35	16.67
CO	31.91	25.55	22.44	10.83	11.24	11.03
CT	20.57	16.02	14.59	19.31	15.16	14.48
DE	19.11	13.22	9.71	36.83	20.77	14.37
FL	29.16	24.12	20.10	26.86	22.87	16.53
GA	21.92	18.91	16.29	16.14	16.98	14.71
HI	3.31	6.50	6.98	4.63	20.29	29.55
IA	25.53	20.08	20.12	19.25	20.51	21.33
ID	39.64	28.84	24.33	6.81	10.11	11.48
IL	17.14	14.70	14.04	15.53	15.80	14.14
IN	36.66	21.10	18.30	14.15	12.53	11.77
KS	17.54	17.75	19.07	6.03	12.44	12.57
KY	12.52	13.33	13.48	5.68	9.84	12.87
LA	5.51	15.35	17.21	0.26	7.53	8.33
MA	23.02	19.21	15.46	9.28	13.41	15.88
MD	29.73	24.47	22.44	19.39	17.84	16.88
ME	33.55	25.41	16.82	14.52	14.17	14.34
MI	27.37	21.00	18.20	11.99	12.58	13.17
MN	39.09	26.80	22.62	31.17	20.66	18.76
MO	21.02	18.62	17.76	13.37	13.29	14.34
MS	18.10	16.90	15.58	12.32	12.63	11.54
MT	44.92	31.56	26.81	12.11	13.50	14.36
NC	2.22	11.85	11.89	2.27	10.99	10.77
ND	28.07	23.90	22.38	28.48	21.33	17.61
NE	14.71	11.98	13.03	14.27	11.82	11.63
NH	18.87	19.08	17.72	8.41	9.75	11.71
NJ	2.67	7.10	8.85	2.45	6.29	9.20
NM	4.26	9.11	10.33	2.80	7.13	9.01
NV	57.93	38.06	26.12	26.31	20.25	14.79
NY	21.57	18.91	15.86	6.39	10.71	12.00
OH	24.06	18.13	16.27	12.47	12.71	12.15
OK	5.93	6.10	6.82	3.21	8.18	9.42
OR	20.92	17.59	18.81	13.91	13.80	15.77
PA	19.58	17.97	16.81	24.76	17.59	16.33
RI	30.30	22.22	17.16	25.94	20.25	15.53
SC	23.40	18.95	16.98	17.17	15.12	15.28
SD	42.24	26.48	19.71	23.99	20.96	20.96
TN	21.82	18.06	15.25	19.11	16.35	15.36
TX	49.62	30.55	23.91	2.06	7.77	10.09
UT	1.28	6.80	10.69	1.01	4.96	7.06
VA	18.11	16.30	15.58	21.25	17.82	17.17
VT	36.95	28.48	18.28	35.71	25.91	20.66
WA	26.18	21.97	19.58	19.64	14.40	13.08
WI	42.07	24.84	19.93	30.38	17.79	15.33
WV	10.42	19.96	21.13	3.80	11.05	12.25
WY	29.11	25.71	26.31	6.15	15.04	17.52

Table 2.4: Forecast Error Variance Decomposition (Disposable Personal Income)

	PIT Shock Horizon (in year)			CIT Shock Horizon (in year)		
	1	5	10	1	5	10
AK	30.33	9.45	9.16	8.75	5.87	6.10
AL	7.65	13.48	14.11	10.03	10.12	9.87
AR	27.13	22.63	18.81	33.41	20.29	16.95
AZ	30.75	23.67	18.07	24.87	16.23	12.72
CA	13.43	17.38	16.43	28.35	25.19	21.07
CO	15.55	19.00	18.13	3.33	7.99	11.03
CT	4.32	11.09	13.01	5.70	11.91	13.69
DE	8.60	11.73	11.36	15.45	17.80	15.21
FL	15.53	19.53	18.59	17.30	18.83	15.97
GA	16.55	18.98	16.91	8.79	11.35	10.99
HI	22.73	18.32	14.66	33.56	28.18	21.89
IA	11.82	16.46	21.25	9.07	10.52	11.77
ID	24.54	24.22	20.16	26.93	18.28	15.88
IL	9.25	13.71	13.60	7.91	13.95	13.39
IN	13.59	16.00	17.05	7.98	9.49	11.59
KS	13.08	15.54	20.93	15.49	21.22	19.00
KY	9.28	14.83	18.27	9.56	12.55	12.23
LA	24.12	21.19	20.18	14.04	16.67	17.01
MA	10.94	14.60	14.94	11.81	13.55	14.10
MD	25.73	28.49	26.27	19.07	21.02	19.74
ME	21.20	24.01	19.94	19.95	12.41	13.94
MI	24.24	20.88	17.89	9.53	12.49	12.62
MN	24.93	24.90	24.54	11.59	14.45	15.51
MO	26.04	22.79	22.11	8.55	12.36	14.34
MS	30.98	23.80	21.04	20.36	16.88	15.01
MT	31.52	30.58	26.57	13.95	14.05	14.51
NC	3.93	12.05	12.23	10.33	14.32	13.07
ND	22.17	22.00	21.06	23.51	16.82	13.60
NE	6.14	12.41	13.94	3.33	11.28	12.84
NH	22.43	22.72	19.58	6.08	8.95	11.17
NJ	7.23	9.31	9.51	5.17	7.91	8.68
NM	29.55	24.04	21.74	8.27	12.95	12.07
NV	24.80	36.47	26.79	19.27	20.02	15.09
NY	10.95	15.18	15.15	5.79	10.30	10.79
OH	8.67	12.53	12.66	2.34	5.69	6.88
OK	0.74	6.52	7.44	2.01	7.39	8.09
OR	11.52	14.45	16.13	10.60	13.23	14.38
PA	3.77	10.58	13.82	2.89	11.69	13.69
RI	6.16	14.97	15.59	5.11	13.43	13.82
SC	16.26	15.59	15.26	15.20	14.10	14.93
SD	24.43	20.57	18.52	25.72	22.92	21.41
TN	27.78	22.19	19.53	19.10	16.95	15.97
TX	26.31	31.36	27.08	6.00	7.81	9.35
UT	25.36	18.13	18.16	14.97	13.03	13.17
VA	23.53	22.42	19.48	7.83	11.86	14.38
VT	32.49	27.43	18.48	28.68	24.00	16.50
WA	16.27	18.22	17.23	19.33	18.12	16.85
WI	13.80	19.00	18.52	9.88	14.97	14.84
WV	28.02	23.48	22.35	11.03	11.55	11.99
WY	29.36	28.22	27.58	7.92	10.31	11.20

2.4.4 Reliability of the FAVAR estimates

The reliability of the identification of tax cut shocks in the FAVAR model is examined using the Median-Target (M-T) approach proposed by Fry and Pagan (2011). There are two advantages of the M-T method, as mentioned by Furlanetto, Ravazzolo, and Sarferaz (2019), Mangadi and Sheen (2017), and Ouliaris, et al. (2015). First, this method tests the significance of the model identification by minimizing the sum of the standardized gap between the impulse responses of sign restricted FAVAR model and the impulse responses drawn from the M-T test rotation. Secondly, it shows how exactly the tax cut shock identified in the model. By minimizing the gap between two impulse responses, the M-T method delivers a single impulse response function that is the closest possible one to the median response of the FAVAR model. As a diagnostic tool, this method identifies a bias between the median response drawn from the sign restriction and the impulse response of the M-T method.

Figure 2.7-2.10 shows the impulse responses of the M-T method (solid red lines) and compares them with the impulse responses of the FAVAR model (dashed blue lines). As in the benchmark model, the narrative tax shock is identified by imposing sign restrictions on the macroeconomic variables with Uhlig's (2005) penalty function. The M-T method replicates the impulse response functions of real GDP, personal income, CPI, and employment. For each impulse response function of these four variables, responses are ranked by state the cumulative responses over a ten-year horizon, and figure 2.7-2.10 reports the responses for the 1st, 2nd, 25th, and 50th states. The method compares how the impulse responses change once the M-T method identifies the single best median impulse vector. The best possible responses for all macroeconomic variables match the FAVAR models' responses perfectly on impact and a 10-year horizon. The method also delivers 95 percent confidence intervals. The confidence intervals associated with the FAVAR impulse responses and M-T's responses are statistically significant and do not contain zero for, except for GDP responses in Oklahoma. So, Fry and Pagan's (2011) M-T diagnostic tool validates the FAVAR model's specification and the identification of the tax shocks in the estimation of the benchmark model.

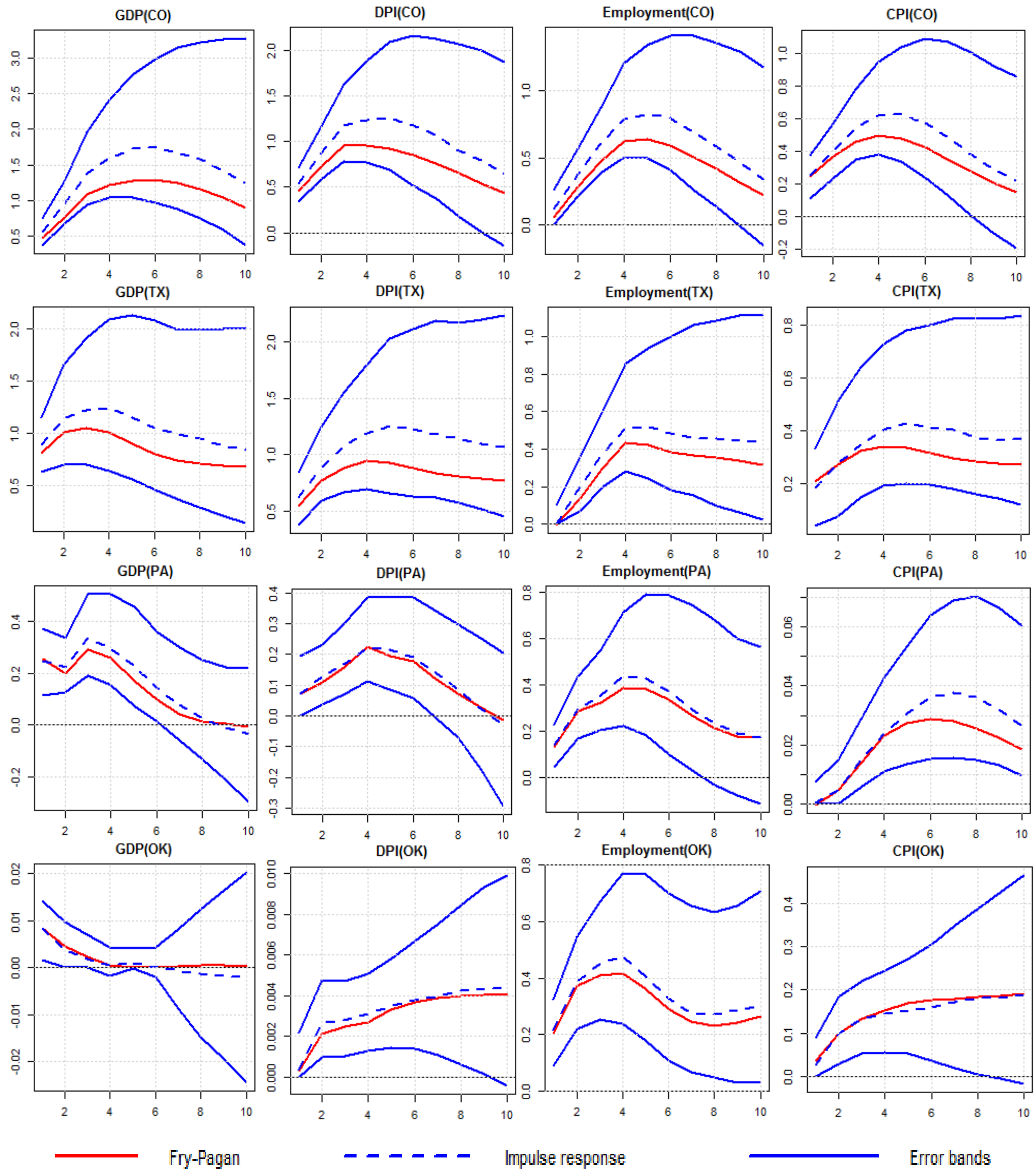

Figure 2.7: Comparison of impulses responses of 1st (CO), 2nd (TX), 25th (PA) and 50th (OK) state's GDP with those state's disposable personal income, CPI and employment responses are drawn from Fry and Pagan's (2011) M-T method (red solid line) and from sign restricted FAVAR models (dashed blue line). The GDP responses of 1st (CO), 2nd (TX), 25th (PA) and 50th (OK) states are ordered by their cumulative impulse responses over a 10-year horizon. Solid blue lines represent the 95 % confidence intervals. Tax shock is measured as 1 percent cut in federal personal income tax rate.

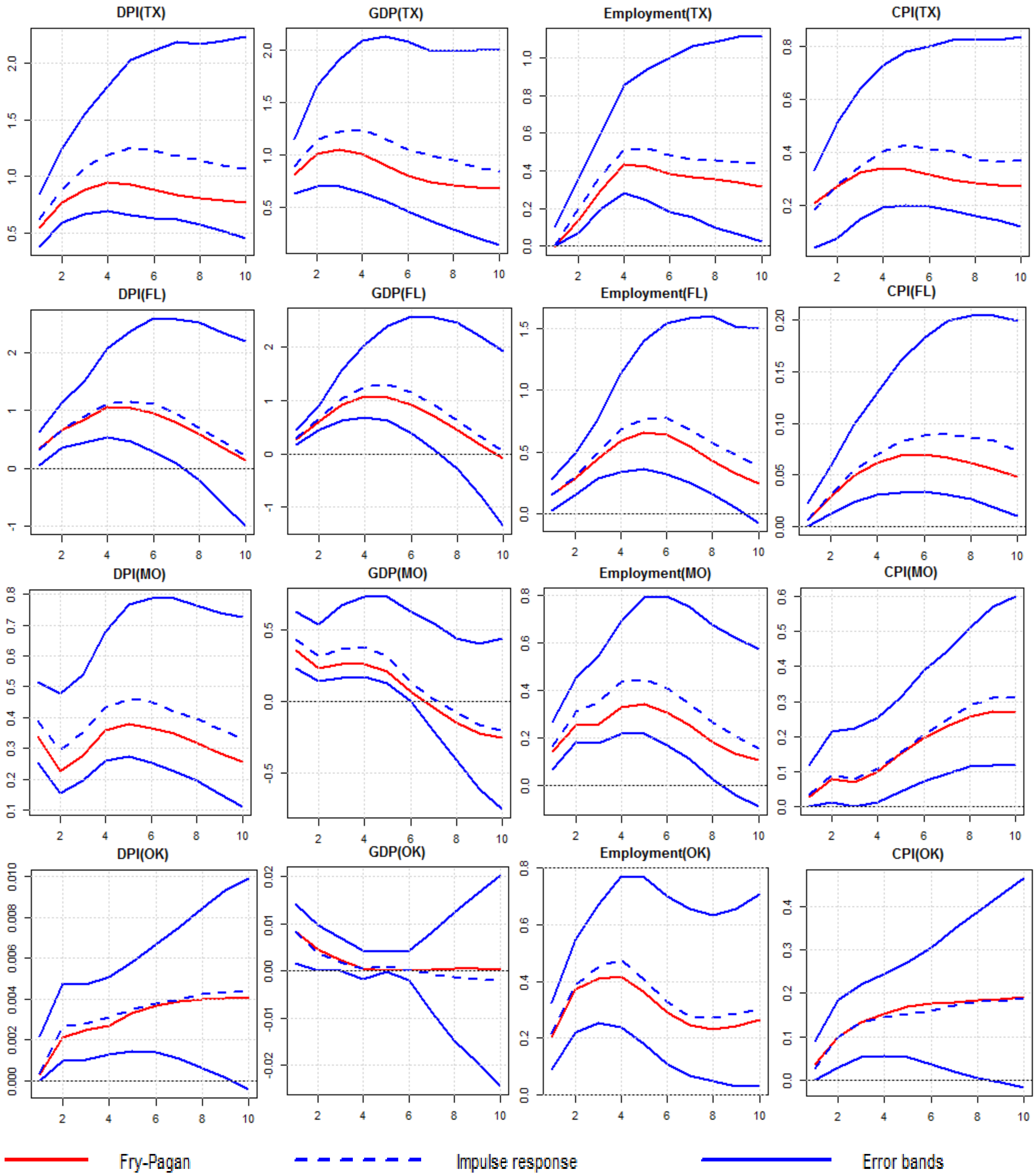

Figure 2.8: Comparison of impulses responses of 1st (TX), 2nd (FL), 25th (MO) and 50th (OK) state's DPI with those state's GDP, CPI and employment responses are drawn from Fry and Pagan's (2011) M-T method (red solid line) and from sign restricted FAVAR models (dashed blue line). The DPI responses of 1st (TX), 2nd (FL), 25th (MO) and 50th (OK) states are ordered by their cumulative impulse responses over a 10-year horizon. Solid blue lines represent the 95 % confidence intervals. Tax shock is measured as 1 percent cut in federal personal income tax rate.

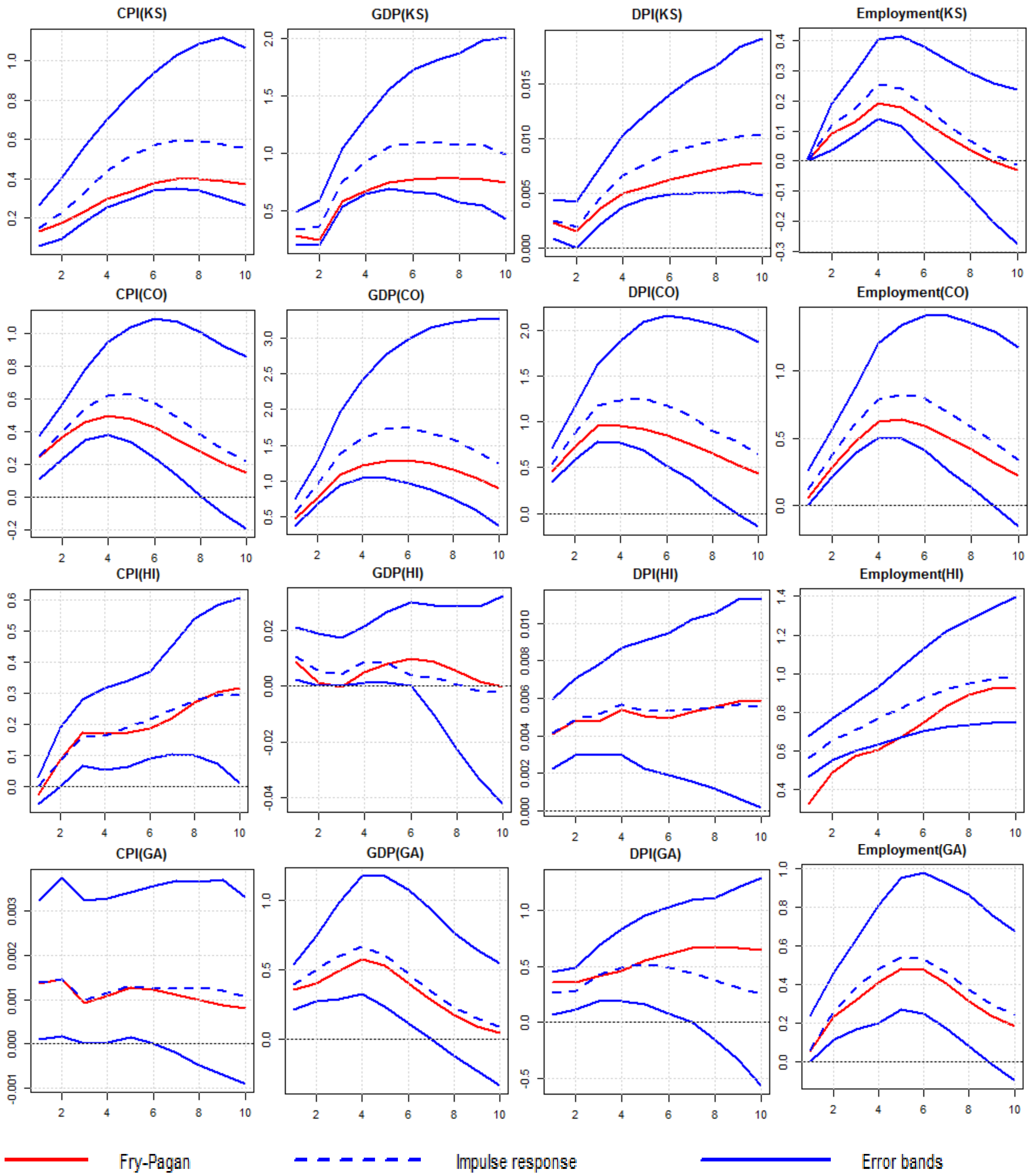

Figure 2.9: Comparison of impulses responses of 1st (KS), 2nd (CO), 25th (HI) and 50th (GA) state's CPI with those state's GDP, DPI and employment responses are drawn from Fry and Pagan's (2011) M-T method (red solid line) and from sign restricted FAVAR models (dashed blue line). The CPI responses of 1st (KS), 2nd (CO), 25th (HI) and 50th (GA) states are ordered by their cumulative impulse responses over a 10-year horizon. Solid blue lines represent the 95 % confidence intervals. Tax shock is measured as 1 percent cut in federal personal income tax rate.

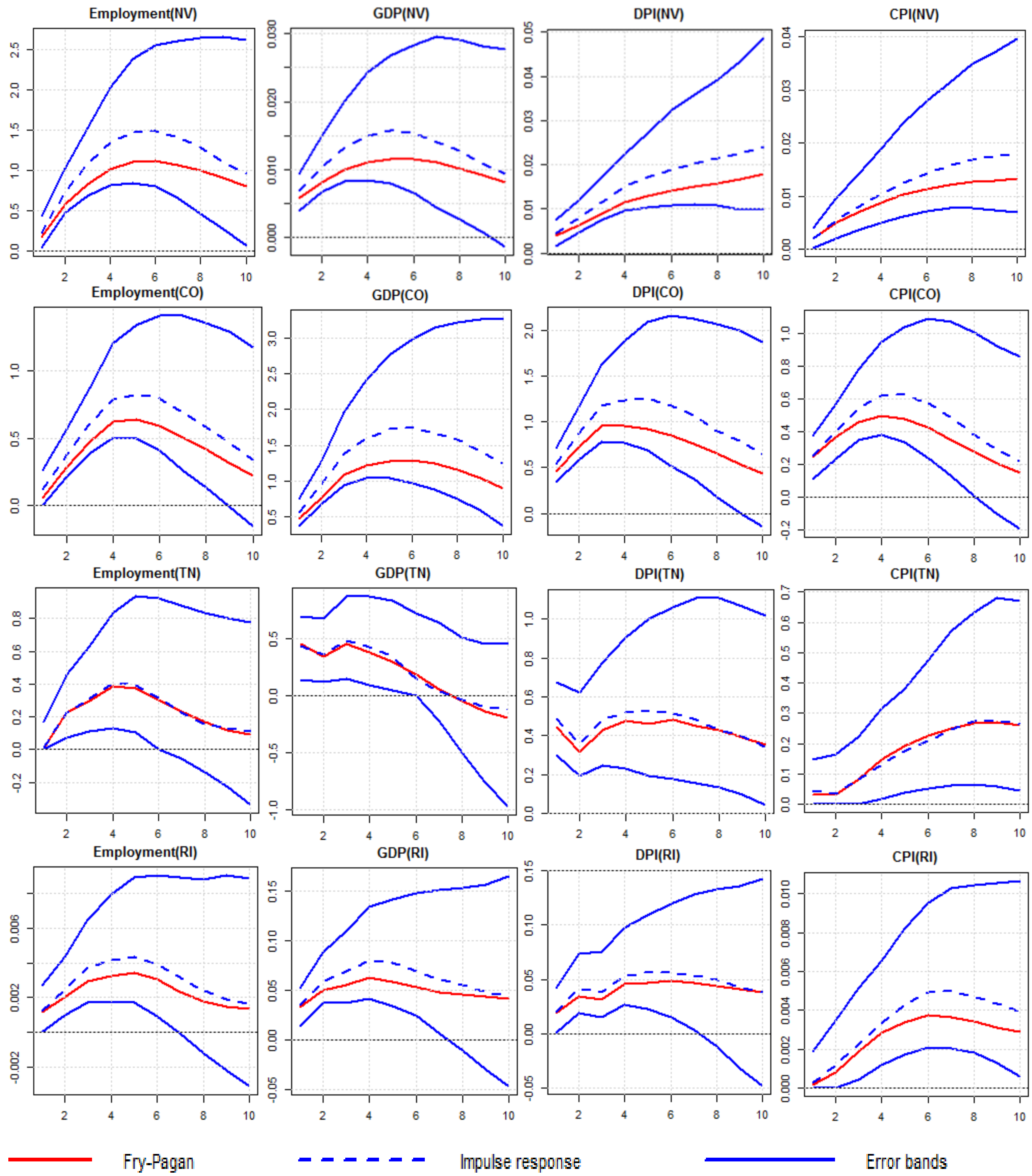

Figure 2.10: Comparison of impulses responses of 1st (NV), 2nd (CO), 25th (TN) and 50th (RI) state's employment with those state's GDP, DPI and CPI responses are drawn from Fry and Pagan's (2011) M-T method (red solid line) and from sign restricted FAVAR models (dashed blue line). The employment responses of 1st (NV), 2nd (CO), 25th (TN) and 50th (RI) states are ordered by their cumulative impulse responses over a 10-year horizon. Solid blue lines represent the 95 % confidence intervals. Tax shock is measured as 1 percent cut in federal personal income tax rate.

2.4.5 Economic significance of the FAVAR estimates

This study examines the prediction of the New-Classical and the Keynesian models using the FAVAR methodology to sort out the short- and long-run links between federal tax shocks and state-level economic activity. In estimation, the FAVAR model requires identifying assumptions that establish significant links among the model's parameters. To attain the statistical and economic significance of the model's parameter, the identifying assumptions of this study come from economic theory that imposes *a-priori* sign restrictions on macroeconomic variables' response. The findings suggest that the magnitude and persistence of GDP, employment, personal income, and price responses in most states are statistically significant. In addition to the statistical significance, the purpose of this section is to offer the economic interpretation of the IRF of a model's variables in response to a one percent tax cut shock. This interpretation allows this study to trace the economic significance of parameter values within a system of structural equations and, thus, provides a better representation of the model's dynamic behavior in evaluating economic policies.

In general, the findings support the short-term prediction of the expansionary effect of tax cuts on real GDP, employment, and prices through the aggregate demand (AD) channel of the New Keynesian model. The cut in taxes increases real GDP in this model in the short run because corporate tax cuts encourage firms to increase investment, and personal income tax cuts increase disposable incomes, increasing demand for goods and services. Specifically, on impact, a one percent cut in personal income tax increases real GDP for 33 states by about 1.2 percent and a maximum of 1.9 percent in five years. Similarly, a one percent cut in corporate income tax cut raises real GDP for 40 states by 0.52 percent on impact and by 0.83 percent in three years. The economic interpretation of these results is related to the national income multiplier. The income multiplier suggests how big a percentage change in real GDP is due to a one percent change in either taxes in the FAVAR model.

Interpreted these parameter values as a multiplier in the Keynesian model, the FAVAR estimates imply a maximum personal income tax’s output multiplier is 1.9, and the corporate income tax’s output multiplier is 0.83. These findings support several previous studies related to the variation in estimates of the U.S. fiscal multipliers. For example, Barro and Redlick (2011) estimate a U.S. personal income tax multiplier of around 1.1, Mountford and Uhlig (2009) find 0.93 after one year of the tax cut, and up to 3.41 at three years, Riera-Crichton et al. (2012) find a tax multiplier of 1.32 using the SVAR approach and 2.76 using the narrative approach for 14 industrial countries. The estimates from the Congressional Budget Office show output multipliers for the lower- and middle-income group is in between 0.3 and 1.5 (Whalen and Reichling, 2015).

At the state level, the value of output multiplier starts rising two years after the personal income tax cut for most states and reaches a maximum of 1.6 for Colorado, 1.2 for Texas, and 0.38 for Pennsylvania at five years. The multipliers decrease gradually over the next five-year horizons. The value of multipliers is much lower at longer horizons because of the "crowding out" of private investment. In the long run, tax cuts increase the federal budget deficit, and the government's increased borrowing "crowds out" state-level private investment.

A one percent change in personal income tax raises disposable personal income by a maximum of 1.2 percent and a minimum of 0.05 percent. A common economic interpretation for the maximum effects is the peak personal income multiplier is $sign\left(d\ln DPI_{t+h}/d\ln PIT_t\right)$, where DPI_t is disposable personal income at time t, PIT_t is personal income tax, h is the 10-years of forecasts horizon. Since the impact response of PIT_t to the tax cut shock is rescaled to unity, the economic significance of the impulse responses of disposable personal income at a 10-year horizon is the 10-years multiplier. The total accumulated responses for 10-year periods ahead of a unit tax cut shock on DPI can be calculated by summing up the corresponding response coefficients. This accumulated value is commonly referred to as the total multiplier effect. As expected, the total effect is higher for CO, TX, FL, and MD, followed by KS, AZ, CA, IA, MN, MA, and WA.

Looking at the labor market, a one percent cut in personal income tax increases employment by a maximum of 1.6 percent compared to 0.92 percent for the corporate income tax cut. Translated into the non-farm employment elasticity, $\varepsilon_{emp} = \left(\%\Delta\, in\ nonfarm employment / \%\Delta\, in\ narrative\ \ tax\right)$ [1], the FAVAR estimates of elasticities are economically consistent with the previous studies (Mourre, 2006; Kapsos, 2006; Seyfried, 2011). Table 2.10 in Appendix reports state-level employment elasticities. The values reveal that

[1] Employment elasticity measures the ratio of the percentage change in the number of non-farm employment in a state to the percentage change in narrative tax rates

the higher non-farm employment responses growth is observed in CO, NV, AZ, FL, ID, TX, CA, WA, NJ, and GA. Examining the state's higher employment growth and their relatively higher output multiplier also reveals that the tax cut's expansionary effects have worked simultaneously in the short-run for most states. The employment elasticity continued to rise from 0.001 to 1.6 until around five years after the cut in either taxes. The average employment elasticity of this study is about 0.424 for the personal income tax changes and 0.295 for the corporate tax changes. These estimates are close to Mourre (2006), who estimates the economy-wide employment elasticity is 0.6. Seyfried (2011) also estimates employment elasticity range from 0.31 to 0.61for the ten specific states with the U.S. average estimate of 0.47.

2. 5 States' Characteristics and Heterogeneities in the Transmission of Tax Shocks

As evidenced in section 2.4.3, state-level responses vary substantially over time and across the states. This variation raises the question of why some states are more responsive to federal tax changes than the other states. What state-level structural characteristics drive the heterogeneous responses of a tax cut shock? This section links the state-level FAVAR results to the state's sectoral contribution to their GDP, fiscal and labor market structures, financial markets, and the housing sector to uncover the determinants of heterogeneous responses. More particularly, it aims to investigate how cross-state differences affect the transmission mechanism of federal tax cut shocks in the short-run and the long-run.

2.5.1 Sectoral composition

States may display heterogeneity in their responsiveness if the sectoral composition of the state's aggregate output is diverse. For example, states with a higher GDP concentration accounted for by the durable and non-durable consumer goods might show a higher response to a personal income tax cut. As in the standard Keynesian model, states output, employment, and price levels should also display a strong positive response to this expansionary tax cut shock through the aggregate demand and income channel. Similarly, states with a larger concentration of capital-intensive industries or production of durable goods might be more responsive to a corporate tax cut. Barth and Ramey (2001) show that corporate tax cut shocks transmit to the state's industrial and manufacturing sectors through the cost channel of firm finance and encourage firms to take advantage of debt finance options rather than equity (Heckemeyer and Mooij, 2017). Several empirical studies, particularly in the response of monetary and fiscal policy shocks find that the composition of GDP share accounted for by state's manufacturing and financial sector can explain the heterogeneous responses and the transmission mechanisms (Bernanke and Gertler, 1995; Carlino and Defina, 1998; Owyang and Zubairy, 2013).

Figure 2.11 shows the concentration of private industries, financial, and manufacturing share as a percentage of the state's GDP. As shown in the bar-graph, there has been significant variation in the states' financial and manufacturing sectors. For example, South Dakota, Iowa, and Delaware have the highest concentration of the financial industry in their GDP, while Idaho and Oregon are noticeably more dependent on the manufacturing sector. The states located in the South, such as Georgia, North Carolina, South Carolina, have a small share of manufacturing and financial industries in their GDP.

With the state-level cumulative impulse responses and the cross-state characteristics, the regression model (3) estimates state-level characteristics that drive the heterogeneous responses:

$$Cum\,\mathrm{Re}_{i,m}^{t} = \varphi + \beta X_i + \varepsilon_i \qquad (3)$$

Where $Cum\,\mathrm{Re}_{i,m}^{t}$ indicates the $t-year$ horizon cumulated impulse responses of state $i's$ macroeconomic variable $m \in [real\,GDP,\, personal\,income, CPI, employment]$. The regressors X_{i} include variables that attempt to explain the cross-state heterogeneities in the financial sector, industry share in state's GDP, fiscal conditions, and the labor and housing market. In contrast to the impact of tax cut shock at a single point in time, the cumulative impulse responses ($Cum\,\mathrm{Re}_{i,m}^{t}$) examine the total accumulated effect of the impact of the tax cut shock to one of the four macroeconomic variables in m across ten year horizons. The cumulative impulse responses have been broadly applied to examine, among others, government spending multipliers (Owyang et al., 2013), macroeconomic impact of oil price shock (Hamilton, 2011), and the output effects of technology shocks (Gali, 1999). Apart from these applications, the cumulative value of impulse response functions is also used by Carlino and DeFina (1998, 1999), Liu and Williams (2019), and Owyang and Zubairy (2013) as a dependent variable in cross-section regression model.

Motivated by previous literature, the first set of covariates comprises the sectoral composition of the state's GDP and the median household income. From 1977 to 2017, the state's sectoral composition measures as the percentage of state's GDP accounted for by agriculture, financial, professional, and business services, manufacturing, oil and mining, housing, construction, and the public sector.

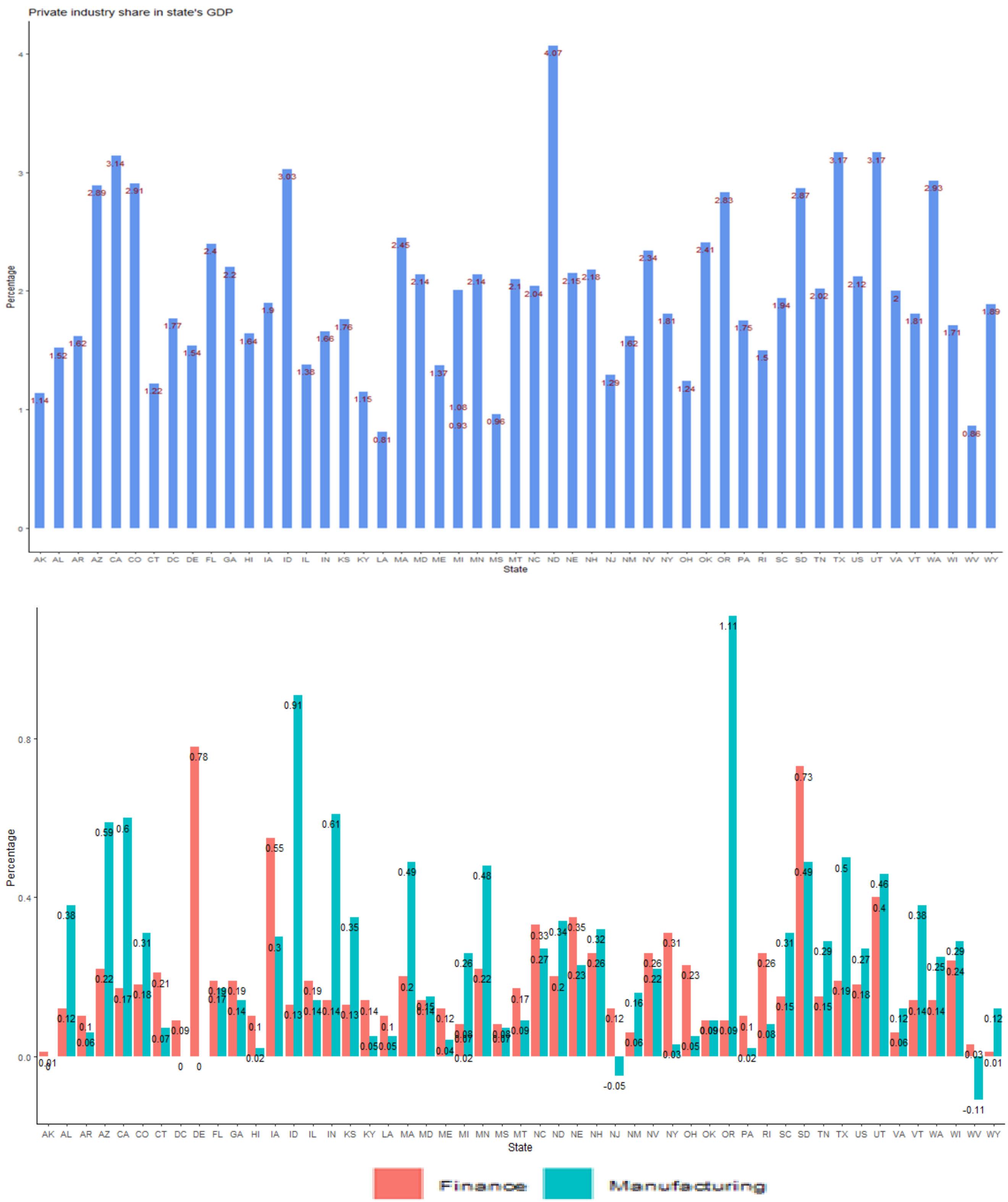

Figure 2.11: State Heterogeneities-Top panel shows share of private industries in state GDP (1977-2018); the bottom panel shows the share of manufacturing and financial sector in state's GSP (1977-2018).

2.5.2 Financial sector

As shown in the bottom panel of Figure 2.11, states differ significantly in the concentration of financial industries. These differences can shed light on the analysis of the cross-states heterogeneities of tax shocks transmission. Mooij (2017) shows that the magnitude of debt finance elasticity to a corporate tax cut significantly correlated with a firm's asset size, where relatively smaller and larger companies show higher response to tax changes. So, corporate tax cuts can have higher and quicker responses in states where those firms located. The recent empirical evidence, as in Fernández-Villaverde (2010), Gertler and Kiyotaki (2010), and Zwick and Mahon (2014) also, emphasize the importance of financial frictions in examining the effects of fiscal policy changes.

Following Carlino and Defina (1998) and Cottarelli and Kourelis (1994), the second set of covariates include total bank loans to households and businesses, loans to state-level small firms, asset and equity for commercial banks, net interest margins, and net income for commercial banks. The proportion of bank loans to households and businesses is the proxy measure of broad credit channel, which assumed to be strongly correlated to the response of output, income, and prices (Dornbusch et al., 1998; Mihov, 2001). The state-level bank's asset, equity, and net income for commercial banks are the proxy measure of the financial sector's response to tax changes. Finally, the bank's net interest margin is a proxy of the banking sector's efficiency.

2.5.3 Fiscal structure

The fiscal structures of U.S. states vary substantially across the states, as shown in Figure 2.12. The top panel of Figure 2.12 presents the average values of the state and local tax burdens, and the bottom panel shows the state's income tax elasticity. California, Missouri, Illinois, New York, Minnesota, and North Carolina are characterized as states with the highest tax burden, while Wyoming, Nevada, South Dakota, and Texas have the lowest tax burdens. Following Liu and Williams (2019) and Owyang and Zubairy (2013), the state-level fiscal policy variables in this study divided into two major categories. The first category consists of state-specific tax variables, such as state and local tax burdens, the elasticity of personal income tax, average personal income, and corporate income tax rate. The second group includes state tax revenue, real sector uncertainty, subsidy, and state unemployment benefits. Many of these series taken either from Mumtaz, et al., (2018) or from the annual survey of state and local government finances of the U.S. Census Bureau.

2.5.4 Housing and Labor markets

The consensus in the empirical literature is that the more rigid labor markets strongly associated with the more robust and persistent responses of output, prices, and employment to a policy change (Brückner and Pappa, 2012; Walsh, 2005; Zanetti, 2007). For example, Zanetti (2007) finds that union bargaining reduces the elasticity of marginal costs to output and increases output. This study includes state-level unemployment rate, civilian labor force participation, and sectoral employment to document the importance of labor market frictions. Besides, the proxy of "Right to Work" laws and the degree of unionization (Mumtaz et al., 2018) use to measure the labor market rigidities. The "Right to work" laws exist in 28 states. The structure of the labor market in those states is flexible because the law allows workers to make their own choice if they want to join a union. The final set of regressors is from the state's housing sector, such as homeownership rate, home vacancy rate, rental vacancy rate, and percentage of the housing sector to the state's GDP.

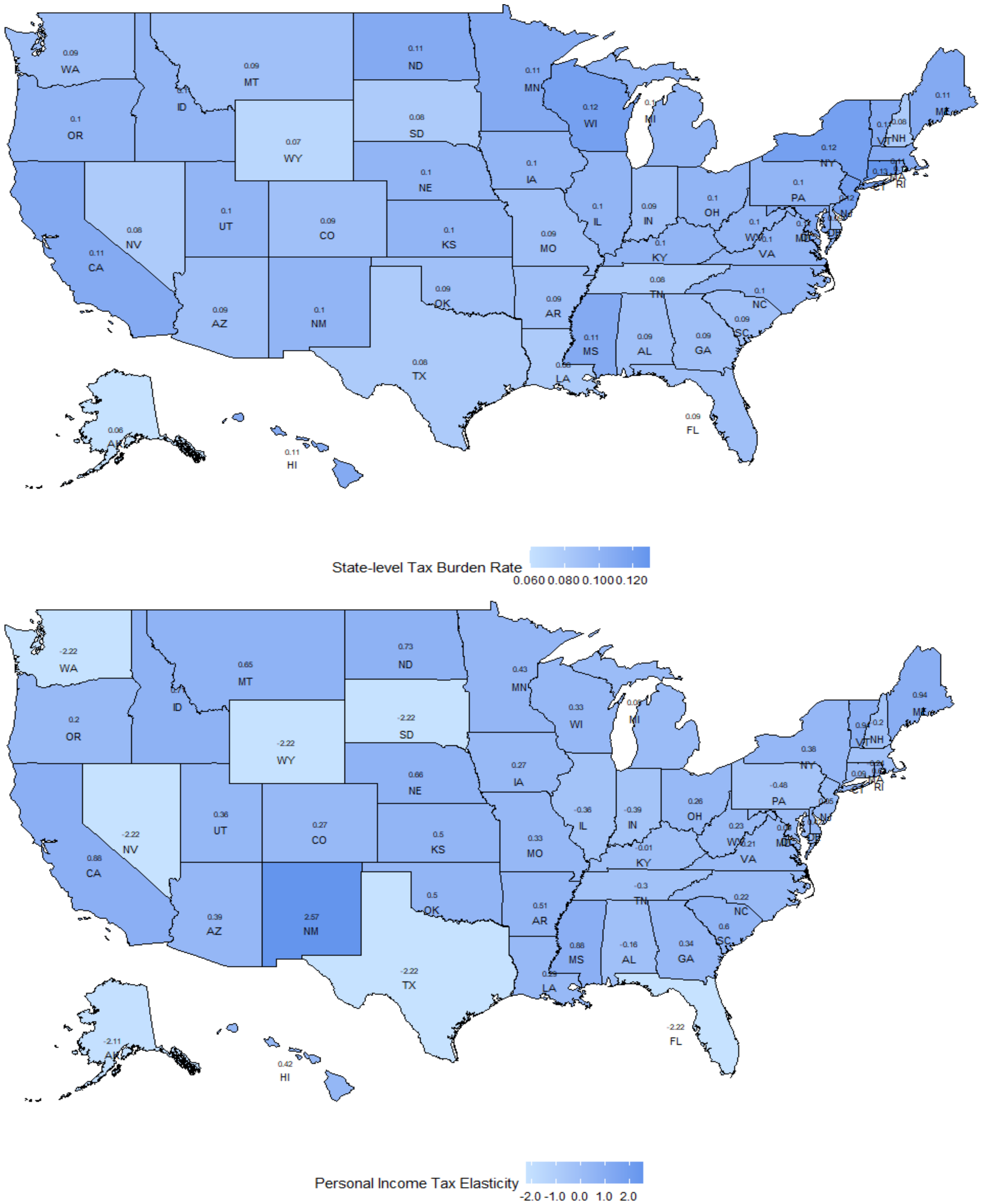

Figure 2.12: State Heterogeneities-top panel shows the statewide tax burden rate; bottom panel shows the statewide elasticity of personal income tax (average over the period of 1984-2018)

2.5.5 Baseline estimation: personal and corporate income tax shocks

Table 2.5 shows the results of the five baseline regression models estimated by OLS. These models include the key regressors explained in section 2.5.1 through 2.5.4. The specification of the baseline models and the inclusion of regressors broadly based on previous empirical literature (as in Carlino and Defina 1998; Oyang and Zubuary, 2013; Liu and Williams 2019). The first four columns of Table 2.5 show the results of the regressions for the impulse response of GDP cumulated at the 10-year horizons. The fifth column shows the regression results where the dependent variable refers to the GDP responses cumulated at the 2-year horizons.

The first column is the simple specification of the baseline model accounting for the share of the financial sector and two key state-level fiscal variables. In addition to manufacturing share and state-level tax elasticity, the second model in column two includes variable from labor markets and financial markets. The third and fourth columns make the model specification more comprehensive by adding housing variables, average corporate income tax, and labor market regulations. The primary focus is on the result from the preferred baseline model in columns four and five, where the dependent variable in column four refers to long-run responses, and the IRF-GDP 2yr indicates the short-run responses.

The cross-state regression analysis applies the standardization regression process that changes state-specific all covariates on the same scale. The advantage of the standardized regression approach is determining the sectors' relative strength to explain heterogeneous impulse responses. So, the interpretation of the regression results in Table 2.5 is the standardized regression coefficients that are based on changes in standard deviation units. For example, for every standard deviation unit increase in the share of financial and manufacturing in the state's GDP in column (4) of Table 2.5, the states' real GDP response increases by 0.59 and 0.38 standard deviation units, respectively. Comparing the relative importance of these two sectors shows that a larger ratio of financial industries in the state's GDP is related to a higher positive response of real output than the manufacturing industries. Similarly, the negative coefficient in Table 2.5 shows that the state's dependency on the debt has the most substantial adverse effect on the output response (-0.34) followed by state policy uncertainty (-0.27) and strict labor market regulation (-0.24).

Table 2.5: Baseline Regression (Personal income tax shock)

	Dependent variable				
	(1) IRF-GDP10 yr	(2) IRF-GDP10 yr	(3) IRF-GDP10 yr	(4) IRF-GDP10 yr	(5) IRF-GDP2 yr
Financial	0.36**	0.59***	0.56***	0.59***	0.65***
	(0.15)	(0.16)	(0.15)	(0.16)	(0.16)
State Govt. debt	-0.307*	-0.41**	-0.39**	-0.34**	-0.39**
	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)
State uncertainty	-0.32**	-0.27**	-0.23*	-0.27**	-0.19
	(0.13)	(0.13)	(0.12)	(0.13)	(0.13)
Manufacturing		0.17*	0.33**	0.38**	0.49***
		(0.12)	(0.14)	(0.14)	(0.14)
State job creation		0.23*	0.30**	0.32**	0.32**
		(0.12)	(0.12)	(0.12)	(0.12)
Loans to small firms		0.25*	0.29**	0.26*	0.21*
		(0.13)	(0.12)	(0.13)	(0.13)
Elasticity of income tax		-0.26**	-0.28**	-0.31**	-0.30**
		(0.12)	(0.12)	(0.14)	(0.14)
Home ownership rate			-0.29*	-0.36**	-0.35**
			(0.14)	(0.15)	(0.15)
State Avg Corp.Inc. Tax				0.001	-0.014
				(0.15)	(0.15)
Labor market regulation				-0.24*	-0.24*
				(0.13)	(0.13)
Observations	50	50	50	50	50
Adjusted R^2	0.25	0.33	0.39	0.39	0.39

Note: *p<0.1; **p<0.05; ***p<0.01

The regressors in preferred baseline models are the key regressors, as explained in sections 2.5.2-2.5.4. As shown in column (1) through (5), the state-level covariates display a robust relationship between the cumulative responses of personal income tax shocks and the state-level economic structures. For the long-run responses, column (1)-(4) of Table 2.5 show that both the financial and manufacturing share in the state-level GDP exert a highly statistically significant positive effect on the expansionary response of tax cut shocks. The positive coefficient on the share of finance suggests that higher concentration of finance, insurance, banks in the state's GDP lead to a higher increase in real GDP in the face of federal tax cuts.

Similarly, states with a higher share of manufacturing in their GDP also experience a positive GDP response. The growth of state-level non-farm job creation enters with a statistically significant positive coefficient in both the short- and long-run, reflecting the persistence response in the state's GDP growth. The homeownership rate has a negative coefficient, as explained in section 2.5.4, significant at the 5 percent level, the percentage of bank loans to small firms has a positive effect on the response of GDP. The responses of GDP are negatively associated with the increase in state income tax. The state's corporate income tax is also showing an adverse effect, but coefficients are statistically insignificant in both the short- and long-run.

The positive correlation between states' financial and manufacturing share and the real GDP response to a corporate tax cut is also positive and statistically significant across the five baseline regressions, as shown in Table 2.6. As in the response of personal income tax cuts, states with higher job creation rates tend to have higher real GDP responses to the corporate tax cuts. The GDP responses are negatively correlated to the state's homeownership rate, while state and local government debt are negative but statistically insignificant.

The findings of the baseline regression have a connection to the impulse responses in section 2.4.3. The personal income tax cut leads to a higher increase in real GDP in states, like Texas, Colorado, Oregon, Idaho, California, and Florida. As shown in figure 2.11, the concentration of private industries, particularly finance and manufacturing share, is also higher in these six states. For example, private industry share accounts for a maximum of 3.87 percent in Texas, followed by 3.14 percent in California and 3.03 percent in Idaho. So, the larger share of financial and manufacturing industries for these states validates the regression results in Tables 2.5 and 2.6 and supports the economic significance of impulse response functions in Figure 2.5

Table 2.6: Baseline Regression (Corporate income tax shock)

	Dependent variable				
	(1) IRF-GDP10 yr	(2) IRF-GDP10 yr	(3) IRF-GDP10 yr	(4) IRF-GDP10 yr	(5) IRF-GDP2 yr
Financial	0.29**	0.27***	0.48**	0.53**	0.42***
	(0.13)	(0.13)	(0.22)	(0.23)	(0.27)
Manufacturing	0.23*	0.24*	0.41**	0.41**	0.48***
	(0.13)	(0.13)	(0.16)	(0.16)	(0.16)
State uncertainty	-0.22	-0.22*	-0.26*	-0.22	-0.13
	(0.13)	(0.13)	(0.14)	(0.15)	(0.14)
State Avg Corp.Inc. Tax	-0.30**	-0.20	-0.11	-0.10	-0.09
	(0.14)	(0.16)	(0.17)	(0.17)	(0.17)
Elasticity of income tax		-0.17	-0.23	-0.25*	-0.28*
		(0.15)	(0.16)	(0.16)	(0.16)
Loans to small firms		0.25*	0.01	0.01	0.005
		(0.13)	(0.14)	(0.15)	(0.14)
State job creation			0.24	0.26*	0.20
			(0.14)	(0.15)	(0.14)
Home ownership rate			-0.41**	-0.40**	-0.32*
			(0.17)	(0.17)	(0.17)
Labor market regulation			-0.03	-0.02	-0.04
			(0.15)	(0.15)	(0.15)
Housing			-0.32	-0.30	-0.18
			(0.21)	(0.22)	(0.21)
State Govt. debt				-0.11	0.18
				(0.17)	(0.17)
Observations	50	50	50	50	50
Adjusted R^2	0.17	0.17	0.21	0.20	0.22

Note: *p<0.1; **p<0.05; ***p<0.01

and 2.6. The scatter plots in Figure 2.13 show the correlation between cumulative impulse responses of states GDP to a change in either taxes and states characteristics. Points above the fitted line with state acronyms indicate states with highest responses.

Additionally, Figure 2.14 shows how the marginal coefficient of the cumulative response of GDP varies with the variation of states covariates. The black straight line represents point estimates, while the shaded areas represent 95 percent bootstrap confidence interval. The top and bottom panels show that state finance and manufacturing share feature an increasing marginal response over the forecasted horizon. At a 2 percent share, the marginal effect of finance share on GDP is 1.2, and the effect is 0.89 for the manufacturing share. These findings are clearly consistent with the industrial share of the state's GDP in Figure 6. States with the smallest industrial share, such as New Jersey and West Virginia, show the smallest GDP responses. If the share of finance exceeds 1 percent, the marginal GDP response is 0.95 percent for the personal income tax cut, while the effect is 0.5 percent for the corporate income tax cut. Contrary to the state's finance and manufacturing sector, the marginal response of GDP is a decreasing function of the state's real sector policy uncertainty.

As expected, the effect of labor market regulation on the impact of the tax cut in GDP is negative and statistically significant. The magnitude of the estimated coefficients is the same for both short- and long-run horizons, and the effects are robust. The coefficient of state-level real sector uncertainty is also negative and significant, suggests that states with higher uncertainty may signal an uncertain future environment when households and businesses are unwilling to incorporate the tax cut incentives in their utility and production functions (Bloom, 2009; Mumtaz et al., 2018; Bloom et al., 2018). However, the coefficient of state uncertainty index, fiscal structure, and labor market regulation does not appear as a significant and robust component in explaining the heterogeneity of GDP responses to federal corporate income tax changes.

The baseline regression specification includes state government debt as a percentage of Gross State Product (GSP), which considered a key measure of state and local government fiscal structure. The coefficient is negative and statistically significant across all baseline models. Rising debt to GSP ratio indicates a state's weaker fiscal conditions, and states experience a negative relationship with the long-run response to a tax cut shock. This finding moderately supports the critique of the "over-borrowing" model, which primarily depends on the principle of the Ricardian

Equivalence Model. The model assumes that higher government debt and future debt payments translate into lower consumption, more private savings, and lower property values (Barro, 1994; Eichenberger and Stadelmann, 2010). As a result, real output and prices decline as in the New Classical and New Keynesian Model through the components of aggregate demand channel. This result is consistent with the U.S. state version of the Ricardian Equivalence Model of Banzhaf and Oats (2012), who find that local debt finance options increase future tax burden and translate into lower property values.

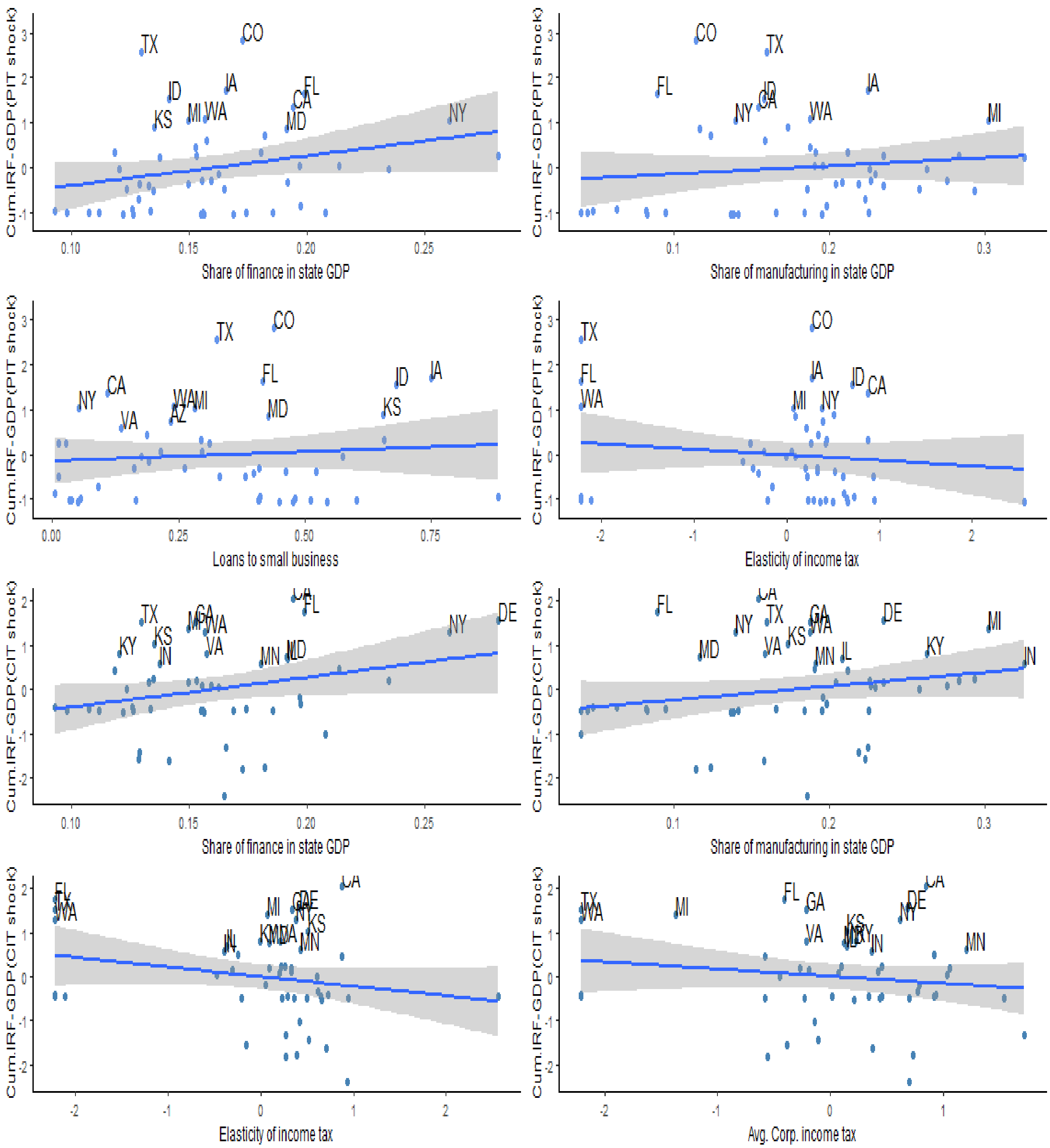

Figure 2.13: The left panel (right panel) shows the correlation between cumulative impulse responses of states GDP to a personal income tax shock (a corporate income tax shock). Points with state acronyms indicate states with highest responses.

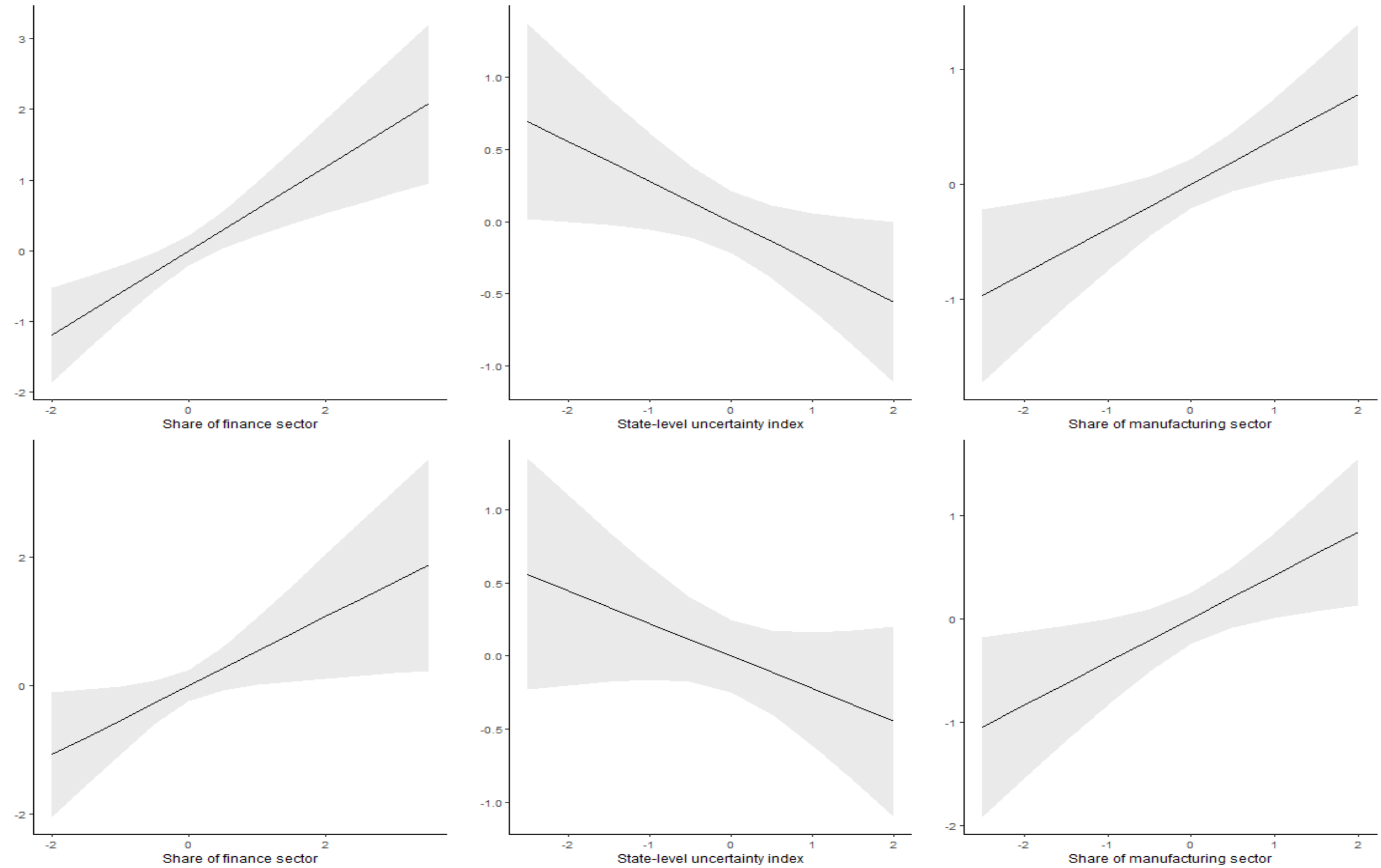

Figure 2.14: The top panel (bottom panel) shows the marginal effect on the cumulative impulse responses of states GDP to a personal income tax shock (a corporate income tax shock). The shaded area represents a 95 % bootstrap confidence interval.

2.5.6 Baseline estimation: Other results

Column (1) and (4) in Table (2.7) and (2.8) show the estimated results of the baseline regression models. The cumulative response of personal income and employment at 10-year horizons is the dependent variable in both tables. The financial and manufacturing share, nonfarm employment, and loan to small firms show a robust and positive effect on the response of personal income and employment. States labor market regulation, government debt, and state-level tax rates decrease employment. The economic policy uncertainty is showing a negative impact as expected, but statistically insignificant.

Regression models in Table 2.9 augment the baseline regression by adding four financial friction-related variables: loans to households and business, the ratio of loan loss to the bank's total asset, the ratio of non-performing loans to total bank's loan, and net interest margin. The rationale of the inclusion of these comes from the empirical framework of Carlino and Defina (1998, 1999), Di Giacinto (2003), Cecchetti (2001), and Lucio and Izquierdo (1999). The focus is on examining the significance of the state-level liquidity and money supply that directly influences the price levels. Corporate tax cuts increase the liquid assets of banks and other lenders, and thus financial institutions respond to tax cuts by providing more loans to consumers and firms (Bernanke 1981; Buiter and Panigirtzoglou, 1999).

The regression results in Table 2.9 support this liquidity effect, where loans to small firms and loans to households and businesses show a robust and positive effect on price levels. The ratio of loan loss to total loan, non-performing loans, and the net interest margins appears as contractionary components. They reduce the bank's solvency and increase the degree of uncertainty about future liquidity. As expected, the coefficient of non-performing loans is negative. It suggests that the rise of loan loss is associated with a lower money supply, leading to a drop in price levels. The ratio of loan loss to total assets is not robust across the baseline models. These findings are broadly consistent with the inflationary effects of marginal tax cuts at the zero lower bound, as in Mertens and Ravn (2014).

Table 2.7: Baseline Regression (personal income tax shock)

	Dependent variable			
	(1) IRF-DPI 10 yr	(2) IRF-DPI 2 yr	(3) IRF-EMP 10 yr	(4) IRF-EMP 2 yr
Financial	0.59***	0.62***	0.76***	0.78***
	(0.15)	(0.16)	(0.17)	(0.16)
State Govt. debt	-0.37**	-0.37**	-0.33**	-0.34**
	(0.15)	(0.15)	(0.15)	(0.13)
Manufacturing	0.44***	0.46***	0.29*	0.31*
	(0.14)	(0.14)	(0.17)	(0.17)
State job creation	0.17	0.23*	0.33**	0.27*
	(0.12)	(0.12)	(0.13)	(0.14)
Loans to small firms	0.37***	0.27**	-0.006	-0.03
	(0.13)	(0.13)	(0.13)	(0.13)
Elasticity of income tax	-0.34**	-0.34**	-0.27	-0.24
	(0.14)	(0.15)	(0.18)	(0.18)
Home ownership rate	-0.37**	-0.34**	-0.10	-0.004
	(0.15)	(0.15)	(0.16)	(0.15)
Labor market regulation	-0.36***	-0.38***	-0.34**	-0.29**
	(0.13)	(0.13)	(0.14)	(0.13)
State uncertainty	-0.14	-0.17	-0.17	-0.14
	(0.13)	(0.13)	(0.13)	(0.13)
State Avg Corp. Inc. Tax	0.05	0.01	0.13	0.21
	(0.15)	(0.15)	(0.18)	(0.19)
Observations	50	50	50	50
Adjusted R^2	0.39	0.38	0.329	0.35

Note: *p<0.1; **p<0.05; ***p<0.01

Table 2.8: Baseline Regression (corporate income tax shock)

	Dependent variable			
	(1)	(2)	(3)	(4)
	IRF-DPI 10 yr	IRF-DPI 2 yr	IRF-EMP 10 yr	IRF-EMP 2 yr
Financial	0.48**	0.51***	0.34*	0.39**
	(0.17)	(0.17)	(0.20)	(0.19)
State Govt. debt	-0.34**	-0.36**	-0.04	-0.15
	(0.16)	(0.16)	(0.19)	(0.17)
Manufacturing	0.48***	0.42**	0.18*	0.30*
	(0.16)	(0.16)	(0.18)	(0.17)
State job creation	0.22	0.27*	0.02	0.04
	(0.14)	(0.14)	(0.16)	(0.15)
Labor market regulation	-0.33**	-0.32**	-0.23	-0.03
	(0.15)	(0.14)	(0.17)	(0.15)
Loans to small firms	0.016	-0.04	0.22	0.08
	(0.14)	(0.14)	(0.16)	(0.15)
Elasticity of income tax	-0.40**	-0.40**	0.09	0.14
	(0.16)	(0.16)	(0.18)	(0.18)
Home ownership rate	-0.22	-0.17	-0.08	0.13
	(0.17)	(0.17)	(0.16)	(0.18)
State uncertainty	-0.11	-0.14	-0.17	-0.14
	(0.14)	(0.15)	(0.13)	(0.13)
State Avg Corp. Inc. Tax	0.11	0.12	-0.14	-0.14
	(0.17)	(0.17)	(0.20)	(0.19)
Observations	50	50	50	50
Adjusted R^2	0.23	0.25	0.38	0.34

Note: *p<0.1; **p<0.05; ***p<0.01

Table 2.9: Baseline Regression (responses of CPI)

	Dependent variable			
	(PIT Shock)		(CIT Shock)	
	(1)	(2)	(3)	(4)
	IRF-CPI 10 yr	IRF-CPI 2 yr	IRF-CPI 10 yr	IRF-CPI 2 yr
Financial	0.38**	0.29*	0.39**	0.37**
	(0.16)	(0.17)	(0.16)	(0.16)
Manufacturing	0.28	0.30*	0.26	0.29*
	(0.17)	(0.17)	(0.16)	(0.16)
Loans to small firms	0.49***	0.38**	0.42**	0.42**
	(0.17)	(0.17)	(0.17)	(0.17)
Loans to HH & Business	0.98**	1.12**	1.17***	1.31***
	(0.46)	(0.47)	(0.44)	(0.45)
Loan loss/total asset	-0.22	-0.17	-0.22	-0.34
	(0.21)	(0.21)	(0.21)	(0.21)
Non-perform loans/total loans	-0.68	-0.17	-0.83*	-0.94*
	(0.44)	(0.45)	(0.43)	(0.43)
Net int. margin	-0.20	-0.25	-0.29	-0.24
	(0.18)	(0.18)	(0.17)	(0.17)
State job creation	0.09	0.12	0.01	0.09
	(0.15)	(0.15)	(0.14)	(0.14)
Labor market regulation	-0.05	-0.06	-0.02	-0.009
	(0.16)	(0.16)	(0.16)	(0.16)
Unemployment insurance	-0.12	-0.07	-0.30*	-0.25
	(0.16)	(0.16)	(0.16)	(0.16)
Observations	50	50	50	50
Adjusted R^2	0.13	0.10	0.16	0.16

Note: *p<0.1; **p<0.05; ***p<0.01

2.6 Robustness Analysis

This section performs several robustness analyses of the baseline regression results by employing four aspects of the state's characteristics. First, the analysis examines whether the inclusion of the state's financial frictions affects the main results. It then examines if the employment and regulatory framework of labor market characteristics are sensitive to the robust relationship across a variety of specifications. Finally, the analysis considers additional variables from the state's fiscal and housing sectors. Table 2.11-2.20 report the results of various robustness analysis.

Table 2.11 and 2.12 examine the effects of controlling loans to households and business, loan loss, equity of commercial banks, and the net interest margin. Column (3) shows that all the variables in the baseline model are significant after controlling financial frictions related variables. For corporate income tax cut, column (2) in Table 2.13 shows that financial and manufacturing share remain significant once the model controls loan loss to total asset ratio and the loan loss reserves.

Table 2.14 and 2.15 explore the role of labor market variables in explaining the heterogeneous responses. Column (2) in both Tables augments the baseline models by including the right to work, sectoral employment, and unemployment insurance. The labor market regulation and the right to work show a negative effect, but the right to work is not significant across the specifications. The effect of unemployment insurance is also robust and shows a positive impact on the response of personal income and employment to either tax cuts.

Next, the model controls the state’s budget deficit, tax, subsidies, and average sales and tax burden rates. As shown in baseline models, columns (1)-(4) in Table 2.16 and 2.17 show that the sign and significance of the baseline variables are significant across models. Consistent with Mertens and Ravn (2013) and Liu and Williams (2019), the marginal effects of the coefficients are higher for the personal income tax cut than the corporate income tax cuts.

Finally, models in Table 2.18 control the state’s housing market-related variables. Column (1)-(4) includes homeownership volume, housing and construction share in states GDP, home vacancy rate, and the rental vacancy rate. Findings show that the baseline regression results remain robust after controlling state-level housing market conditions. As in the baseline models, finance and manufacturing share, job creation, and loan to small firms are significant and robust. Contrary to the baseline model, the homeownership rate in Table 2.18, 2.19, and 2.20 turns out to be positive and insignificant. In all specifications, the relationship between the cumulative responses and state-level key characteristics are also robust when the cumulative responses change from 10-year horizons to 2-year horizons.

Table 2.11: Controlling financial market

	Dependent variable:			
	IRF(PIT)-GDP10 yr			
	(1)	(2)	(3)	(4)
Financial	0.457***	0.396**	0.508***	0.594***
	(0.166)	(0.159)	(0.155)	(0.164)
State uncertainty	-0.353**	-0.407***	-0.346**	-0.277**
	(0.133)	(0.130)	(0.128)	(0.133)
State Govt. debt	-0.342**	-0.330**	-0.333**	-0.354**
	(0.158)	(0.152)	(0.143)	(0.163)
Manufacturing	0.305*	0.307**	0.391***	0.388**
	(0.152)	(0.144)	(0.140)	(0.149)
State job creation	0.348**	0.344**	0.339**	0.325**
	(0.138)	(0.129)	(0.128)	(0.131)
Home ownership rate	-0.313*	-0.298*	-0.325**	-0.374**
	(0.168)	(0.155)	(0.153)	(0.161)
State Avg. Corp. Inc. Tax	0.026	0.063	0.047	0.003
	(0.162)	(0.157)	(0.150)	(0.159)
State Avg. Pers. Inc. Tax	-0.263*	-0.280*	-0.328**	-0.314**
	(0.154)	(0.145)	(0.141)	(0.148)
Labor market regulation	-0.284**	-0.352**	-0.332**	-0.236*
	(0.140)	(0.139)	(0.134)	(0.138)
Loans to small firms			0.327**	0.309
			(0.139)	(0.440)
Tot loan loss/total assets	-0.096		0.051	
	(0.154)		(0.224)	
Loan loss reserve		-0.270*	-0.381*	
		(0.135)	(0.189)	
Equity comm. banks				-0.051
				(0.449)
Observations	50	50	50	50
Adjusted R2	0.336	0.390	0.460	0.374

Note: *p<0.1; **p<0.05; ***p<0.01

Table 2.12: Response of CPI to PIT shock

	Dependent variable:			
	IRF-CPI (PIT) 10 yr			
	(1)	(2)	(3)	(4)
Financial	0.452**	0.384**	0.407*	0.373*
	(0.185)	(0.176)	(0.209)	(0.211)
Manufacturing	0.410*	0.385*	0.394*	0.382*
	(0.225)	(0.220)	(0.216)	(0.224)
Public	0.176	0.185	0.136	0.112
	(0.213)	(0.218)	(0.212)	(0.216)
Loan to small firms	0.443**	0.733	0.476**	0.454**
	(0.171)	(0.496)	(0.181)	(0.180)
Non-performing loans	-0.623	-0.819*	-0.720	-0.760
	(0.479)	(0.470)	(0.461)	(0.460)
Loan to households and business	0.999*	1.032*	1.075**	1.123**
	(0.521)	(0.518)	(0.482)	(0.479)
Unemployment insurance	-0.108	-0.042	-0.110	-0.116
	(0.169)	(0.163)	(0.169)	(0.171)
Labor market regulation	-0.007	-0.001		
	(0.171)	(0.176)		
Loan loss reserves	-0.053	-0.112		
	(0.227)	(0.220)		
State job creation	0.078		0.095	
	(0.153)		(0.166)	
Net interest margin	-0.205		-0.205	-0.216
	(0.191)		(0.183)	(0.183)
Equity comm. banks		-0.316		
		(0.527)		
Right to work			-0.064	-0.140
			(0.369)	(0.363)
Total loan loss/ total asset			-0.151	-0.117
			(0.235)	(0.235)
Emp (educ., fin and health)				0.001
				(0.176)
Observations	50	50	50	50
Adjusted R2	0.098	0.095	0.108	0.100

Note: *p<0.1; **p<0.05; ***p<0.01

Table 2.13: Controlling financial market

	Dependent variable:		
	IRF(CIT)-GDP10 yr		
	(1)	(2)	(3)
Financial	0.350*	0.367*	0.327*
	(0.185)	(0.190)	(0.191)
State uncertainty	-0.181	-0.161	-0.181
	(0.150)	(0.152)	(0.154)
Manufacturing	0.457***	0.476***	0.470***
	(0.168)	(0.172)	(0.170)
Elasticity of income tax	-0.251	-0.287	-0.277
	(0.167)	(0.172)	(0.169)
State job creation	0.226	0.189	0.218
	(0.147)	(0.157)	(0.149)
Home ownership	-0.298	-0.387*	-0.336*
	(0.181)	(0.191)	(0.181)
Labor market regulation	-0.078	-0.034	-0.069
	(0.156)	(0.156)	(0.161)
State Avg. Corp. Inc. Tax	-0.134	-0.116	-0.110
	(0.179)	(0.183)	(0.182)
State Govt. debt	-0.053	-0.137	-0.125
	(0.184)	(0.178)	(0.177)
Equity comm banks	0.712	0.023	0.098
	(0.506)	(0.182)	(0.163)
Loan to small firms	-0.668		
	(0.496)		
Total loan loss/Total asset		0.086	
		(0.200)	
Loan loss reserve			-0.123
			(0.163)
Observations	50	50	50
Adjusted R2	0.204	0.171	0.179
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 2.14: Controlling labor market

	Dependent variable:			
	IRF(PIT)-GDP10 yr			
	(1)	(2)	(3)	(4)
Financial	0.603***	0.560***	0.471***	0.591***
	(0.175)	(0.184)	(0.173)	(0.168)
State uncertainty	-0.234*	-0.234	-0.255*	-0.279**
	(0.133)	(0.139)	(0.141)	(0.133)
State Govt. debt	-0.367**	-0.364**	-0.303*	-0.354**
	(0.161)	(0.170)	(0.167)	(0.149)
Manufacturing	0.342**	0.364**	0.288*	0.468***
	(0.150)	(0.171)	(0.153)	(0.163)
Home ownership rate	-0.297*	-0.287	-0.253	-0.292*
	(0.159)	(0.176)	(0.164)	(0.160)
State Avg. Corp. Inc. Tax	-0.060	-0.042	0.015	0.068
	(0.158)	(0.165)	(0.170)	(0.160)
Elasticity of income tax	-0.247*	-0.246	-0.265*	-0.386**
	(0.146)	(0.154)	(0.156)	(0.159)
Loans to small firms	0.304**	0.293**	0.258*	0.273**
	(0.137)	(0.143)	(0.144)	(0.130)
Right to work	0.123	0.048	-0.239	
	(0.300)	(0.310)	(0.336)	
State job creation	0.323**			0.370***
	(0.136)			(0.130)
Emp (educ, fin and health)		0.229		
		(0.161)		
Labor force participation			-0.255	
			(0.168)	
Unemployment insurance				0.192
				(0.127)
Labor market regulation				-0.229*
				(0.133)
Observations	50	50	50	50
Adjusted R2	0.345	0.288	0.293	0.413
Note:	*p<0.1; **p<0.05; ***p<0.01			

Table 2.15: Controlling labor market

	Dependent variable: IRF(CIT)-GDP10 yr	
	(1)	(2)
Financial	0.508**	0.441*
	(0.236)	(0.242)
State uncertainty	-0.221	-0.207
	(0.149)	(0.159)
Manufacturing	0.408**	0.410**
	(0.165)	(0.192)
Elasticity of income tax	-0.239	-0.243
	(0.159)	(0.175)
Loan to small firms	-0.043	-0.016
	(0.150)	(0.156)
Home ownership rate	-0.339*	-0.360*
	(0.174)	(0.196)
State Avg. Corp. Inc. Tax	-0.134	-0.089
	(0.172)	(0.185)
Housing	-0.361	-0.232
	(0.223)	(0.223)
State Govt. debt	-0.159	-0.092
	(0.176)	(0.182)
State job creation	0.235	
	(0.151)	
Emp (educ., fin and health)		0.113
		(0.176)
Right to work	-0.349	
	(0.335)	
Labor market regulation		-0.025
		(0.160)
Observations	50	50
Adjusted R2	0.224	0.152

Note: *p<0.1; **p<0.05; ***p<0.01

Table 2.16: Controlling fiscal structure

	Dependent variable:			
	IRF(PIT)-GDP10 yr			
	(1)	(2)	(3)	(4)
Financial	0.650***	0.652***	0.670***	0.725***
	(0.188)	(0.187)	(0.188)	(0.187)
State uncertainty	-0.265*	-0.326**	-0.269*	-0.327**
	(0.144)	(0.153)	(0.143)	(0.143)
State Govt. debt	-0.396**	-0.449**	-0.408**	-0.374**
	(0.166)	(0.175)	(0.166)	(0.158)
Manufacturing	0.413**	0.351*	0.454**	0.385**
	(0.190)	(0.204)	(0.192)	(0.184)
State job creation	0.357**	0.399**	0.365**	0.388***
	(0.142)	(0.148)	(0.144)	(0.138)
Loans to small firms	0.267*	0.245*	0.266*	0.255*
	(0.143)	(0.144)	(0.143)	(0.137)
Home ownership rate	-0.177	-0.193	-0.173	-0.103
	(0.182)	(0.167)	(0.182)	(0.181)
Elasticity of income tax	-0.352*	-0.334*	-0.307	-0.341**
	(0.177)	(0.184)	(0.198)	(0.139)
Public	0.172	0.082	0.204	0.207
	(0.232)	(0.234)	(0.229)	(0.220)
Tax	-0.051	-0.130	-0.033	-0.236
	(0.181)	(0.199)	(0.189)	(0.207)
Subsidy	-0.066		-0.071	-0.095
	(0.148)		(0.150)	(0.143)
Budget deficit	-0.049	0.051		-0.002
	(0.141)	(0.173)		(0.138)
State Avg. Corp. Inc. Tax		0.0003		0.008
		(0.170)		(0.172)
Insurance		0.175		
		(0.199)		
State Avg. Pers. Inc. Tax			-0.022	-0.071
			(0.195)	(0.199)
State Avg. sales Tax				0.258
				(0.155)
Observations	50	50	50	50
Adjusted R2	0.316	0.328	0.316	0.364

Note: *p<0.1; **p<0.05; ***p<0.01

Table 2.17: Controlling fiscal structure

	Dependent variable: IRF(CIT)-GDP10 yr (1)	(2)
Financial	0.549**	0.522**
	(0.236)	(0.248)
Manufacturing	0.450**	0.454**
	(0.173)	(0.176)
Elasticity of income tax	-0.181	-0.354*
	(0.192)	(0.180)
State job creation	0.281*	0.225
	(0.152)	(0.156)
Loan to small firms	-0.043	0.032
	(0.151)	(0.155)
Home ownership rate	-0.403**	-0.447**
	(0.174)	(0.202)
Labor market regulation	-0.004	-0.029
	(0.156)	(0.159)
Housing	-0.301	-0.272
	(0.219)	(0.244)
State Govt. debt	-0.148	-0.215
	(0.175)	(0.170)
State Avg. Pers. Inc. Tax	-0.195	
	(0.210)	
Tax burden rate		0.053
		(0.209)
State Avg. sales tax	-0.233	
	(0.152)	
Tax		0.048
		(0.183)
Observations	50	50
Adjusted R2	0.213	0.151

Note: *p<0.1; **p<0.05; ***p<0.01

Table 2.18: Controlling housing variables

	Dependent variable:			
	IRF(PIT)-GDP10 yr			
	(1)	(2)	(3)	(4)
Financial	0.733***	0.622***	0.701***	0.643***
	(0.174)	(0.229)	(0.170)	(0.235)
State uncertainty	-0.313**	-0.318**	-0.318**	-0.327**
	(0.142)	(0.144)	(0.142)	(0.147)
State Govt. debt	-0.334**	-0.370**	-0.318*	-0.336*
	(0.160)	(0.158)	(0.167)	(0.174)
Manufacturing	0.434**	0.383**	0.364**	0.371**
	(0.180)	(0.164)	(0.164)	(0.168)
State job creation	0.337**	0.299**	0.350**	0.327**
	(0.137)	(0.142)	(0.142)	(0.154)
Loan to small firms	0.258*	0.238*	0.251*	0.256*
	(0.141)	(0.137)	(0.139)	(0.144)
State Avg. Corp. Inc. Tax	-0.002	0.006	0.019	0.018
	(0.169)	(0.169)	(0.168)	(0.172)
Elasticity of income tax	-0.382**	-0.376**	-0.367**	-0.372**
	(0.168)	(0.169)	(0.169)	(0.171)
Public	0.350*	0.294	0.329*	0.312
	(0.184)	(0.187)	(0.180)	(0.192)
Labor market regulation	-0.135	-0.168	-0.134	-0.142
	(0.136)	(0.134)	(0.138)	(0.145)
Home ownership vol	0.107			
	(0.143)			
Housing		0.112		0.097
		(0.204)		(0.209)
Home vacancy rate			0.106	
			(0.153)	
Rental vacancy rate				0.080
				(0.164)
Observations	50	50	50	50
Adjusted R2	0.347	0.342	0.345	0.329
Note:	*p<0.1; **p<0.05; ***p<0.01			

Table 2.19: Controlling housing variables

	Dependent variable:		
	IRF(PIT)-DPI10 yr		
	(1)	(2)	(3)
Financial	0.783***	0.580**	0.612***
	(0.165)	(0.227)	(0.225)
State Govt. debt	-0.325**	-0.361**	-0.322*
	(0.152)	(0.168)	(0.167)
Manufacturing	0.592***	0.454***	0.438***
	(0.172)	(0.163)	(0.161)
State Avg. Corp. Inc. Tax	0.038	0.068	0.091
	(0.161)	(0.166)	(0.165)
Income elasticity of tax	-0.440***	-0.417**	-0.418**
	(0.160)	(0.166)	(0.163)
Public	0.443**	0.340*	0.368*
	(0.175)	(0.185)	(0.184)
Loan to small firms	0.410***	0.378***	0.406***
	(0.134)	(0.137)	(0.138)
State job creation	0.218	0.172	0.206
	(0.131)	(0.148)	(0.148)
Labor market regulation	-0.233*	-0.279*	-0.242*
	(0.130)	(0.138)	(0.139)
State uncertainty	-0.148	-0.154	-0.191
	(0.135)	(0.143)	(0.141)
Home ownership vol	0.251*		
	(0.136)		
Home vacancy rate		0.102	
		(0.154)	
Rental vacancy rate			0.197
			(0.158)
Housing		0.181	0.175
		(0.207)	(0.200)
Observations	50	50	50
Adjusted R2	0.409	0.366	0.384
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 2.20: Controlling financial, labor, fiscal and housing variables

	Dependent variable:			
	IRF (CIT)-EMP10 yr			
	(1)	(2)	(3)	(4)
Financial	0.759***	0.773***	0.797***	0.558**
	(0.166)	(0.205)	(0.171)	(0.221)
State Govt. debt	-0.323**	-0.400**	-0.338**	-0.374**
	(0.156)	(0.173)	(0.156)	(0.154)
State uncertainty	-0.130	-0.128	-0.164	-0.134
	(0.144)	(0.144)	(0.137)	(0.136)
Manufacturing	0.375*	0.261	0.303*	0.281*
	(0.200)	(0.187)	(0.170)	(0.162)
State job creation	0.335**	0.343**	0.347**	0.265*
	(0.137)	(0.155)	(0.136)	(0.138)
Elasticity of income tax	-0.226	-0.147	-0.125	-0.273
	(0.189)	(0.186)	(0.167)	(0.176)
Public	0.557***	0.568***	0.499**	0.521***
	(0.181)	(0.200)	(0.189)	(0.168)
Loan to households and business	0.141			
	(0.181)			
Home ownership rate	-0.113	0.014	-0.082	
	(0.164)	(0.174)	(0.167)	
Labor market regulation	-0.277		-0.294**	-0.344**
	(0.166)		(0.138)	(0.131)
State Avg. Pers. Inc. Tax	0.107	-0.016		0.107
	(0.190)	(0.194)		(0.184)
Loan to small firms		0.023	-0.011	-0.002
		(0.147)	(0.135)	(0.132)
Right to work		0.067		
		(0.326)		
State Avg. Corp. Inc. Tax			-0.108	
			(0.167)	
Housing				0.304
				(0.196)
Observations	50	50	50	50
Adjusted R2	0.371	0.261	0.359	0.392
Note:	*p<0.1; **p<0.05; ***p<0.01			

2.7 Conclusion

This paper estimates panel FAVAR models to examine the state-level response of GDP, personal income, price levels, and employment to U.S. federal narrative tax changes. The findings uncover a substantial heterogeneity on the impact of personal and corporate income tax cuts on state-level macroeconomic variables. The magnitude and persistence of the GDP, personal income, and employment responses to either tax cut are estimated to be largest in Colorado, Texas, Florida, California, Kansas, Arizona, and Nevada. In contrast, the federal personal income tax cut has a smaller impact on the GDP, personal income, and employment in states such as Oklahoma, Rode Island, New Mexico, Maine, New Hampshire, and Vermont. The FAVAR results highlight the significance of the New-Classical and the Keynesian models that link federal tax cuts with state-level real GDP and income growth. The findings of the FAVAR model are moderately consistent in directions and persistence with the conclusions of Liu and Williams (2019), and Marten and Ravn (2013), and Romer and Romer (2009).

Cross-states regression analysis suggests that real GDP, personal income, and employment rise in states with a larger share of finance and manufacturing industries, higher nonfarm employment, and flexible supply of loans to small firms. States characterized by a higher amount of government debt, strict labor market regulations, a higher degree of economic policy uncertainty, and a higher tax burden appear to be negatively affected by federal tax changes. The cross-state regression analysis provides new insight into microeconomic channels of tax shock's transmission mechanism. The analysis broadly supports the economic significance of impulse response functions.

References

Asimakopoulos, P., & Asimakopoulos, S. (2019). Fiscal policy with banks and financial frictions. Journal of Financial Stability, 40, 94-109.

Bania, N., Gray, J. A., & Stone, J. A. (2007). Growth, taxes, and government expenditures: growth hills for US states. National Tax Journal, 193-204.

Banzhaf, H. S., & Oates, W. E. (2012). On fiscal illusion and Ricardian equivalence in local public finance (No. w18040). National Bureau of Economic Research.

Barro, R. J. (1974). Are government bonds net wealth?. Journal of political economy, 82(6), 1095-1117.

Barro, R. J., & Furman, J. (2018). Macroeconomic effects of the 2017 tax reform. Brookings papers on economic activity, 2018(1), 257-345.

Barth III, M. J., & Ramey, V. A. (2001). The cost channel of monetary transmission. NBER macroeconomics annual, 16, 199-240.

Bartik, T. J. (1994). Jobs, productivity, and local economic development: What implications does economic research have for the role of government?. National Tax Journal, 47(4), 847-861.

Bernanke, B. S., & Gertler, M. (1995). Inside the black box: the credit channel of monetary policy transmission. Journal of Economic perspectives, 9(4), 27-48.

Bernanke, B. S. (1981). Bankruptcy, liquidity, and recession. The American Economic Review, 71(2), 155-159.

Bernanke, B. S., Boivin, J., & Eliasz, P. (2005). Measuring the effects of monetary policy: a factor-augmented vector autoregressive (FAVAR) approach. The Quarterly journal of economics, 120(1), 387-422.

Blanchard, O., & Perotti, R. (2002). An empirical characterization of the dynamic effects of changes in government spending and taxes on output. the Quarterly Journal of economics, 117(4), 1329-1368.

Blau, F. D., & Kahn, L. M. (2007). Changes in the labor supply behavior of married women: 1980–2000. Journal of Labor economics, 25(3), 393-438.

Blinder, A. S., & Solow, R. M. (1973). Does fiscal policy matter?. Journal of public economics, 2(4), 319-337.

Bianchi, Javier, 2016, "Efficient Bailouts?" American Economic Review, Vol. 106, No. 12, pp. 3607–59.

Brave, S. A., Butters, R. A., & Kelley, D. (2019). A New "Big Data" Index of US Economic Activity. Economic Perspectives, (1), 1-30.

Brückner, M., & Pappa, E. (2012). Fiscal expansions, unemployment, and labor force participation: Theory and evidence. International Economic Review, 53(4), 1205-1228.

Buiter, W. H., & Panigirtzoglou, N. (1999). Liquidity traps: how to avoid them and how to escape them (No. w7245). National bureau of economic research.

Carlino, G., & DeFina, R. (1998). The differential regional effects of monetary policy. Review of economics and statistics, 80(4), 572-587.

Carlino, G., & DeFina, R. (1999). The differential regional effects of monetary policy: Evidence from the US states. Journal of Regional science, 39(2), 339-358.

Carlino, G., & Inman, R. P. (2013). Macro fiscal policy in economic unions: states as agents (No. w19559). National Bureau of Economic Research.

Carlino, G., & Inman, R. P. (2016). Fiscal stimulus in economic unions: what role for states?. Tax Policy and the Economy, 30(1), 1-50.

Cecchetti, S. G. (2001). Legal structure, financial structure and the monetary policy transmission mechanism. In The Monetary Transmission Process (pp. 170-207). Palgrave Macmillan, London.

Chetty, R. (2012). Bounds on elasticities with optimization frictions: A synthesis of micro and macro evidence on labor supply. Econometrica, 80(3), 969-1018.

Christ, C. F. (1968). A simple macroeconomic model with a government budget restraint. journal of Political Economy, 76(1), 53-67.

Christiano, L., Eichenbaum, M., & Rebelo, S. (2011). When is the government spending multiplier large?. Journal of Political Economy, 119(1), 78-121.

De Lucio, J. J., & Izquierdo, M. (1999). Local responses to a global monetary policy: The regional structure of financial systems. Documento de trabajo, 99, 14.

Di Giacinto, V. (2003). Differential regional effects of monetary policy: a geographical SVAR approach. International Regional Science Review, 26(3), 313-341.

Eichenberger, R., & Stadelmann, D. (2010). How federalism protects future generations from today's public debts. Review of Law & Economics, 6(3), 395-420.

Fernández-Villaverde, J. (2010). Fiscal policy in a model with financial frictions. *American Economic Review*, *100*(2), 35-40.

Furlanetto, F., Ravazzolo, F., & Sarferaz, S. (2019). Identification of financial factors in economic fluctuations. The Economic Journal, 129(617), 311-337.

Gali, J. (1999). Technology, employment, and the business cycle: do technology shocks explain aggregate fluctuations?. American economic review, 89(1), 249-271.

Gertler, M., & Kiyotaki, N. (2010). Financial intermediation and credit policy in business cycle analysis. In Handbook of monetary economics (Vol. 3, pp. 547-599). Elsevier.

Gruber, J., & Saez, E. (2002). The elasticity of taxable income: evidence and implications. Journal of public Economics, 84(1), 1-32.

Giroud, X., & Rauh, J. (2019). State taxation and the reallocation of business activity: Evidence from establishment-level data. Journal of Political Economy, 127(3), 1262-1316.

Gale, W. G., Krupkin, A., & Rueben, K. S. (2015). The relationship between taxes and growth at the state level: New evidence. National Tax Journal, 68(4).

Godley, W., & Lavoie, M. (2006). Monetary economics: an integrated approach to credit, money, income, production and wealth. Springer.

Greenwald, Bruce, Joseph E. Stiglitz, and Andrew Murray Weiss, 1984, "Informational Imperfections in the Capital Market and Macroeconomic Fluctuations," American Economic Review, Vol. 74, No. 2, pp. 194–99.

Hamilton, J. (2011). Nonlinearities and the macroeconomic effects of oil prices. Macroeconomic Dynamics, 15(S3), 364-378.

Heckemeyer, J., & de Mooij, R. A. (2017). Taxation and corporate debt: Are banks any different. National Tax Journal, 70(1), 53-76.

Helms, L. J. (1985). The Effect of State and Local Taxes on Economic Growth: A Time Series--Cross Section Approach. The Review of Economics and Statistics, 574-582.

Hansen, L. P., & Sargent, T. (2019). Rational expectations econometrics. CRC Press.

Herrera, A. M., & Rangaraju, S. K. (2019). The quantitative effects of tax foresight: Not all states are equal. Journal of Economic Dynamics and Control, 107, 103726.

Hussain, S. M., & Malik, S. (2016). Asymmetric effects of exogenous tax changes. Journal of Economic Dynamics and Control, 69, 268-300.

Holcombe, R. G., & Lacombe, D. J. (2004). The effect of state income taxation on per capita income growth. Public Finance Review, 32(3), 292-312.

Hooker, M. A., & Knetter, M. M. (1997). The effects of military spending on economic activity: Evidence from state procurement spending. Journal of Money, Credit, and Banking, 400-421.

Jääskelä, J. P., & Jennings, D. (2011). Monetary policy and the exchange rate: Evaluation of VAR models. Journal of International Money and Finance, 30(7), 1358-1374.

Kapsos, S. (2006). The employment intensity of growth: Trends and macroeconomic determinants. In Labor Markets in Asia (pp. 143-201). Palgrave Macmillan, London.

Kirchner, M., & van Wijnbergen, S. (2016). Fiscal deficits, financial fragility, and the effectiveness of government policies. Journal of Monetary Economics, 80, 51-68.

Kraus, A., & Litzenberger, R. H. (1973). A state-preference model of optimal financial leverage. The journal of finance, 28(4), 911-922.

Kydland, F. E., & Prescott, E. C. (1982). Time to build and aggregate fluctuations. Econometrica: Journal of the Econometric Society, 1345-1370.

Leland, H. E. (1994). Corporate debt value, bond covenants, and optimal capital structure. The journal of finance, 49(4), 1213-1252.

Leeper, E. M. (1991). Equilibria under 'active' and 'passive' monetary and fiscal policies. Journal of monetary Economics, 27(1), 129-147.

Liu, C., & Williams, N. (2019). State-level implications of federal tax policies. Journal of Monetary Economics, 105, 74-90.

Long, J. B., & Plosser, C. I. (2006). Real Business Cycles', Journal of Political Economy, 91 (1), February, 39-69. International Liberty of Critical Writings in Economics, 192, 237.

Mangadi, K., & Sheen, J. (2017). Identifying terms of trade shocks in a developing country using a sign restrictions approach. Applied Economics, 49(24), 2298-2315.

Mazumdar, D. (2003). Trends in employment and the employment elasticity in manufacturing, 1971–92: an international comparison. Cambridge Journal of Economics, 27(4), 563-582.

McClelland, R., & Mok, S. (2012). A review of recent research on labor supply elasticities. Congressional Budget Office. DC, Washington.

McCallum, B. T., & Whitaker, J. K. (1979). The effectiveness of fiscal feedback rules and automatic stabilizers under rational expectations. Journal of Monetary Economics, 5(2), 171-186.

Mertens, K. (2019). State-level implications of federal tax policies: Comments. Journal of Monetary Economics, 105, 91-93.

Mertens, K. R., & Ravn, M. O. (2014). Fiscal policy in an expectations-driven liquidity trap. The Review of Economic Studies, 81(4), 1637-1667.

Modigliani, F., & Miller, M. H. (1958). The cost of capital, corporation finance and the theory of investment. The American economic review, 48(3), 261-297.

Mourre, G. (2006). Did the pattern of aggregate employment growth change in the euro area in the late 1990s?. Applied Economics, 38(15), 1783-1807.

Mullen, J. K., & Williams, M. (1994). Marginal tax rates and state economic growth. Regional Science and Urban Economics, 24(6), 687-705.

Mumtaz, H., Sunder-Plassmann, L., & Theophilopoulou, A. (2018). The State-Level Impact of Uncertainty Shocks. Journal of Money, Credit and Banking, 50(8), 1879-1899.

Nekarda, C. J., & Ramey, V. A. (2011). Industry evidence on the effects of government spending. American Economic Journal: Macroeconomics, 3(1), 36-59.

Ouliaris, S., Pagan, A. R., & Restrepo, J. (2015). A new method for working with sign restrictions in SVARs (No. 105). National Centre for Econometric Research.

Owyang, M. T., & Zubairy, S. (2013). Who benefits from increased government spending? A state-level analysis. Regional Science and Urban Economics, 43(3), 445-464.

Owyang, M. T., Ramey, V. A., & Zubairy, S. (2013). Are government spending multipliers greater during periods of slack? Evidence from twentieth-century historical data. American Economic Review, 103(3), 129-34.

Poulson, B. W., & Kaplan, J. G. (2008). State income taxes and economic growth. Cato J., 28, 53.

Ramey, V. A. (2016). Macroeconomic shocks and their propagation. In Handbook of macroeconomics (Vol. 2, pp. 71-162). Elsevier.

Reed, W. R. (2008). The robust relationship between taxes and US state income growth. National Tax Journal, 57-80.

Reichling, Felix and Charles Whalen. 2012. Assessing the Short-Term Effects on Output of Changes in Federal Fiscal Policies. Congressional Budget Office Working Paper, No. 2012-08.

Riera-Crichton, Daniel, Carlos A. Vegh, and Guillermo Vuletin. 2012. “Tax Multipliers: Pitfalls in Measurement and Identification.” National Bureau of Economic Research Working Paper, No.18497.

Riera-Crichton, Daniel, Carlos A. Vegh, and Guillermo Vuletin. 2014. “Procyclical and Countercyclical Fiscal Multipliers: Evidence From OECD Countries.” National Bureau of Economic Research Working Paper, No. 20533.

Romer, C. D., & Romer, D. H. (2010). The macroeconomic effects of tax changes: estimates based on a new measure of fiscal shocks. American Economic Review, 100(3), 763-801.

Rotemberg, J. J. (1987). The new Keynesian microfoundations. NBER macroeconomics annual, 2, 69-104.

Serrato, J. C. S., & Zidar, O. (2018). The structure of state corporate taxation and its impact on state tax revenues and economic activity. Journal of Public Economics, 167, 158-176.

Stock, J.H., Watson, M.W., 2018. Identification and estimation of dynamic causal effects in macroeconomics. Econ. J. 128 (610), 917–948. doi: 10.1111/ecoj. 12593 .

Seyfried, W. (2011). Examining the relationship between employment and economic growth in the ten largest states. Southwestern Economic Review, 32, 13-24.

Uhlig, H. (2005). What are the effects of monetary policy on output? Results from an agnostic identification procedure. Journal of Monetary Economics, 52(2), 381-419.

Walsh, C. E. (2005). Labor market search, sticky prices, and interest rate policies. Review of economic Dynamics, 8(4), 829-849.

Whalen, Charles J., and Felix Reichling. 2015. “The Fiscal Multiplier and Economic Policy Analysis in the United States.” Working Paper 2105-2. Washington, DC: Congressional Budget Office.

Yang, S. C. S. (2005). Quantifying tax effects under policy foresight. Journal of Monetary Economics, 52(8), 1557-1568.

Zanetti, F. (2007). A non-Walrasian labor market in a monetary model of the business cycle. Journal of Economic Dynamics and Control, 31(7), 2413-2437.

Zidar, O. (2019). Tax cuts for whom? Heterogeneous effects of income tax changes on growth and employment. Journal of Political Economy, 127(3), 1437-1472.

Zwick, E., & Mahon, J. (2014). Do financial frictions amplify fiscal policy? Evidence from business investment stimulus. Unpublished manuscript.

Appendix Figure: Impulse Response Functions

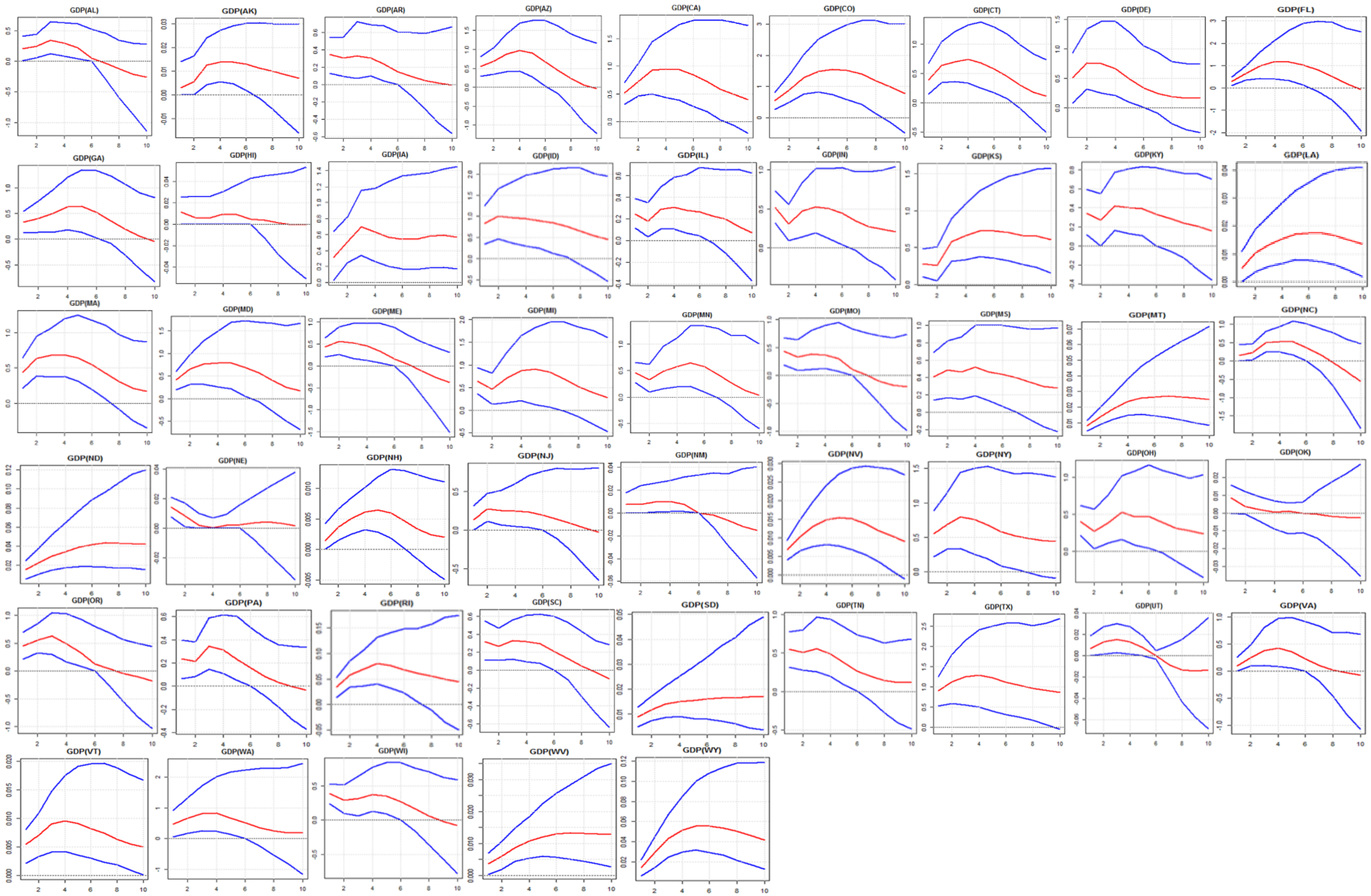

Figure 2.15: Impulses responses of state's GDP to a 1 percent cut to the federal personal income tax rate.

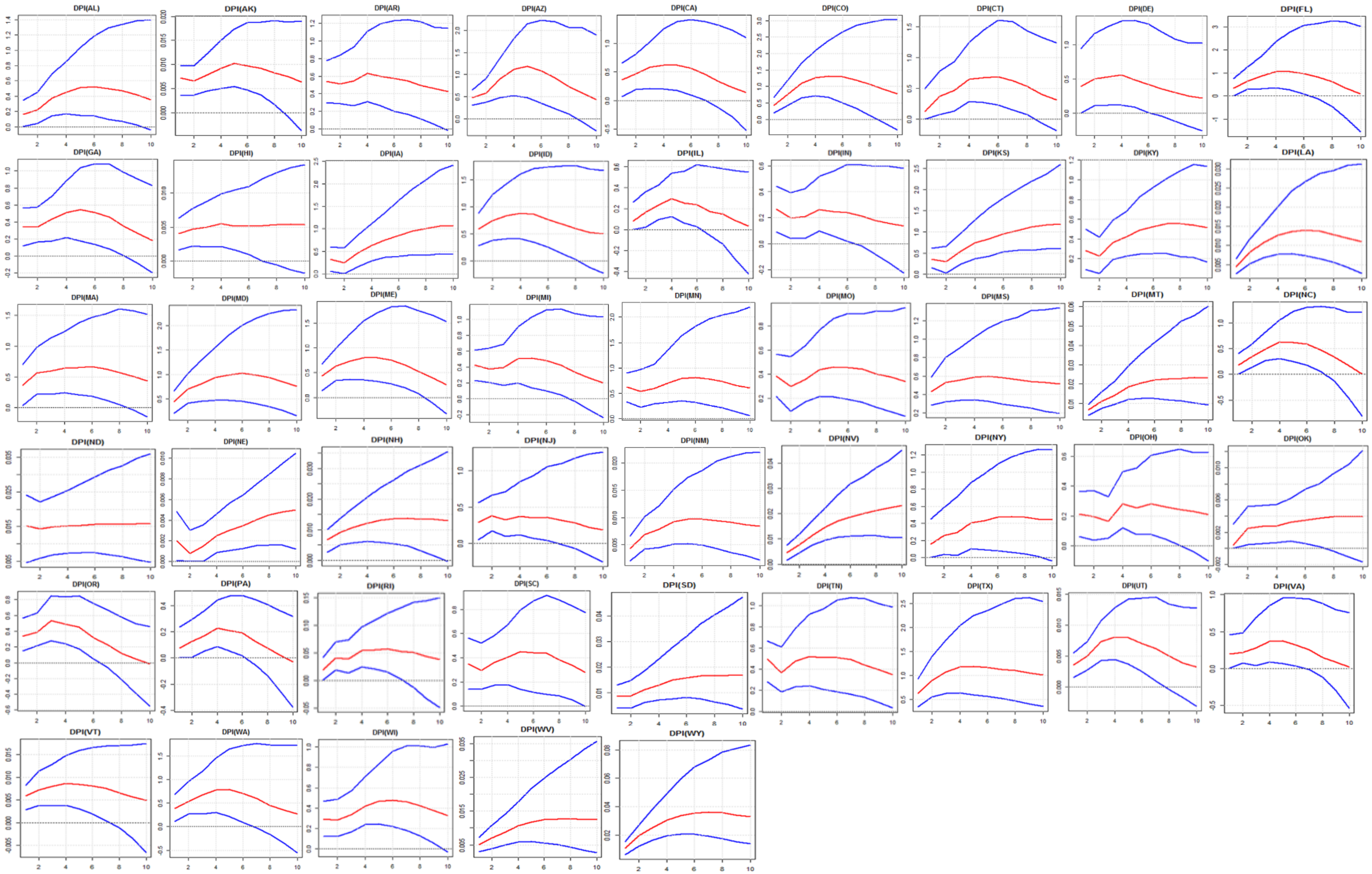

Figure 2.16: Impulses responses of state's disposable personal income to a 1 percent cut to the federal personal income tax rate.

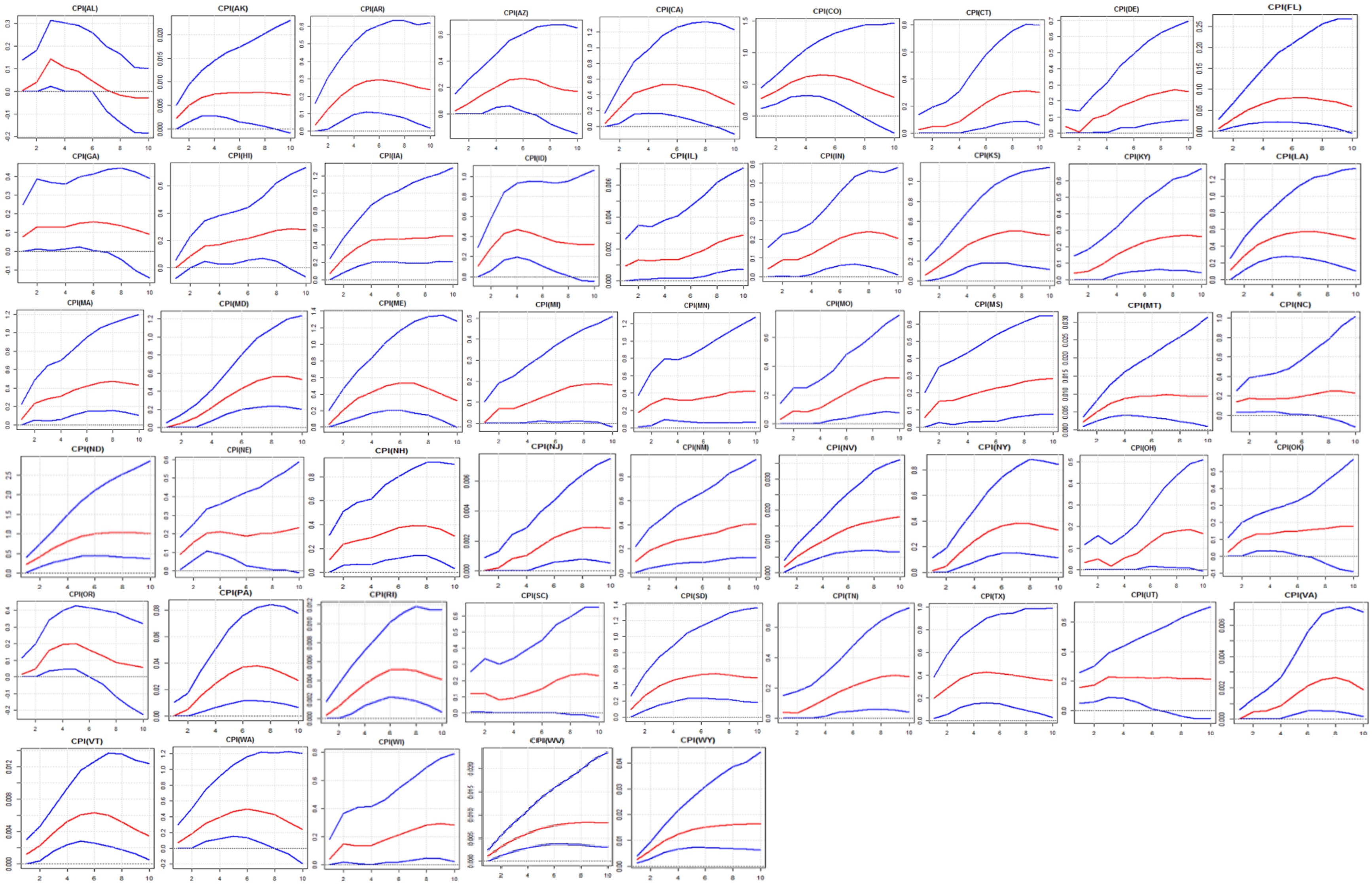

Figure 2.17: Impulses responses of state's CPI to a 1 percent cut to the federal personal income tax rate.

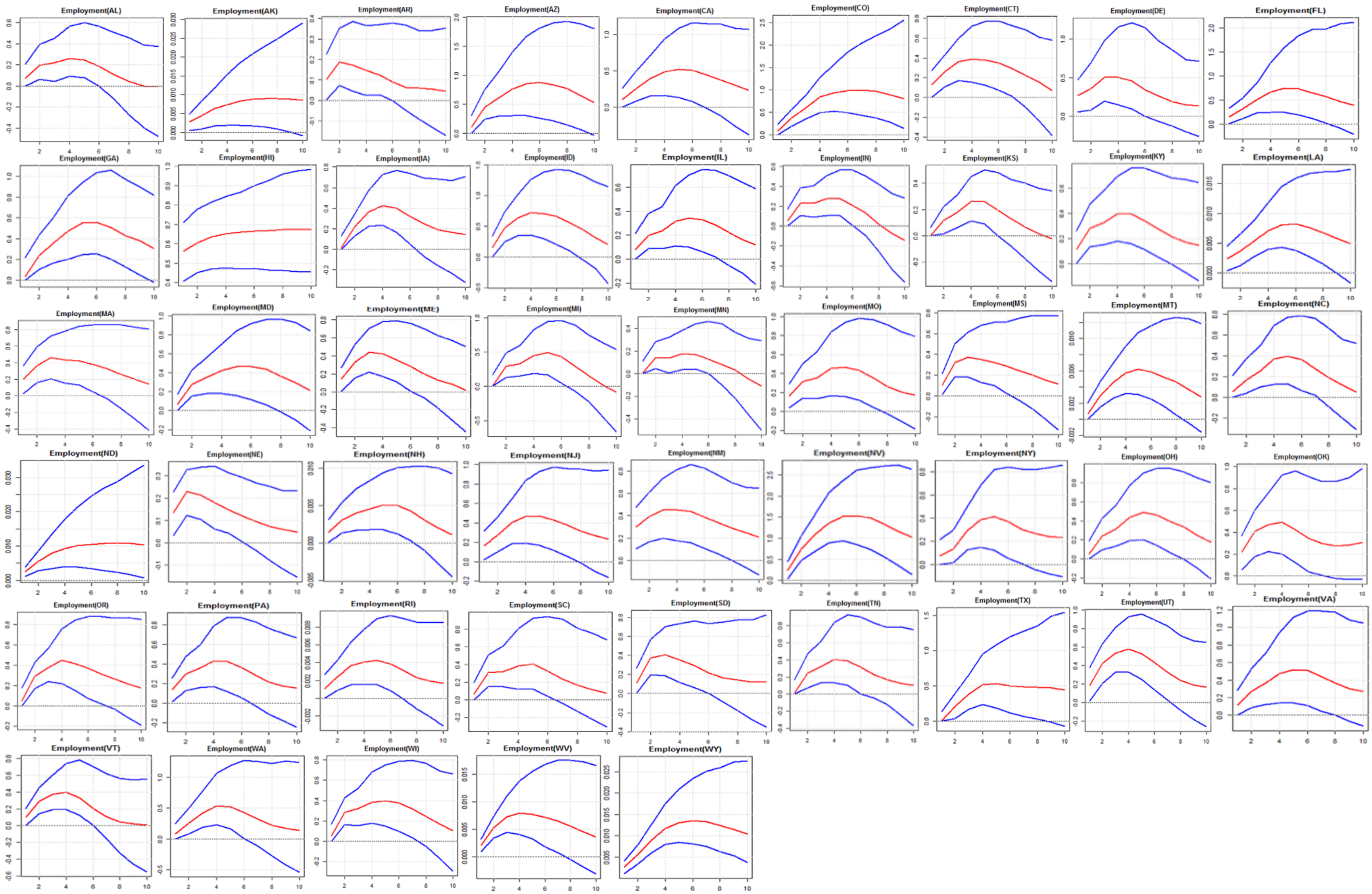

Figure 2.18: Impulses responses of state’s employment to a 1 percent cut to the federal personal income tax rate.

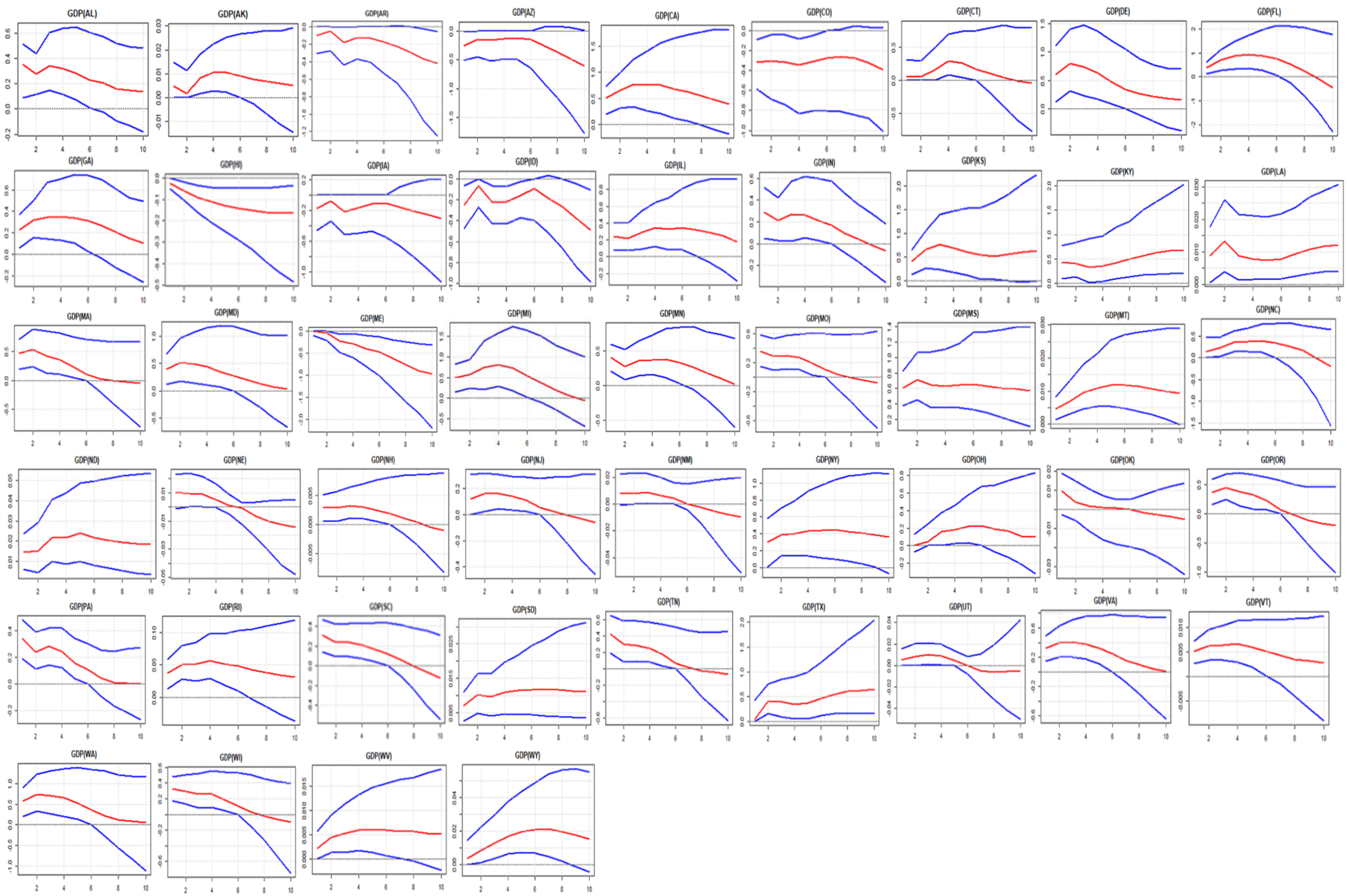

Figure 2.19: Impulses responses of state’s GDP to a 1 percent cut to the federal corporate income tax rate.

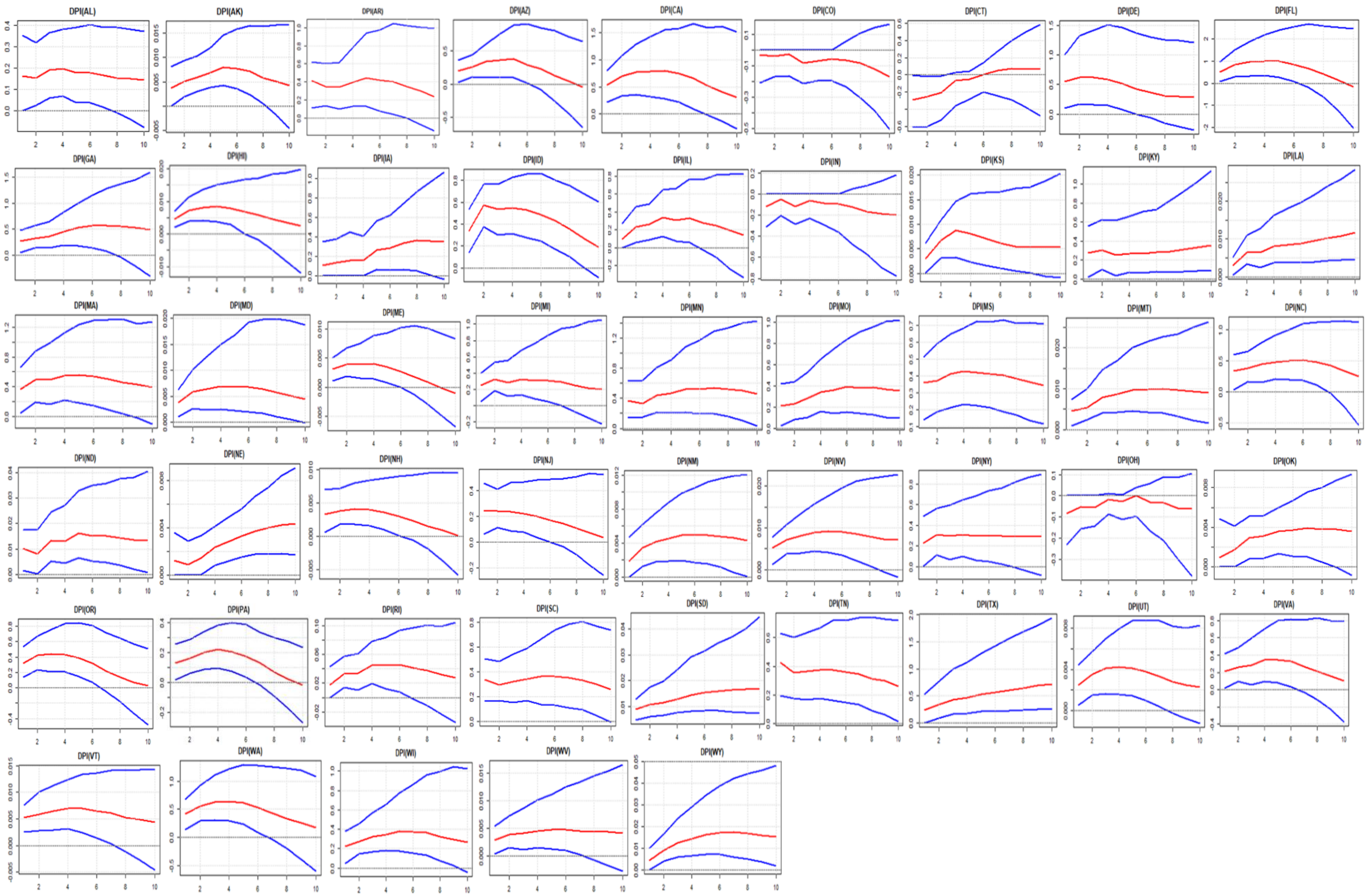

Figure 2.20: Impulses responses of state’s disposable personal income to a 1 percent cut to the federal corporate income tax rate.

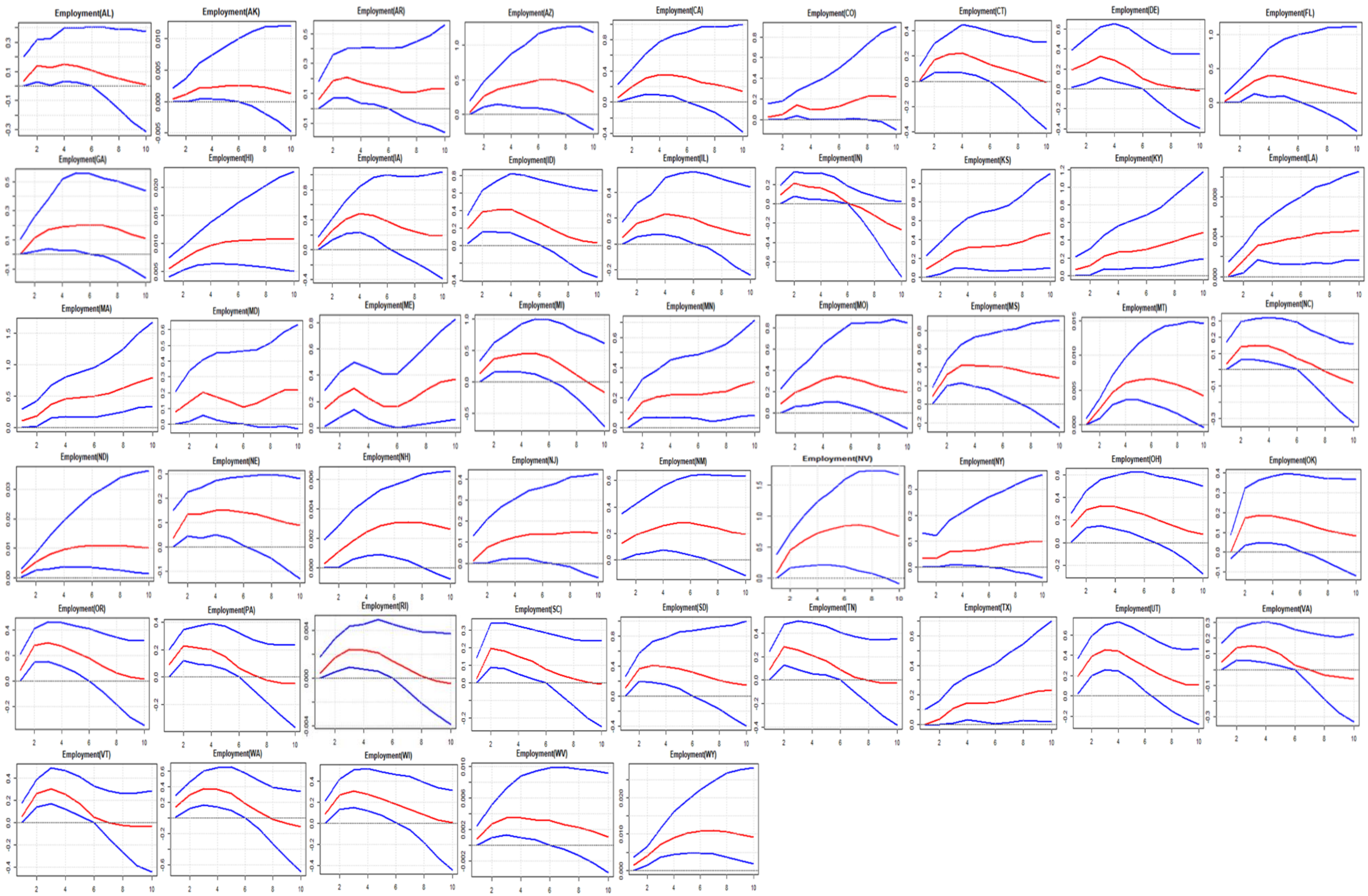

Figure 2.21: Impulses responses of state’s employment to a 1 percent cut to the federal corporate income tax rate.

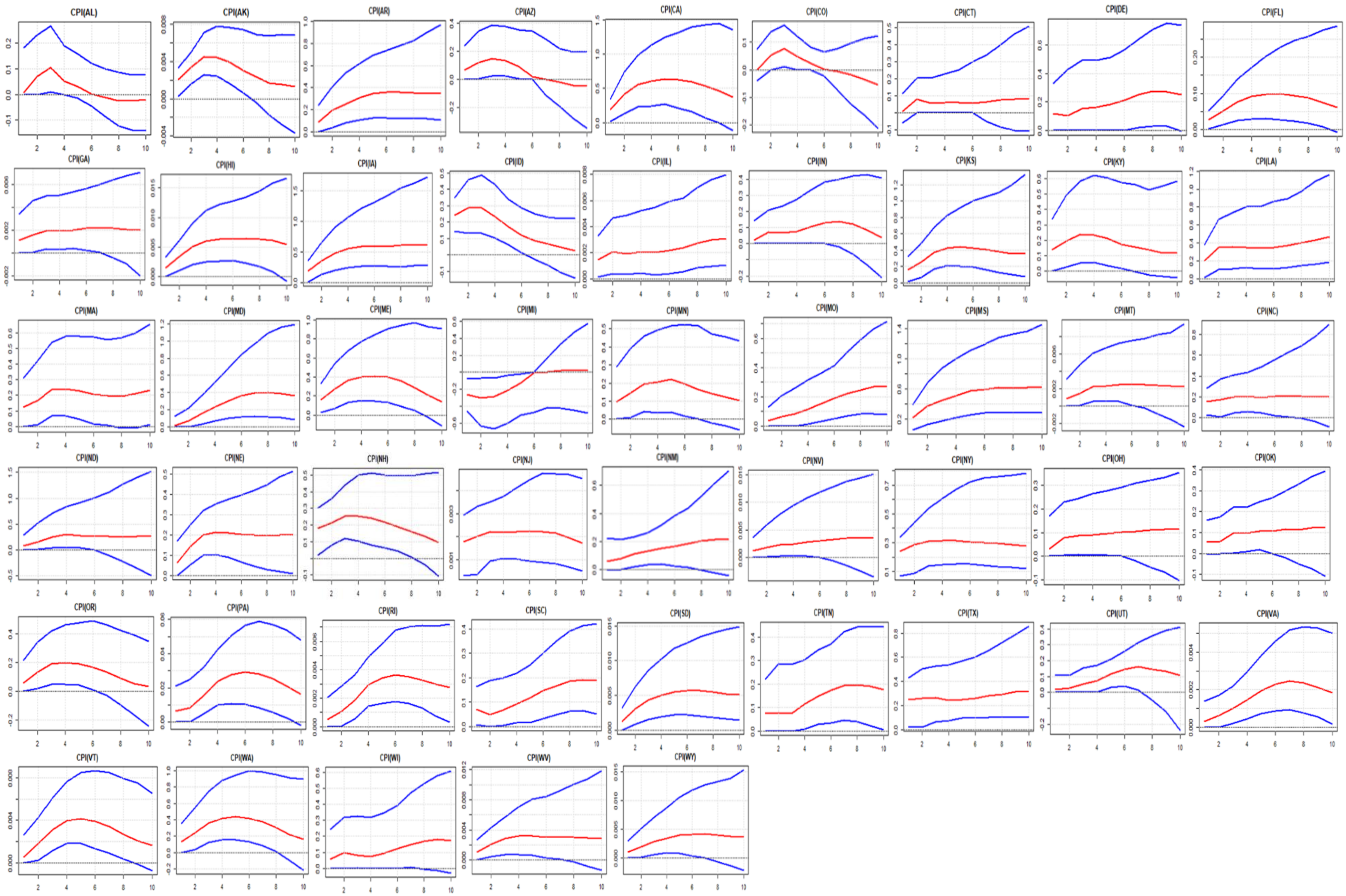

Figure 2.22: Impulses responses of state’s CPI to a 1 percent cut to the federal corporate income tax rate.

Appendix Table

Table 2.10: Nonfarm employment elasticity

State	PIT	CIT
AL	0.31	0.18
AK	0.015	0.002
AR	0.21	0.23
AZ	0.81	0.57
CA	0.61	0.37
CO	1.2	1.28
CT	0.41	0.24
DE	0.5	0.36
FL	0.8	0.48
GA	0.6	0.21
HI	0.6	0.012
IA	0.53	0.51
ID	0.91	0.43
IL	0.38	0.24
IN	0.31	0.22
KS	0.34	0.43
KY	0.42	0.4
LA	0.005	0.004
MA	0.4	0.72
MD	0.4	0.22
ME	0.42	0.32
MI	0.5	0.48
MN	0.21	0.32
MO	0.44	0.37
MS	0.42	0.4
MT	0.005	0.004
NC	0.4	0.18
ND	0.012	0.01
NE	0.23	0.16
NH	0.005	0.003
NJ	0.45	0.18
NM	0.42	0.28
NV	1.5	0.92
NY	0.41	0.12
OH	0.43	0.38
OK	0.45	0.18
OR	0.42	0.33
PA	0.41	0.25
RI	0.005	0.003
SC	0.42	0.21
SD	0.43	0.41
TN	0.41	0.26
TX	0.51	0.23
UT	0.61	0.45
VA	0.58	0.18
VT	0.41	0.3
WA	0.51	0.4
WI	0.41	0.32
WV	0.001	0.002
WY	0.015	0.001