State-Dependent Macroeconomic Effects of Tax Changes*

RUHOLLAH ESKANDARI†

Abstract

This paper provides evidence on the state-dependent macroeconomic effects of tax liability changes in the US. We estimate a state-dependent model where the state of the economy is measured by unemployment rate, economic growth, and level of uncertainty in the economy. Our estimates show that while tax policy becomes more effective during low unemployment states and expansions (good times), it has a lower impact on output when uncertainty is low (tranquil times). Thus, while our identified tax shocks based on narrative records are indeed unrelated to the state of the economy, the macroeconomic effects of the shocks are different depending on the state of the economy. Results are shown to be robust to many alternative specifications. We show that this nonlinearity in the output responses is primarily driven by lumpy investment. In addition, we use our estimates to project the near-term growth impact of the Tax Cuts and Jobs Act (TCJA) and predict a level of GDP to be 2.06 percent higher by 2020.

Keywords: Narrative approach, Fiscal policy, State-dependent

JEL Codes: E62, E22, E27, H20, H60

* I am particularly indebted to Roberto Perotti and Valerie Ramey for their valuable advice and also grateful to David Romer, Francesco Giavazzi, Roger Gordon, Dario Caldara, Emanuele Bacchiocchi, Nelson Lind, Morteza Zamanian and seminar participants at the UCSD Macroeconomics Seminar, CIdE Bank of Italy, Bocconi University, University of York and University of Milan for insightful comments. Part of this work was carried out while the author was visiting the Department of Economics, University of California at San Diego, whose kind hospitality is gratefully acknowledged.

† University of York, ruhollah.eskandari@york.ac.uk

1 Introduction

The recent Great Recession has sparked a renewed interest in the macroeconomic effects of fiscal policy. This revival has been fueled by the Tax Cuts and Jobs Act (TCJA), passed in December 2017, which is the largest tax overhaul since 1986. In this paper, we study the macroeconomic effects of tax changes in good and bad times and also uncertain and tranquil times to provide empirical answers to the following questions. How do the amount of slack in the economy, state of the business cycle, and uncertainty affect the effectiveness of tax policy? What drives the state-dependent properties of output? How simulative will TCJA be for output?

We use a state-dependent model that allows the effect of tax changes to vary depending on circumstances. In particular, we use Jordà(2005) local projection method to estimate a state-dependent model where the state of the economy is distinguished between periods with slack and without slack in the economy, times of recession and expansion, and times of high and low uncertainty. We shall refer periods with slack in the economy or times of recession as "bad times", without slack or expansion as "good times", times of high uncertainty as "uncertain times", and finally low uncertainty as "tranquil times". We follow three leading empirical studies to measure the state of the economy. As in Ramey and Zubairy(2018), we first define an economy to be in a slack state when the unemployment rate is above 6.5 percent, as our baseline indicator of slack. Second, Auerbach and Gorodnichenko(2012) 7-quarter moving average of GDP growth is used to define recession periods that indicate periods in which the economy is moving from its peak to its trough.[1] Third, we follow Bloom(2009) and use VXO, an equity volatility index, as a proxy for uncertainty and identify periods of uncertain times as those with unusual spikes in uncertainty. Romer and Romer(2010) narratively identified exogenous changes in total tax revenues are used as policy instruments, which is implicitly viewed as structural shocks. These tax changes are then classified according to whether they are undertaken in good times, during bad times, or during those uncertain or tranquil periods. We first apply this methodology to US data between 1947Q1 and 2009Q4 and construct impulse responses for different states of the economy using local projection method and then use our non-linear estimates to predict the near term impact of TCJA on US GDP growth.

Our estimates of the impact of narrative tax shocks on output using linear model are very similar to many preexisting studies (e.g. Romer and Romer(2010), Mertens and Ravn(2012,

[1] Note that using the unemployment rate to measure the amount of slack in the economy is different from using NBER recessions or Auerbach and Gorodnichenko(2012) moving average of GDP growth, see Figures 1-2 and also Ramey and Zubairy(2018) for details.

2014), and Cloyne(2013), among others) that are large and persistent. However, the state-dependent responses are very different from them. We find that linear responses are being about halfway between the large estimated responses during good times (in which unemployment is low or output is relatively high) and much smaller and statistically insignificant effects during bad times. On the other hand, we find that tax changes have large effects on output during uncertain times but small and statistically insignificant effects in tranquil times. We carry out an extensive robustness analysis with respect to our measure of states, to the identification method, and to the inclusion of a wide variety of control variables and find little change in the baseline results. Moreover, we extend our findings by evaluating the behavior of the various components of output and show that non-linear responses of investment to tax changes, in particular nonresidential fixed investment, is the main transmission mechanism of tax policy. Finally, as an implication of our result, we predict that the near-term growth impact of TCJA on the level of GDP to be 2.06% higher by 2020.

Our strong evidence of the procyclical responses of investment and output to tax shack is consistent with the existing studies stressing the relevance of lumpy investment for aggregate dynamics.[2] For instance, Bachmann et al.(2013) shows that the sensitivity of US aggregate investment to shocks is procyclical and then argue that this nonlinearity in the data follows naturally from a DSGE model with lumpy microeconomic investment. In addition, Winberry (2018) argue that the procyclical elasticity of aggregate investment with respect to shocks is primarily driven by changes in the number of firms undertaking an investment project – the extensive margin – rather than changes in the size of investment projects – the intensive margin. Our results for good and bad times are also consistent with the one New Keynesian DSGE analysis by Sims and Wolff(2018) who obtain estimates of tax multipliers that are procyclical, i.e. all point tax multipliers being greater in magnitude during expansions than in recessions. On the other hand, Alesina et al.(2018) find higher multipliers in expansions using their narrative analysis of taxed based consolidations across OECD countries. They show that fiscal adjustments are costly when started during a downturn and they are not during an expansion. Using the Romer and Romer(2010) narrative tax shocks but different methods, Arin et al.(2015) and Demirel(2016) find similar results that tax multipliers are greater in good times than in bad times. In contrast, using the same instrument and similar framework, Biolsi(2017) finds that the average responses of output to tax changes documented in Romer and Romer(2010) are driven entirely by tax changes when unemployment is relatively high.

[2]There is, however, considerable debate in the literature about the "relevance" of lumpy investment to business cycles. See, for example, Thomas(2002), Khan and Thomas(2003,2008), Miao and Wang(2009), and House(2014).

The debate concerning the effects of fiscal policy on macroeconomic aggregates is wide and the recent Great Recession (2007-2009) has raised again several fundamental issues about the size (and sometimes also the sign) of fiscal multipliers. Numerous studies have attempted to estimate the dynamic macroeconomic effects of fiscal policy and found very large intervals for the size of fiscal multipliers. The focus of these studies differs depending on their underlying arguments so that the range of estimated multipliers are as wide within studies as it is across studies. Ramey(2019) summarizes the current state of knowledge about the effects of fiscal policies that for average spending and tax change multipliers lie in a fairly narrow range, 0.6 to 1 for spending multipliers and -2 to -3 for tax multipliers. The extent to which fiscal multipliers depend on the state of the economy is a question that has received much attention in recent years. Some empirical studies have provided evidence that the effect of government spending on output is state dependent and support the view that multipliers are larger and more effective when the economy is in recession.[3] However, the most recent empirical studies find no evidence that spending multipliers are greater during bad times in US.[4]

On the other hand, there is a growing literature on the macroeconomic effects of uncertainty more generally and on the uncertainty-dependent effects of monetary and fiscal policy more specifically. A well-established empirical fact is that an unexpected increase in un- certainty is associated to a significant and persistent drop in real activity in the US and a number of other countries.[5] More recently, the empirical literature has begun addressing the uncertainty-dependent effects of monetary policy and showing that the effectiveness of monetary shocks in the US is significantly reduced in presence of high uncertainty.[6] However, there is little evidence on how uncertainty affects the effectiveness of fiscal policy. Alloza (2018) points to a weak impact of government spending shocks on output during times of high uncertainty in the US.

In December 2017, the United States Congress passed the most sweeping set of tax changes in a generation, popularly known as the Tax Cuts and Jobs Act (TCJA). It is estimated that this policy changes will lower government revenues by a cumulative total of almost US$ 1.5 trillion (7.5% of current GDP) over the next ten decade (Joint Committee on Taxation, 2017 (JCX-67-17)). It is clear that this magnitude of revenue loss will have important consequences

[3]See, for example, Auerbach and Gorodnichenko(2012,2013), Fazzari et al.(2015), Bachmann and Sims (2012), Baum et al.(2012), Batini et al.(2012), and Caggiano et al.(2015), among others.

[4]See, for example, Ramey and Zubairy(2018) and Alloza(2018), among others.

[5]This literature has become voluminous. See, for example, Bloom(2009), Jurado et al.(2015), and Baker et al.(2016), among others.

[6]See, among others, Aastveit et al.(2017), Eickmeier et al.(2016), Pellegrino(2017), and Pellegrino (2018).

for the U.S. macroeconomic outlook in the coming years. Most existing empirical studies suggest that TCJA will raise GDP between 0.3 and 2.74 percent over the first three years (2018–20).[7]

Another important dimension along which fiscal multipliers are found to differ is related to the empirical approaches to identifying exogenous shifts in fiscal policy. One strand of the empirical literature considers exogenous shifts as unobservable and estimates the effects of fiscal policy shocks using a vector autoregressive (VAR) model by imposing short-run restrictions (Blanchard and Perotti(2002), and Mountford and Uhlig(2009)). On the other hand, a very different identification strategy introduces a new dataset of observable exogenous tax changes identified via the narrative method (Ramey and Shapiro(1998), Romer and Romer (2010), and Cloyne(2013)). Alesina et al.(2015) point out some of the main advantages of using narrative approach, such as the possibility of distinguishing between different shifts in fiscal policy, permanent and temporary policy, also shocks identified via a narrative method is model independent and therefore are not affected by the possible omitted variables, and finally with the narrative approach we can distinguish between anticipated and unanticipated components of fiscal policy shocks, which is important to prevent the biases in the estimates of fiscal multipliers in the presence of fiscal foresight (see Leeper et al.(2013) and Mertens and Ravn(2012)).

The paper is organized as follows. The next section of the paper lays out the basic specification of our econometric methodology and also describes our measure of states. Section 3 reports our empirical results using linear and state-dependent models. Section 4 discusses a number of robustness checks. Section 5 develops possible explanations for our baseline results. Section 6 contains our projection about the impact of TCJA, and discuss its interpretation. Finally, Section 7 concludes.

2 Estimation Approach

To estimate the macroeconomic effects of tax changes under different regimes, we first introduce a state-dependent model where the states of the economy are allowed to vary according to different circumstances. We then propose three possible indicators of the state of the economy based on the amount of slack in the economy (measured by the unemployment rate), times of recession and expansion (output growth rate), and the level of uncertainty

[7] See Mertens(2018), Barro and Furman(2018), Slemrod(2018), CBO(2018), IMF(2018), Gale et al. (2018), Cohen-Setton et al.(2018), and Hodge(2018).

(using the VXO index of implied volatility). Lastly, Romer and Romer(2010) exogenous tax changes are classified according to whether they occur during periods with slack and without slack in the economy, times of recession and expansion, and times of high and low uncertainty.

2.1 Econometric Methodology

We use the local projection methodology proposed by Jordà(2005) to estimate our linear and state-dependent impulse responses. The Jordà model is based on sequential regressions that can be estimated by simple regression techniques for each horizon h and for each variable and then construct the impulse response function. Auerbach and Gorodnichenko(2013), Ramey and Zubairy(2018) and Mertens and Montiel Olea(2018) employ and discuss the properties of this method. The state-dependent model can be written as follows:

$$y_{t+h} = I_{t-1}\{\alpha_{A,h} + A_{A,h}(L)Y_{t-1} + \beta_{A,h} shock_t\} + (1 - I_{t-1})\{\alpha_{B,h} + A_{B,h}(L)Y_{t-1} + \beta_{B,h} shock_t\} + s_{t+h} \quad (1)$$

$shock$ is Romer and Romer(2010) exogenous tax shocks.[8] y is the variable of interest and defined as $y_{t+h} \equiv Y_{t+h} - Y_{t-1}$ where Y is the logarithm of real output.[9] $A_h(L)$ is a polynomial in the lag operator of order 4 that controls the lagged output itself.[10] I is a dummy variable that indicates the state of the economy one period before the shock occurs (discussed in detail in Section 2.2). This dummy variable is dated by $(t - 1)$ to avoid contemporaneous feedback from policy actions to the state of the regime. We allow all of the coefficients of the model to vary according to the state of the economy and therefore the forecast of y_{t+h} differs according to the state of the economy when the shock hit. The coefficients $\beta_{A,h}$ gives the response of y at time $t + h$ to the shock at time t during state A, and, conversely, $\beta_{B,h}$ captures the response during state B. In fact, each step in the IRFs is obtained from a single

[8]It should be noted that these shocks are as a percent of nominal GDP. The scaling by GDP means that the estimates of β_h have the familiar interpretation as 'tax multipliers'.

[9]This transformation is the one used by Hall(2009), Barro and Redlick(2011), and Ramey and Zubairy (2018).

[10]Since the exogenous tax changes reflect policies adopted for reasons essentially unrelated to other factors likely to influence real output in the near term, then our estimation of (1) without any controls should, in principle, yield unbiased estimates of the reduced-form impact of changes in the level of taxes on output. However, including lagged output obviously helps to control the normal dynamics of output. See Romer and Romer(2010) for more details.

equation. We also estimate a linear version of equation (1) by setting $I_t = 0$ for all periods t. The Newey and West(1987) corrected standard errors is employed to control the serial correlation in the error terms induced by the successive leading of the dependent variable.

Local projection technique computes impulse responses without specification and estimation of the underlying multivariate dynamic system. Thus, in contrast to the vector autoregression (VAR) model, where the impulse response coefficients are high-dimensional nonlinear functions of estimated parameters, local projection method directly estimates impulse response coefficients as a sequence of the β_h's estimated in a series of single regressions for each horizon similar to a direct forecasting method. In fact, the impulse response estimate for output at horizon $t + h$ is a forecast of how output will differ at $t + h$ if a shock hits the economy (i.e. $shock_t = 1$) rather than no shock (i.e. $shock_t = 0$). This direct regression approach also easily adapts to estimate a state-dependent model that are impractical or infeasible in a multivariate context. Moreover, estimated responses obtained from the non-linear VAR models (e.g. smooth-transition VAR model used by Auerbach and Gorod- nichenko(2012)) is based on the assumption that the state of the economy remains constant for at least the 20 quarters over which multipliers are computed. However, as discussed in Ramey and Zubairy(2018), this assumption may not be a good approximation for bad times (times of slack, recession or high uncertainty) which are mostly short-lived. The Jordã method imposes no restrictions on the evolution of the regime in response to policy shocks. In fact, in this direct regression approach, if the average shock is likely to change the state of the economy, it will be reflected in the impulse response estimate. On the other hand, natural transitions between states that are independent of the shock should be captured by the state-dependent control variables; i.e., the coefficients on the state-dependent constant terms and lagged variables will embed information on the average behavior of the economy to transition to the other state at future horizons. Thus, this method is a preferable alternative to VARs when calculating impulse responses is the object of interest.

2.2 Measurement of the State Variables

There are various potential variables of the state of the economy, such as the amount of slack, economic growth, level of economic uncertainty, capacity utilization, and credit and financial market conditions. We use three leading measures in the literature of monetary and fiscal policy to describe the state of the economy, i.e. dummy variable I in (1). We distinguish between periods with slack and without slack in the economy, times of recession and expansion, and times of high and low uncertainty. In particular, we use the following methods to define each of these states.

As in Owyang et al.(2013) and Ramey and Zubairy(2018), in our baseline model, we consider 6.5 percent unemployment rate as a fixed threshold and define the slack time when the unemployment rate exceeds this threshold, i.e. $I = 1$ in (1). Using this definition of threshold results in about 25 percent of the observations being above the threshold in our sample from 1947 through 2009 for the US. The top panel of Figure 1 shows Romer and Romer(2010) exogenous tax shocks along with the slack times (when the unemployment rate exceeds 6.5 percent). This figure shows that exogenous tax changes are distributed across periods with a variety of unemployment rates. In fact, 26 percent of the economy is being in slack states and 43 percent of the shocks occur when the unemployment rate is above the threshold. The top panel of Figure 2 shows the unemployment rate along with 6.5 percent threshold and NBER dates. Table 1 provides additional details about the distribution of tax changes over the slack states. In the robustness analysis, however, we analyze the sensitivity of the results to the different values of the fixed thresholds and also we consider, as an alternative, time-varying thresholds based on the Hodrick-Prescott filtered unemployment rate.

An alternative indicator of the state of the economy is the Auerbach and Gorodnichenko (2012) moving average of GDP growth. This measure, that is highly correlated with NBER business cycle dates, indicates periods in which the economy is moving from its peak to its trough, and therefore do not measure the slack states. In our sample about 25 percent of the quarters that are NBER dates or recessions are also periods of high unemployment. We use the same definition of the logistic transition function as Auerbach and Gorodnichenko (2012), which is given by ??, where $F(z)$ captures the probability of being in a recession, z is a standardized seven-quarter moving average of the output growth rate as transition variable, and γ is a transition parameter. We set $\gamma = 1.7$, so that the economy spends about 21 percent of time in a recessionary regime which is consistent with most of the empirical literature and also the duration of recessions in our sample according to NBER business cycle dates.[11] In fact, we define an economy to be in a recession ($I = 1$ in equation (1)) if $F(z_t) > 0.79$ (that is, $Pr(F(z_t) > 0.79) = 0.21$). The second panel of Figure 2 shows the dynamics of F together with the threshold and NBER dates. In the second panel of Figure 1, we plot Romer and Romer(2010) exogenous tax shocks along with our recessions. We see that exogenous tax changes are fairly distributed over the sample (see Table 1 for details) and therefore there is no systematic relationship between the two series. We will also

[11]See, among others, Auerbach and Gorodnichenko(2012), Bachmann and Sims(2012), Berger and Vavra (2014), and Caggiano et al.(2015).

check the robustness of our results to alternative definitions of recessions. Henceforth, for parsimony, we refer periods with slack in the economy or times of recession as "bad times" and without slack or expansion as "good times".

Following Bloom(2009), we define periods of high uncertainty as of the unusual spikes in the VXO, as our baseline measure of uncertainty. Major uncertainty realizations pursued in Bloom(2009) are those spikes exceeding the value 1.65 times the standard deviation of the Hodrick–Prescott filtered series of the VXO at a monthly frequency. Using this method to construct quarterly spikes in the stock market volatility (based on the monthly events described above) reveals 31 quarters as our high uncertainty states, which is 12 percent of the observations in our sample. However, to maximize the precision of the estimates in the two regimes and, at the same time, minimize the probability of finding different dynamics due to small-sample issues in one of the two regimes, we use similar procedure as in Castelnuovo and Pellegrino(2018) and consider high uncertainty states as deviations (instead of 1.65 times the standard deviation) from trend for a Hodrick-Prescott filtered VXO. Using this definition of threshold results in about 37 percent of the observations as episodes of high uncertainty. In addition, this procedure brings 36 percent of the tax shocks to occur during times of high uncertainty. The third panel of Figure 1 depicts the uncertain and tranquil regimes conditional on this choice along with the Romer and Romer(2010) exogenous tax changes. Finally, the third panel of Figure 2 plots the HP-filtered data along with NBER dates, and Table 2 provides additional details. As a robustness check, we will limit the measure of high uncertainty states to the original uncertainty realizations pursued in Bloom (2009). We will also conduct various robustness checks with respect to our measures of uncertainty by using two other widely-used measures of uncertainty.

Figures 1 and 2

Tables 1-2

3 Empirical Results

We begin by presenting the linear response of GDP to a tax cut and then show our baseline results of the state-dependent analysis. We estimate a linear and state-dependent Jordà method for quarterly data from 1947Q1 to 2009Q4.

3.1 Linear Response

We first present the impact of an exogenous tax cut on GDP with no variations in the state of the economy. We estimate a linear version of equation (1) by setting $I_t = 0$ for all periods t. As shown in Figure 3, our linear estimate of the impact of tax changes on output is large and persistent. This result is very similar to many preexisting studies (e.g. Romer and Romer(2010), Mertens and Ravn(2012,2014), Cloyne(2013), and Hayo and Uhl(2013)).[12] Following a cut in exogenous tax liabilities corresponding to 1 percent of GDP, GDP rises by around 3 percent over three years. In particular, in the first three quarters after the tax change, the response is small and statistically insignificant, but then steadily and rapidly rise for the next two years, reaching a maximum effect of 2.99 percent (t = 3.64) after eleven quarters. This implies that an exogenous tax cut sets off a major expansion of the economy. The light and dark shaded areas represent, respectively, 95% and 68% confidence bands for the linear model and are based on Newey-West corrected standard errors.

Figure 3

3.2 Baseline State-Dependent Responses

We now present the main results of our analysis using the state-dependent local projections method. In fact, the main question addressed in this paper is whether the effect of tax changes on output depends upon the state of the economy. The impulse response functions in the state-dependent case are derived from the estimated $\beta_{A,h}$ and $\beta_{B,h}$ for output in (1). As shown in Figure 4, state-dependent responses look very different from the linear model. The first column of Figure 4 compares linear and state-dependent responses. The dashed black line shows the output response in the linear model. For parsimony and comparability, however, we only report impulse responses without confidence intervals. The second and third columns illustrate the effect of the tax cut on output across different states. The light and dark shaded areas represent, respectively, 95% and 68% confidence intervals.

Panel A shows the responses when we estimate the state-dependent model where we distinguish between periods with and without slack in the economy (high and low unemployment states). We find that, while output responds strongly and quickly to tax policy during low unemployment states, it is relatively unaffected during periods of slack. A tax cut that occurs in good times (low unemployment states) has a maximum impact

[12] Most of the narrative methods for tax changes yield multiplier estimates that are surprisingly large and surprisingly uniform across a number of countries, generally between -2 and -3 as summarized by Ramey (2019).

of 3.77 percent (t = 3.98) after eight quarters. This estimated maximum effect is more than half as large as that associated maximum impact found in bad times (high unemployment states), which is 1.58 percent (t = 1.41). The difference is statistically significant from quarter three to quarter eight (at the 5% level) but not for the peaks.[13] In addition, the effect is larger than that obtained using the linear model, as presented in the first column of Figure 4.

Panel B illustrates the effect of the tax cut on output during periods of recession and expansion. Although periods of recession and expansion are different from periods of slack and non-slack, as discussed in Section 2.2, our estimates are remarkably similar across the two measures of the state of the economy. As shown in the second and third columns of panel B, while output responds positively and strongly to a tax cut during expansions and also significant at every horizon, during recessions the estimate is not even significantly different from zero over the first two years after a tax change. It then becomes significant and more similar to those obtained in expansions two years after the shock. In fact, the differences between recession and expansion are primarily with respect to timing rather than size, with the most positive responses occurring rapidly in expansions but with several quarters delay in recessions. In particular, when a tax cut is legislated to take effect in an expansion, output rises steadily and reaches a maximum value of about 3 percent (t = 2.80) after eight quarters. A tax cut that hits in recession, on the other hand, has no significant effect on output over the first two years and then rises rapidly to a peak of 3.74 percent (t = 3.37) three years after the shock. The difference is statistically significant three quarters out but again not for the peaks. The first column of panel B suggests, however, that the average response of output obtained in the linear model closely mimics its behavior during expansion.

The overall message of our analysis, measuring the output responses to tax changes in good times and bad, is that a tax cut that occurs in good times (low unemployment states or expansionary regimes) has larger effects on output than the corresponding linear model. In addition, output response to tax shocks is largely insignificant when the policy takes effect in bad times (high unemployment states or recessionary regimes). Thus, overall we find strong evidence that the tax multipliers are procyclical. Although in Section 5 we discuss in detail about the possible explanations of our state-dependent responses, these results are consistent with the one estimated New Keynesian DSGE analysis of the state-dependent effects of tax shocks. Using a highly stylized model, Sims and Wolff(2018) provide analytical expressions suggesting that a tax rate cut is most stimulative for output in periods in which output is

[13] To assess whether the effects are different across states, we test the null hypothesis of equal responses at each horizon h, i.e. $H_0 : \beta_{A,h} = \beta_{B,h}$, and for the peak effects, i.e. $H_0 : max(\beta_{A,h}) = max(\beta_{B,h})$.

relatively high (i.e. in periods of expansion). In addition, they solve and simulate a medium-scale DSGE model with tax rates on labor and capital income and on consumption and find that tax multipliers are generally largest in periods in which output is relatively high. For example, while the average capital tax multiplier is 1.5, it is 1 in recessions and about 2 in expansions. The strong procyclicality of tax rate cut multipliers obtained from the DSGE model is consistent with the intuition from the author's stylized model.

Finally, panel C performs estimation of equation (1) during periods of high and low uncertainty. The second and third columns of panel C show the output response to a tax cut during periods of high and low uncertainty, respectively. Perhaps the most controversial result of this exercise is the conflicting predictions about the effects of tax shocks on out- put across good and bad times and across uncertain and tranquil times. While tax policy is surely more effective during good times (low unemployment states and expansions), the effect of tax changes on output is relatively small and highly insignificant during tranquil times (low uncertainty). Panel C illustrates the response of output obtained in linear and state-dependent models and shows that linear response is being about halfway between the large estimated response during uncertain times and the much smaller and mostly statistically insignificant effects during tranquil times. For a unit exogenous shock to tax revenue in the period of high uncertainty, output rises immediately by just over 1 percent and gradually increases until it reaches a maximum effect of 4.15 percent (t = 2.24) after eleven quarters. For tranquil times, on the other hand, we find that a tax cut has no significant effect on output over the first two years and becomes significant afterward. The difference between the two regimes is statistically significant at all horizons (at the 5% level) and also for the peaks.

Figure 4

4 Robustness Analysis

In this section, we conduct various robustness checks with respect to our measure of states, to the inclusion of a variety of control variables, and to the identification method.

4.1 Sensitivity to the Measures of Sate Variables

Our baseline results are potentially sensitive to the numerous specification choices we made that were not guided by theory. Thus, in this section, we explore the sensitivity of our findings to these choices. Since there are different measures and degrees (deep vs. mild) of slack, economic recession, and uncertainty, we verify the sensitivity of our benchmark results with respect to the different measures and degrees of our state variables.

Alternative Measures of slack and recession. In the baseline version of our estimates, we simply consider 6.5 percent unemployment rate as our indicator of slack, and it results in about 25 percent of the economy being in slack periods. Therefore, we conduct various robustness checks using different thresholds for the unemployment rate. We first choose different fixed thresholds and then allow for a time-varying threshold. We pick two fixed thresholds to have a smaller and larger amount of slack in the economy. Following Barro and Redlick(2011), we choose the value of the threshold to be the median of the unemployment rate in our sample (i.e. setting a threshold of 5.53) to get a relatively smaller amount of slack in the economy (50 percent of the economy being in slack periods). On the other hand, defining slack as periods with unemployment rate being one standard deviation above the sample mean (i.e. setting a threshold of 7.2), we get a larger amount of slack in the economy (16 percent of the economy being in slack periods). Also to verify the sensitivity of our benchmark results with respect to the time-varying thresholds, we consider deviations from trend for a Hodrick-Prescott filtered unemployment rate with a very high smoothing parameter of ($\lambda = 10^6$). Using this definition of threshold results in about 45% of the observations being above the thresholds.[14] Finally we perform a robustness check to test how results vary using alternative definition of recessions. In our benchmark results, we used smooth transition threshold based on 7-quarter moving average of output growth, as in Auerbach and Gorodnichenko(2012), and here we consider NBER recession periods. Table 1 shows the distribution of tax shocks using alternative state indicators, which are consistent with those from baseline.

The top panel of Figure 5 shows the sensitivity of GDP response to our different measures of slack and recession along with the baseline results across good and bad times. For parsimony and comparability, however, we report impulse responses along with the 95% and 68% confidence intervals of our baseline estimates. Using this robustness check, we find results in line with our baseline findings; a tax cut is most stimulative for output in good times rather than bad. However, it is clear from the second column of Figure 5 that increasing the amount of slack in the economy brings down the effectiveness of tax policy.

Figure 5

Alternative definitions of uncertainty. The measure of uncertainty used for our baseline

[14] Ramey and Zubairy(2018) also consider a time-varying threshold that results in about 50% of their observations being above the threshold from 1889 through 2015 for the U.S.

estimates is based on the (implied) stock market volatility as in Bloom(2009). However, as discussed previously in the paper, in order to maximize the precision of our estimates we defined high uncertainty states as deviations from the trend for a Hodrick-Prescott filtered VXO. We now test the sensitivity of the results to the value of the threshold by considering the realizations of the cyclical component of the VXO index larger than 1.65 times its standard deviation. Using 1.65 standard deviations above a Hodrick-Prescott trend, which commonly used in the literature, reveals 31 quarters as our high uncertainty states, which is 12 percent of the observations in our sample. In addition, we use alternative proxies of uncertainty including Economic Policy Uncertainty (EPU) index of Baker et al.(2016) based on newspaper coverage, and a broad-based measure of macroeconomic uncertainty of Jurado et al.(2015). For comparison, in both cases, we consider deviations (mean) from and 1.65 standard deviations above the Hodrick-Prescott trend (assuming a value of the smoothing parameter of 1600). Table 2 shows the distribution of Romer and Romer(2010) tax shocks over the new measures of uncertainty. The last two panels of Figures 1 and 2 plot, respectively, tax shocks along with the uncertain times and the HP-filtered data along with NBER dates.

The bottom panel of Figure 5 compares output response to a tax cut across different measure of uncertainty and suggests that the baseline estimates are quite durable. Again, for parsimony and comparability, we report impulse responses along with the 95% and 68% confidence intervals of the baseline estimates. While the impact of an exogenous tax cut on GDP becomes stronger and overwhelmingly significant in good times, it has weaker and highly statistically insignificant effect during tranquil times. Conversely, we find suggestive evidence that tax cut is most stimulative for output in periods in which uncertainty is relatively high.

4.2 Controls

Since Romer and Romer(2010) narratively identified tax changes are treated as proxy measures of latent structural tax shocks, they are unlikely to be systematically correlated with other factors affecting output in the short or medium run, then there should be no need to control for other shocks.[15] In addition, most existing studies using narrative tax changes in

[15]Romer and Romer(2010) exploit historical tax reforms as quasi-experiments to identify those tax changes motivated by factors unrelated to the current or prospective state of the economy. Mertens and Ravn(2012) also examine the predictability of the tax changes using both a linear model and an ordered probit model and find weak evidence of endogeneity which is ignorable.

the linear models support this view.[16] However, correlation with other factors could be present just by accident in small samples or across different states of the economy. In order to rule out the possibility of such correlations, we experiment with augmenting our state-dependent model with two other policy variables.

Perhaps the most obvious omitted variables to consider are changes in government spending and monetary policy. In particular, it is possible to have a positive correlation between tax changes and spending, even if the link is not explicitly mentioned in the narrative record, and therefore it is possible that the results are sensitive to in-sample correlation with shocks to fiscal spending. We include three variables in the model to address this issue: logarithm of the real per capita gross federal purchases of goods and services, logarithm of the real per capita federal government total receipts and also nominal federal deficit scaled by lagged nominal GDP. In addition, we investigate the sensitivity of the results to monetary policy shocks by including the federal funds rate, and the inflation rate in the model. The top panel of Figure 6 shows our baseline results for slack and recession with and without controlling government spending and monetary policy along with the 95% and 68% confidence intervals of the baseline estimates. The results are very similar to the benchmark estimates.

Perhaps somewhat surprising is the high sensitivity of the results to the inclusion of monetary policy variables during uncertain times. To make the comparison more stringent, we also check the robustness of the results with the EPU index and JLM macroeconomic uncertainty measure. As shown in the bottom panel of Figure 6 including the federal funds rate and inflation as additional controls weaken the estimated effects of tax policy noticeably during high uncertainty periods.[17] But even then, they remain relatively large and significant. It has little effect on the estimated responses during tranquil times, though. Overall, while one should be cautious generalizing our estimated impulse responses, the results are suggestive that tax cut is considerably more effective in uncertain times than in tranquil. We find no sign of any significant change in our results when we control government spending in high and low uncertainty periods.

Figure 6

[16] See, for example, Romer and Romer(2010), Cloyne(2013), Mertens and Ravn(2014), and Favero and Giavazzi(2012), among others.

[17] Romer and Romer(2010) consider three measures of monetary policy in their liner model and show that the effect of including the monetary policy controls varies with which series is used. For example, including the federal funds rate lessens the contractionary impact of a tax increase by about 20 percent relative to their baseline effect, which is also consistent with our findings.

4.3 Alternative Identifications of the Exogenous Tax Changes

Romer and Romer(2010) pioneered the use of narrative methods to identify tax changes that are exogenous to the state of the economy. Mertens and Ravn(2012) improved their measure by splitting their series into anticipated and unanticipated tax changes and provided evidence on how the distinction between anticipated and unanticipated tax policy changes are empirically appropriate. Anticipated changes in fiscal policy affect the economy in advance of their implementation, while unanticipated policy changes affect only when they are implemented. While these studies have concentrated on exogenous changes in total tax revenues, Mertens and Ravn(2013) distinguish between changes in average personal and corporate income tax rates and develop a new narrative account of the total tax revenue changes in these two tax components. They find large short-run effects on the output of unanticipated changes in either tax rates. In addition, Barro and Redlick(2011) and Mertens and Montiel Olea(2018) construct new measures of the average marginal tax rates based on the Romer and Romer (2010) narrative account and provide evidence that the aggregate responses are mainly due to marginal rather than average tax rates.

In this section, we assess the robustness of our main results with respect to these alternatives tax policy instruments. First, we distinguish between anticipated and unanticipated tax changes (using Mertens and Ravn(2012) data) and estimate the state-dependent output effects of unanticipated tax shocks. We then investigate the effects of changes in marginal tax rates (constructed in Barro and Redlick(2011) and Mertens and Montiel Olea(2018)) on output using our non-linear model. However, as discussed in Mertens and Ravn(2013), average personal and corporate income tax rates are likely to be systematically correlated and for isolating the causal effects of a change in only one of the tax rates, it is thus important to control for changes in the other tax rate, which requires imposing more restrictions.[18] In this paper, we do not examine the state-dependent effects of the average personal and corporate income tax rates because to do so we should use a regime-switching proxy-VAR model.

Our findings for the impact of an exogenous unanticipated tax cut using the linear model is very similar to Mertens and Ravn(2012), we do not report the results here though.[19] However, state-dependent impulse responses are quite different from the linear model but very similar to our earlier state-dependent baseline results. Figure 7 compares baseline estimates with

[18]They find show that the output responses depend importantly on whether one controls for the correlation between the proxies or not. When the correlation is ignored, they find sizable differences.

[19]This implies that our estimation based on Jordà's linear mode is consistent with the linear VAR model used by Mertens and Ravn(2012)

the effect of unanticipated tax changes on output across good times and bad and also across uncertain and tranquil times.

Figure 7

Figures 8-9 depict the responses in the linear and state-dependent model using Barro and Redlick(2011) and Mertens and Montiel Olea(2018) average marginal tax rates, respectively.[20] Barro and Redlick(2011) find that a 1 percentage point cut in the average marginal tax rate raises per capita GDP by around 0.5% in the following year which is also consistent with our linear result (0.58% in quarter 8). In addition, using Mertens and Montiel Olea (2018) average marginal tax rate, we get 1.02% (t = 1.85) three years after a marginal tax cut which is remarkably similar to that of Mertens and Montiel Olea(2018) estimates. Nevertheless, the results are qualitatively similar to our baseline results, the estimates here are a degree of magnitude smaller. On the other hand, the corresponding non-linear estimates, as shown in the first and second columns of Figures 8 and 9, display very similar patterns to those from the baseline estimates, especially for slack and uncertain times. In particular, while output responds strongly to a marginal tax cut during low unemployment states, it is relatively unaffected during periods of high unemployment states. Under different circumstances, using Barro and Redlick(2011) series, a marginal tax cut that occurs in uncertain times has a much stronger effect on output than the tranquil times. Although these results are in line with our baseline findings, it is not consistent with Mertens and Montiel Olea (2018) marginal tax rates. We suspect that the reason for these differences lies in the poor distribution of Mertens and Montiel Olea(2018) over the uncertain and tranquil times, as shown in the third panel of Figures 1-2.

Figures 8-9

To summarize, we showed through extensive robustness analysis that our baseline results are robust to many alternative specifications. We find strong evidence that the responses are different across states. While the large and significant response of output to a tax cut during good times, it is largely insignificant during bad times. In addition, we find that a tax cut has large effects on output during uncertain times but small and statistically insignificant effects in tranquil times.

[20]We note that both measures of average marginal tax rates are provided annually (based on the year-Aggregated Romer and Romer(2010) series) and using Romer and Romer(2010) original identification at quarterly frequency, we adopt the marginal tax rates to get the quarterly data.

5 Extension

In this section, we extend our findings by shedding light on the large and state-dependent response of output to tax shocks. We first examine how tax changes affect the components of GDP, such as consumption and investment. We then discuss the transmission mechanism of tax changes by highlighting the behavior of nonresidential and residential fixed invest- ment. In fact, another way to address the possible importance of the response of the various components of GDP is to investigate the behavior of the subcomponents of GDP, such as residential and nonresidential fixed investment.

5.1 The Components of Output and the Transmission Mechanism

Based on our baseline estimation we find that the effects of exogenous tax cuts on output are strong and different depending on the state of the economy. An obvious question is whether we can shed light on how or why fiscal changes have such pronounced and state-dependent effects. To that end, we examine the response of the various components of GDP, such as consumption and investment, to exogenous tax shocks.

Output Components. We include logarithm of real per capita private sector consumption expenditure and logarithm of real aggregate per capita gross private sector investment. The results are presented in Figure 10.[21] For simplicity, we do not report confidence intervals. We also repeat the estimated response of GDP to make a comparison with consumption and investment. The first, second and third columns present, respectively, the estimated linear and state-dependent responses of output, consumption, and investment to an exogenous tax cut. According to our linear responses (dashed lines), the key results are that both components increase and that the rise in investment is much larger than the rise in consumption. In response to an exogenous tax cut of one percent of GDP, the maximum increase in personal consumption expenditures is 2.78 percent ($t = 4.43$), just slightly less than the maximum increase in GDP. The maximum increase in gross private domestic investment is 9.88 percent ($t = 4.24$). In fact, investment is one of the most responsive components of GDP to tax shocks.[22] These estimates are remarkably similar to the Romer and Romer(2010) linear

[21]This focus on the behavior of the components is similar to the approach in Romer and Romer(2010). Also, the responses of exports and imports to a tax cut are exactly what one would expect: exports fall and imports rise.

[22]Aggregate investment is also one of the most responsive components of GDP to monetary shocks. Ottonello and Winberry(2018) study the role of financial frictions and firm heterogeneity in determining this investment channel of monetary policy. Using a heterogeneous firm New Keynesian model with default risk, they find that the low-risk firms are more responsive to monetary policy than other firms are.

results and also very similar to many preexisting studies who find that the percentage rise in investment is substantially larger than the percentage rise in consumption (e.g. Blanchard and Perotti(2002), Mertens and Ravn(2011,2012), and Cloyne(2013)). This implies that the average investment behavior is the main transmission mechanism of fiscal policy shocks on average output.[23]

However, the most striking feature of this comparison is that the state-dependent pattern of output mirror the relative state-dependent pattern of investment behavior. On the other hand, we find no strong evidence that the response of consumption expenditure is state-dependent. While the difference between the two states (for all the three definitions of state variables) is statistically significant for investment at all horizons (at the 5% level), it is statistically insignificant for consumption. Interestingly, the strong and state-dependent response of investment provides support for our baseline conflicting predictions about the effects of tax shocks on output across good and bad times and across uncertain and tranquil times. As discussed in a previous section and also presented in Figure 10, while tax policy is surely more effective during good times (low unemployment states and expansions), the effect of tax changes on output is relatively small and highly insignificant during tranquil times (low uncertainty). Importantly, these findings also suggest that the output state-dependent responses are largely driven by the procyclical and non-linear behavior of investment. Also, several papers have analyzed the effects of tax changes on investment and show that investment responses depend strongly on cash flow and overall economic conditions (e.g. Abel and Blanchard(1986), Fazzari et al.(1988), and Oliner et al.(1995), among others.).

Figure 10

Transmission Mechanism. Aggregate investment accounts for approximately 17% of GDP in our sample and it is one of the most volatile components of GDP over the business cycle. In addition, our findings show that investment is the most responsive and state-dependent components of GDP to tax shocks and suggest that the main transmission mechanism of tax changes on output could be investment behavior. However, this intuition ignores the significant heterogeneity among subcomponents of GDP such as residential and nonresidential fixed investment. Berger and Vavra(2014,2015) highlight the subcomponents of GDP and provide strong empirical evidence and theoretical explanation that the aggregate durable spending responds to fiscal shocks substantially larger during expansions than during recessions. We now study how the main components of investment respond to tax changes in

[23]See section VI, part C, of Romer and Romer(2010) for a discussion of this issue.

order to understand more deeply the forces driving the state-dependent response of output. We include logarithm of real per capita private fixed, residential, and nonresidential investments and estimate our linear and state-dependent models. The results are presented in Figure 11. In keeping with this focus on investment and also to make a comparison with the components of investment, we report responses of aggregate investment. The first, second and third columns present, respectively, the estimated linear and state-dependent responses of aggregate investment, nonresidential fixed investment and residential fixed investment to an exogenous tax cut. As before, panels A, B, and C present estimated responses during high and low unemployment rate, during recession and expansion, and periods of high and low uncertainty, respectively. This graph makes clear that there is significant heterogeneity among the two main components of investment. Therefore, we argue that accounting for the importance of the behavior of the subcomponents of GDP does matter for our understanding of the behavior of aggregate investment and output. Our argument has three main components. First, we find that the procyclical responses of nonresidential fixed investment to tax shacks drive the procyclical responses of aggregate investment and output (across good and bad times: panels A and B). Second, we show that the responses of the residential fixed investment with respect to shocks are countercyclical (across good and bad times: panels A and B). Third, we provide strong evidence that the countercyclical responses of aggregate investment and output with respect to shocks (during high and low uncertainty periods: panel C) are mainly driven by countercyclical responses of residential fixed investment.

Our first argument is consistent with the existing studies stressing the relevance of lumpy investment for aggregate dynamics. For instance, Thomas(2002), Khan and Thomas(2003, 2008), Caballero et al.(1995), Caballero and Engel(1999), and Gourio and Kashyap(2007) analyze aggregate consequences of lumpy investment in the context of general equilibrium and partial equilibrium models. Although there is still significant debate in the literature, the lumpiness of investment activity at the plant level is a well-established fact. In line with our results, Bachmann et al.(2013) first provide empirical evidence showing that the sensitivity of US aggregate investment to shocks is procyclical; investment responds more to a given shock during booms than during slumps. Next, they show that this nonlinearity in the data follows naturally from a DSGE model with lumpy microeconomic investment. A more recent paper by Winberry(2018) argues that accounting for the importance of the extensive margin does matter for our understanding of aggregate investment. Using a quantitative heterogeneous firm model, he shows that the procyclicality of aggregate investment with respect to shocks is due to more firms are close to making an extensive margin investment in expansions. One of the most important implications of this model is that the effectiveness of investment stimulus policies is state dependent and falls in recession as in our empirical findings.

However, our second and third arguments should motivate future theoretical work to develop realistic DSGE models with potentially nonlinear features to understand more deeply the forces driving differences in the size of tax multipliers over the states of the economy, the microeconomic mechanism that drives our result, and the role of GDP subcomponents behavior in explaining the non-linear impact of tax changes on aggregate investment and output.

6 Macroeconomic Effects of the 2017 Tax Reform

The Tax Cuts and Jobs Act (TCJA), signed into law by President Trump on December 22, 2017, constitutes the most substantial overhaul of the US tax system since President Reagan's 1986 reform. It is estimated that through substantial cuts to statutory tax rates for individuals, pass-through businesses, and corporations, TCJA will lower government revenues by a cumulative total of almost US$ 1.5 trillion (7.5% of current GDP) over the next ten decade (Joint Committee on Taxation, 2017 (JCX-67-17)). The TCJA will increase the budget deficit by $136, $280, and $256 billion in fiscal years 2018, 2019 and 2020, respectively. It is therefore clear that this magnitude of revenue loss will have important consequences for the U.S. macroeconomic outlook in the coming years. Most existing empirical studies suggest that TCJA will raise GDP between 0.3 and 2.74 percent over the first three years (2018–20).[24] For instance, CBO(2018) estimates that the 2017 tax act would increase the level of GDP by 0.7 percent on average over the 2018–2028 period due to increases in labor supply and investment. In CBO's projections, real GDP is boosted by 0.3 percent in 2018, by 0.6 percent in 2019, by 0.8 percent in 2020, and the effect peaks at 1.0 percent in 2022. Using six leading methods of estimation, Mertens(2018) predicts that TCJA will yield, by average, a level of GDP 1.32 percent higher by the end of 2020. In particular, by applying three direct regression approaches (Romer and Romer(2010), Favero and Giavazzi(2012), and Mertens and Ravn(2012)) which are very similar to our linear model, and three indirect approaches (Blanchard and Perotti(2002), Mertens and Ravn(2014), and Caldara and Kamps(2017)), he obtained, respectively, a range of 0.82% to 2.74% and a fairly narrow range of 0.77% to 1.13% for a total cumulative increase of GDP growth by 2020. These estimates are for a tax shock that occurs in 2018Q1 and equals the entire revenue impact of -1.1% of GDP. These projections, however, ignore the possibility that the impact of tax policy on output may vary over the business cycle.

As we discussed in details in this paper, failing to account for non-linearity in the response

[24] See Gale et al.(2018) for a review of the empirical literature.

of output growth to a tax shock could lead to biased estimates. Specifically, we showed that the linear responses are being about halfway between the large estimated responses during good times (in which unemployment is low or output is relatively high) and much smaller and statistically insignificant effects during bad times. In addition, we found that a tax cut has large effects on output during uncertain times but small and statistically insignificant effects in tranquil times. In this section, we apply our state-dependent methodology along with the current state of the US economy to project the near term impact of the Tax Cuts and Jobs Act on US GDP growth. Figures 1-2 illustrate the current state of the US economy (from 2018Q1 onwards) which is characterized with low unemployment rate and relatively high output growth (good times), but, at the same time, uncertain times.[25] On the other hand, almost all of the provisions in TCJA became effective in the 2018 tax year and also taken for more exogenous reasons, since the motivation for the low is predominantly ideological.

Given the current state of the US economy (good but uncertain times) and an unanticipated-exogenous reduction in total tax revenues in 2018Q1 equal to -1.1% of GDP, we apply our estimated state-dependent tax multipliers and compare with the existing liner predictions. Table 3 presents our predictions along with some other estimates of the impact on real GDP growth of TCJA. The results in the first row present our projections and obtained by averaging the output responses over three states of the economy (states of low unemployment, expansion, and high Uncertainty). The results in the second row are from Mertens(2018) who applied three direct regression approach. [26] The results in the third and fourth rows are from, respectively, CBO(2018), and IMF(2018). Our non-linear model and Mertens and Ravn(2012) direct linear regression approaches yield very similar dynamics for output growth through 2018 and 2020, a positive effect on GDP growth that persists in 2019 and a sharp reversal in 2020. However, we obtained a total cumulative increase of 2.06 percentage points by 2020 as compared to 1.65 percentage point from Mertens(2018). Our higher predictions are consistent with the results of this paper that tax multipliers are higher in good and uncertain times than those obtained in linear model (see Figure 4). The CBO (2018), and IMF(2018) estimates instead show a moderate but continued positive impact on GDP growth rates through 2018 and 2020 and a total cumulative increase of 2.37 and 1.70 percentage points by 2020, respectively.

[25] In the last five years, politics have been the main driver of uncertainty. US policy uncertainty returned to high levels in 2016 in response to two major political surprises: United Kingdom voted to leave the European Union (Brexit), and the election of Donald Trump to the US Presidency in November 2016, see Barrero et al. (2017) and Davis(2017).

[26] Romer and Romer(2010), Favero and Giavazzi(2012), and Mertens and Ravn(2012). These three specifications are chosen by Mertens(2018) because they generate results that are representative for the range of estimates typically obtained using the direct regression approach. In addition, these three specifications are very similar to our linear model.

Figure 12 plots the cumulative responses of four projections for each horizon from impact to 3 years out. One advantage of our multipliers over these three studies is that the tax policies underlying our model estimates are closer to TCJA at current state of the US economy.

Table 3

Figure 12

7 Conclusion

A growing number of studies have been recently devoted to the size of fiscal multipliers when the economy is in recession. There is considerable disagreement about the size of government spending multipliers across different states of the economy. Although, most of the studies show that spending multipliers are larger when the economy is in recession than expansion, but some other studies find no differences across states. This paper contributes new evidence to this debate. We investigate the dynamic macroeconomic effects of tax liability changes across states in the United States. We use a state-dependent model where the state of the economy is distinguished between periods of good and bad times (measured by unemployment rate and output growth) and also periods of uncertain and tranquil times (measured by VXO).

Our estimates of the impact of tax changes on output using linear model are similar to many preexisting studies, but the state-dependent responses are very different from them. We find that linear responses are being about halfway between the large estimated responses during good times and much smaller and statistically insignificant effects during bad times. This implies that the effects of tax changes on output are state dependent, which the effectiveness of tax policy is considerably larger in good times than in bad times. On the other hand, we find that a tax cut has large effects on output during uncertain times but small and statistically insignificant effects in tranquil times. Moreover, our results indicate that, the important part of the output state-dependent responses appears to be due to the procyclicality of investment, and more precisely, it is due to the higher procyclicality of nonresidential fixed investment, which is consistent with the theory of lumpy investment.

Finally, as an implication of our findings, we predict that TCJA will yield an extra boost to GDP of 2.06 percent by 2020.

References

Aastveit, K. A., G. J. Natvik, and S. Sola (2017). Economic uncertainty and the influence of monetary policy. *Journal of International Money and Finance 76*, 50–67.

Abel, A. B. and O. J. Blanchard (1986). Investment and sales: Some empirical evidence. *National Bureau of Economic Research Cambridge, Mass., USA*.

Alesina, A., G. Azzalini, C. Favero, F. Giavazzi, and A. Miano (2018). Is it the "how" or the "when" that matters in fiscal adjustments? *IMF Economic Review 66*(1), 144–188.

Alesina, A., C. Favero, and F. Giavazzi (2015). The output effect of fiscal consolidation plans. *Journal of International Economics 96*, S19–S42.

Alloza, M. (2018). Is fiscal policy more effective in uncertain times or during recessions? *Centre for Macroeconomics Working Paper CFM-DP2016-31, Banco de España Working Paper Nº1730* .

Arin, K. P., F. Koray, and N. Spagnolo (2015). Fiscal multipliers in good times and bad times. *Journal of Macroeconomics 44*, 303–311.

Auerbach, A. J. and Y. Gorodnichenko (2012). Measuring the output responses to fiscal policy. *American Economic Journal: Economic Policy 4* (2), 1–27.

Auerbach, A. J. and Y. Gorodnichenko (2013). Fiscal multipliers in recession and expansion. pp. 63–98.

Bachmann, R., R. J. Caballero, and E. M. Engel (2013). Aggregate implications of lumpy investment: new evidence and a dsge model. *American Economic Journal: Macroeconomics 5* (4), 29–67.

Bachmann, R. and E. R. Sims (2012). Confidence and the transmission of government spending shocks. *Journal of Monetary Economics 59* (3), 235–249.

Baker, S. R., N. Bloom, and S. J. Davis (2016). Measuring economic policy uncertainty. *The Quarterly Journal of Economics 131* (4), 1593–1636.

Barrero, J. M., N. Bloom, and I. Wright (2017). Short and long run uncertainty. *National Bureau of Economic Research*.

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

Barro, R. J. and C. J. Redlick (2011). Macroeconomic effects from government purchases and taxes. *The Quarterly Journal of Economics 126* (1), 51–102.

Batini, N., G. Callegari, and G. Melina (2012). Successful austerity in the united states, europe and japan. *IMF working paper* .

Baum, M. A., M. M. Poplawski-Ribeiro, and A. Weber (2012). Fiscal multipliers and the state of the economy. *International Monetary Fund* (12-286).

Berger, D. and J. Vavra (2014). Measuring how fiscal shocks affect durable spending in recessions and expansions. *American Economic Review 104* (5), 112–15.

Berger, D. and J. Vavra (2015). Consumption dynamics during recessions. *Economet- rica 83* (1), 101–154.

Biolsi, C. (2017). Nonlinear effects of fiscal policy over the business cycle. *Journal of Economic Dynamics and Control 78*, 54–87.

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

Bloom, N. (2009). The impact of uncertainty shocks. *Econometrica 77* (3), 623–685.

Caballero, R. J. and E. M. Engel (1999). Explaining investment dynamics in us manufac- turing: a generalized (s, s) approach. *Econometrica 67* (4), 783–826.

Caballero, R. J., E. M. Engel, J. C. Haltiwanger, M. Woodford, and R. E. Hall (1995). Plant- level adjustment and aggregate investment dynamics. *Brookings papers on economic activity*, 1–54.

Caggiano, G., E. Castelnuovo, V. Colombo, and G. Nodari (2015). Estimating fiscal multi- pliers: News from a non-linear world. *The Economic Journal 125* (584), 746–776.

Caldara, D. and C. Kamps (2017). The analytics of svars: a unified framework to measure fiscal multipliers. *The Review of Economic Studies 84* (3), 1015–1040.

Castelnuovo, E. and G. Pellegrino (2018). Uncertainty-dependent effects of monetary policy shocks: A new-keynesian interpretation. *Journal of Economic Dynamics and Control 93*, 277–296.

CBO (APRIL 2018). The budget and economic outlook: 2018 to 2028. *Congressional Budget Office*.

Cloyne, J. (2013). Discretionary tax changes and the macroeconomy: new narrative evidence from the united kingdom. *American Economic Review 103* (4), 1507–28.

Cohen-Setton, J., E. Gornostay, and C. L. de Lacharrière (2018). Impact of the trump fiscal stimulus on us economic growth. *The Peterson Institute for International Economics*.

Davis, S. J. (2017). Regulatory complexity and policy uncertainty: headwinds of our own making. *Becker Friedman Institute for Research in Economics Working Paper* (2723980).

Demirel, U. D. (2016). The short-term effects of tax changes-evidence for state dependence. *Congressional Budget Office Working Paper 2016-03* .

Eickmeier, S., N. Metiu, and E. Prieto (2016). Time-varying volatility, financial intermediation and monetary policy. *Bundesbank Discussion Paper No. 46/2016* .

Favero, C. and F. Giavazzi (2012). Measuring tax multipliers: The narrative method in fiscal vars. *American Economic Journal: Economic Policy 4* (2), 69–94.

Fazzari, S., R. G. Hubbard, and B. Petersen (1988). Investment, financing decisions, and tax policy. *The American Economic Review 78* (2), 200–205.

Fazzari, S. M., J. Morley, and I. Panovska (2015). State-dependent effects of fiscal policy. *Studies in Nonlinear Dynamics & Econometrics 19* (3), 285–315.

Gale, W. G., H. Gelfond, A. Krupkin, M. J. Mazur, and E. J. Toder (2018). Effects of the tax cuts and jobs act: a preliminary analysis. *Tax Policy Center— Urban Institute & Brookings Institution*.

Gourio, F. and A. K. Kashyap (2007). Investment spikes: New facts and a general equilibrium exploration. *Journal of Monetary Economics 54*, 1–22.

Hall, R. E. (2009). By how much does gdp rise if the government buys more output? Technical report, National Bureau of Economic Research.

Hayo, B. and M. Uhl (2013). The macroeconomic effects of legislated tax changes in germany. *Oxford Economic Papers 66* (2), 397–418.

Hodge, S. A. (2018). Testimony: The positive economic growth effects of the tax cuts and jobs act. *Tax Foundation*.

House, C. L. (2014). Fixed costs and long-lived investments. *Journal of Monetary Economics 68*, 86–100.

IMF (2018). The tax cuts and jobs act: An appraisal. *International Monetary Fund WP/18/185*.

Jordà, Ò. (2005). Estimation and inference of impulse responses by local projections. *American economic review 95* (1), 161–182.

Jurado, K., S. C. Ludvigson, and S. Ng (2015). Measuring uncertainty. *American Economic Review 105* (3), 1177–1216.

Khan, A. and J. K. Thomas (2003). Nonconvex factor adjustments in equilibrium business cycle models: do nonlinearities matter? *Journal of monetary economics 50* (2), 331–360.

Khan, A. and J. K. Thomas (2008). Idiosyncratic shocks and the role of nonconvexities in plant and aggregate investment dynamics. *Econometrica 76* (2), 395–436.

Leeper, E. M., T. B. Walker, and S.-C. S. Yang (2013). Fiscal foresight and information flows. *Econometrica 81* (3), 1115–1145.

Mertens, K. (2018). The near term growth impact of the tax cuts and jobs act. *journal=FRB of Dallas Working Paper No. 1803* .

Mertens, K. and J. L. Montiel Olea (2018). Marginal tax rates and income: New time series evidence. *The Quarterly Journal of Economics 133* (4), 1803–1884.

Mertens, K. and M. O. Ravn (2011). Understanding the aggregate effects of anticipated and unanticipated tax policy shocks. *Review of Economic Dynamics 14* (1), 27–54.

Mertens, K. and M. O. Ravn (2012). Empirical evidence on the aggregate effects of anticipated and unanticipated us tax policy shocks. *American Economic Journal: Economic Policy 4* (2), 145–81.

Mertens, K. and M. O. Ravn (2013). The dynamic effects of personal and corporate income tax changes in the united states. *American Economic Review 103* (4), 1212–47.

Mertens, K. and M. O. Ravn (2014). A reconciliation of svar and narrative estimates of tax multipliers. *Journal of Monetary Economics 68*, S1–S19.

Miao, J. and P. Wang (2009). Does lumpy investment matter for business cycles? *Available at SSRN 1393025* .

Mountford, A. and H. Uhlig (2009). What are the effects of fiscal policy shocks? *Journal of applied econometrics 24* (6), 960–992.

Newey, W. K. and K. D. West (1987). Hypothesis testing with efficient method of moments estimation. *International Economic Review* , 777–787.

Oliner, S., G. Rudebusch, and D. Sichel (1995). New and old models of business investment: a comparison of forecasting performance. *Journal of Money, Credit and Banking 27* (3), 806–826.

Ottonello, P. and T. Winberry (2018). Financial heterogeneity and the investment channel of monetary policy. Technical report, National Bureau of Economic Research.

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

Pellegrino, G. (2017). Uncertainty and monetary policy in the us: A journey into non-linear territory. *Melbourne Institute Working Paper No. 6/17* .

Pellegrino, G. (2018). Uncertainty and the real effects of monetary policy shocks in the euro area. *Economics Letters 162*, 177–181.

Ramey, V. A. (2019). Ten years after the financial crisis: What have we learned from the renaissance in fiscal research? *National Bureau of Economic Research*.

Ramey, V. A. and M. D. Shapiro (1998). Costly capital reallocation and the effects of government spending. In *Carnegie-Rochester Conference Series on Public Policy*, Volume 48, pp. 145–194. Elsevier.

Ramey, V. A. and S. Zubairy (2018). Government spending multipliers in good times and in bad: evidence from us historical data. *Journal of Political Economy 126* (2), 850–901.

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

Sims, E. and J. Wolff (2018). The state-dependent effects of tax shocks. *European Economic Review 107*, 57–85.

Slemrod, J. (2018). Is this tax reform, or just confusion? *Journal of Economic Perspec- tives 32* (4), 73–96.

Thomas, J. K. (2002). Is lumpy investment relevant for the business cycle? *Journal of Political Economy 110* (3), 508–534.

Winberry, T. (2018). Lumpy investment, business cycles, and stimulus policy. *NBER/University of Chicago Booth School of Business*.

Table 1: Distribution of Tax Shocks across Bad and Good Times

	Unemp 6.5% (baseline)	Unemp 5.5% (robust)	Unemp 7.2% (robust)	Unemp Time-varying (robust)	MA of GDP Growth (baseline)	NBER Dates (robust)
Bad Times						
Observation (%)	25.79	51.19	15.87	44.84	21.43	21.03
Tax Shocks (%)	43.18	77.27	22.73	65.91	15.91	20.45
Tax Shocks (|*mean*|)	0.35	0.39	0.46	0.40	0.58	0.52
Good Times						
Observation (%)	74.21	48.81	84.13	55.16	78.57	78.97
Tax Shocks (%)	56.82	22.72	77.27	34.09	84.09	79.55
Tax Shocks (|*mean*|)	0.40	0.36	0.36	0.34	0.34	0.34

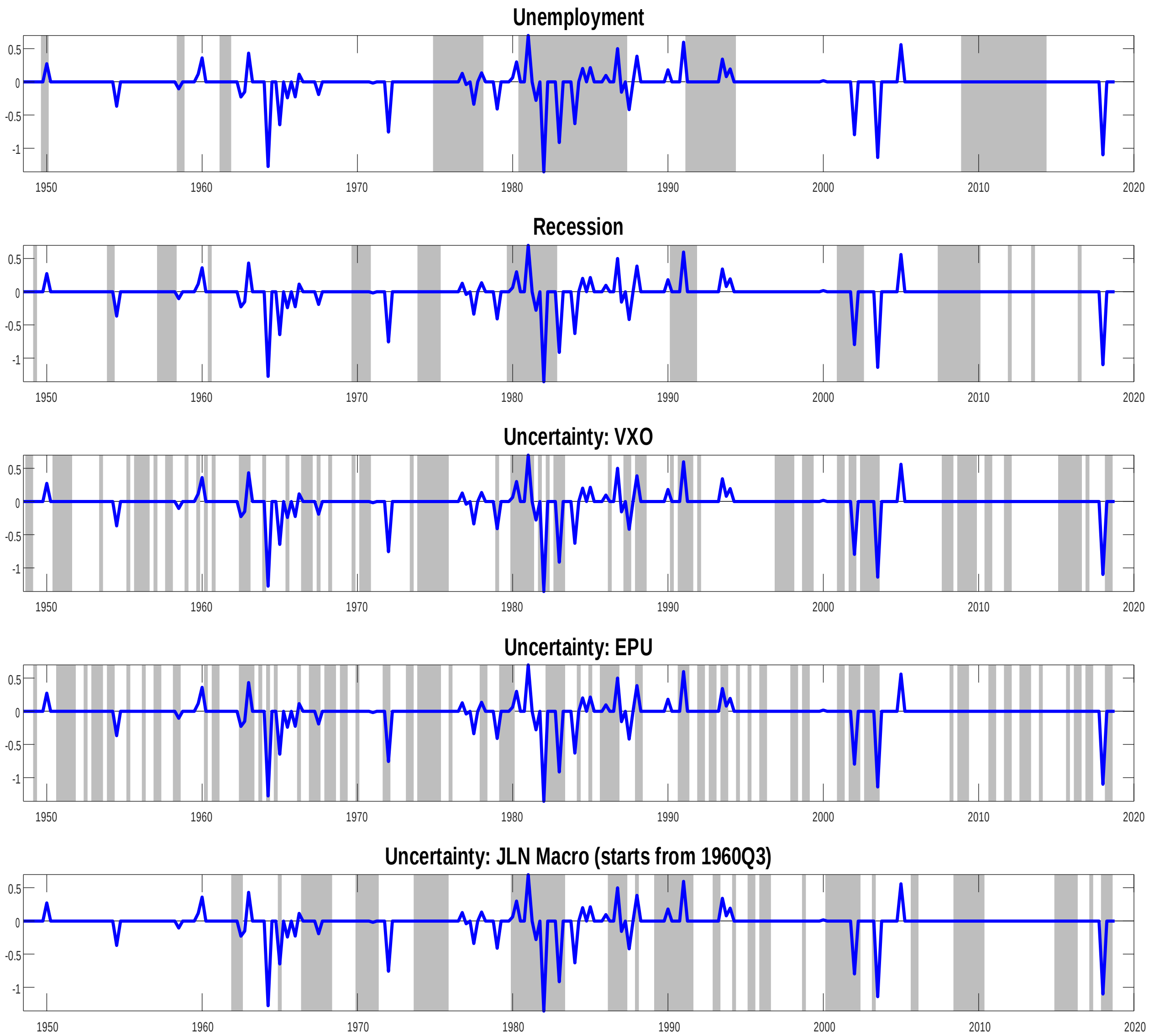
Table 2: Distribution of Tax Shocks across Uncertain and Tranquil Times

	VXO HP mean (baseline)	VXO HP 1.65 sd (robust)	EPU HP mean (robust)	EPU HP 1.65 sd (robust)	JLN HP mean (robust)	JLN HP 1.65 sd (robust)
Uncertain Times						
Observation (%)	37.30	12.30	41.27	11.11	44.95	8.59
Tax Shocks (%)	36.36	15.91	45.45	11.36	43.59	7.69
Tax Shocks (|*mean*|)	0.44	0.52	0.43	0.74	0.50	0.60
Tranquil Times						
Observation (%)	62.70	87.70	58.73	88.89	55.05	91.41
Tax Shocks (%)	63.63	84.09	54.54	88.64	56.41	92.31
Tax Shocks (|*mean*|)	0.34	0.35	0.34	0.33	0.32	0.38

Table 3: Estimates of the Impact on Real GDP Growth of TCJA

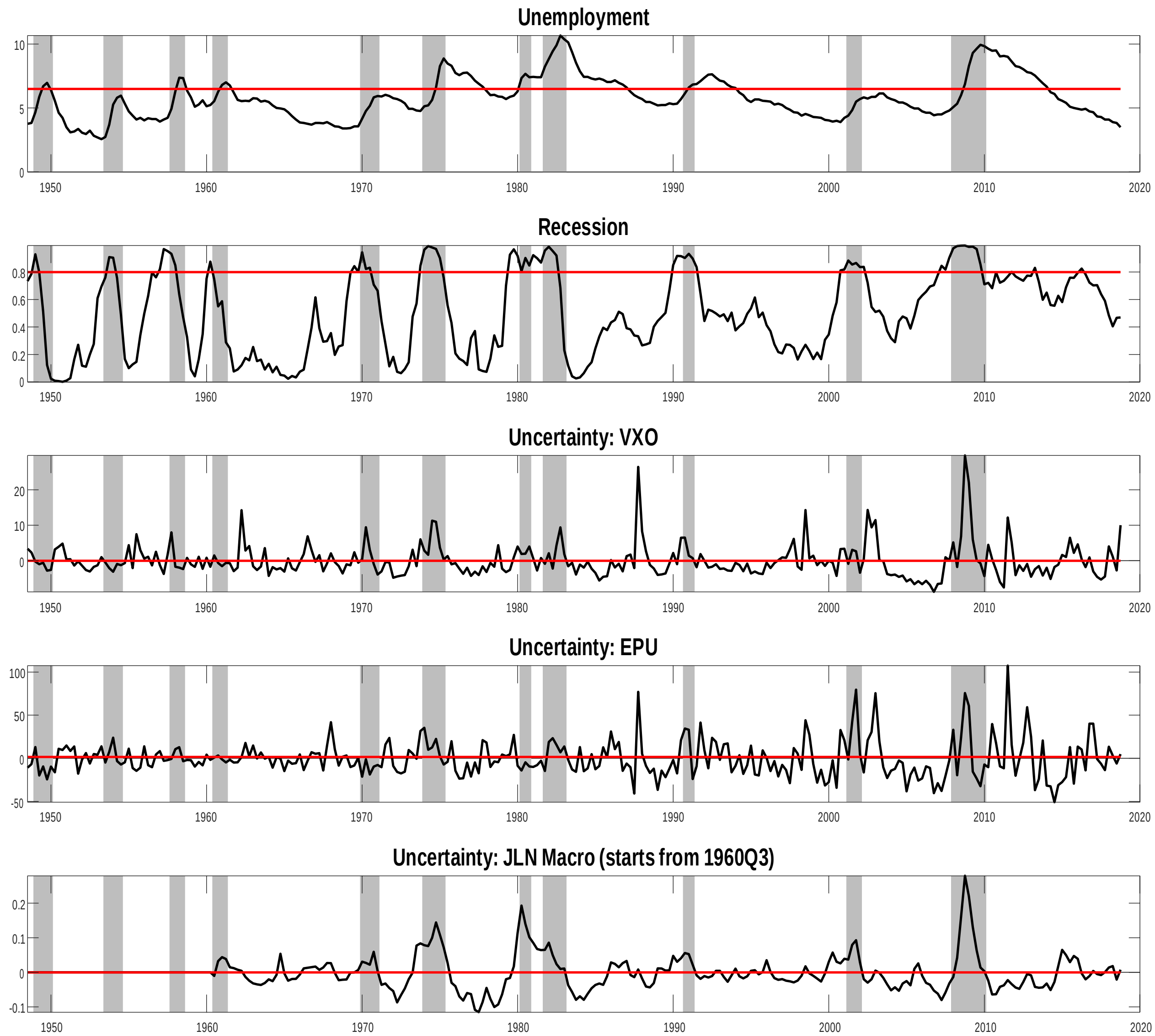
(percentage points)	2018	2019	2020	Cumulative 2018-20
Eskandari (2019)	1.67	0.93	-0.53	2.06
Mertens(2018)	1.30	0.63	-0.27	1.65
CBO(2018)	0.27	0.90	1.20	2.37
IMF(2018)	0.30	0.60	0.80	1.70

Figure 1: Exogenous Tax Shocks and State Variables



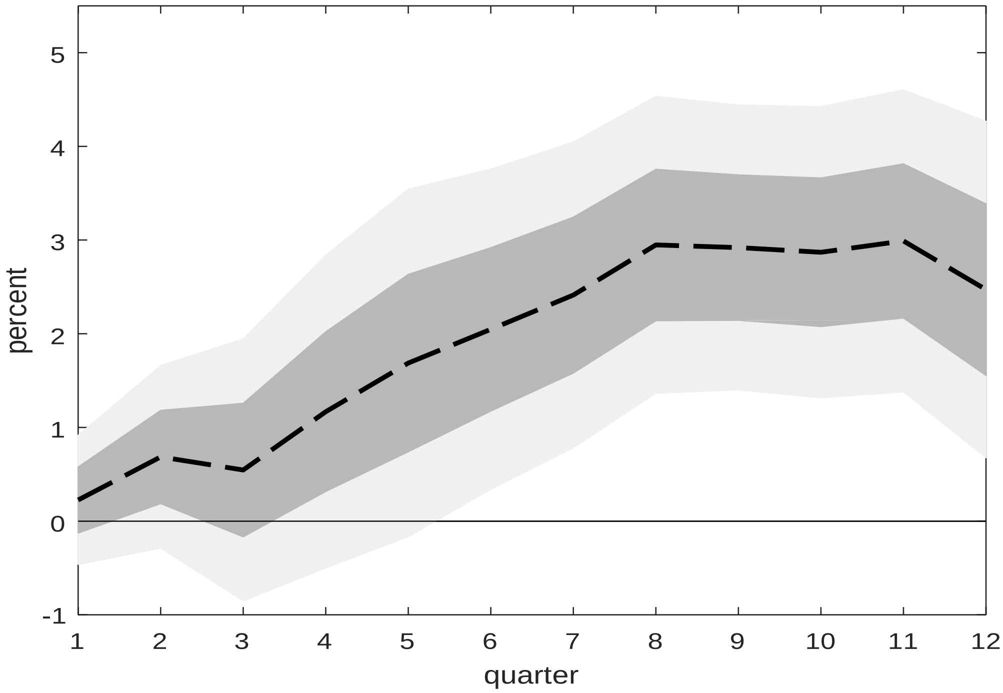
Note: Blue lines indicate Romer and Romer(2010) exogenous tax shocks, and shaded areas represent our definition of bad times (first and second panels) and uncertain times (last three panels).

Figure 2: State Variables, Thresholds and NBER Recessions



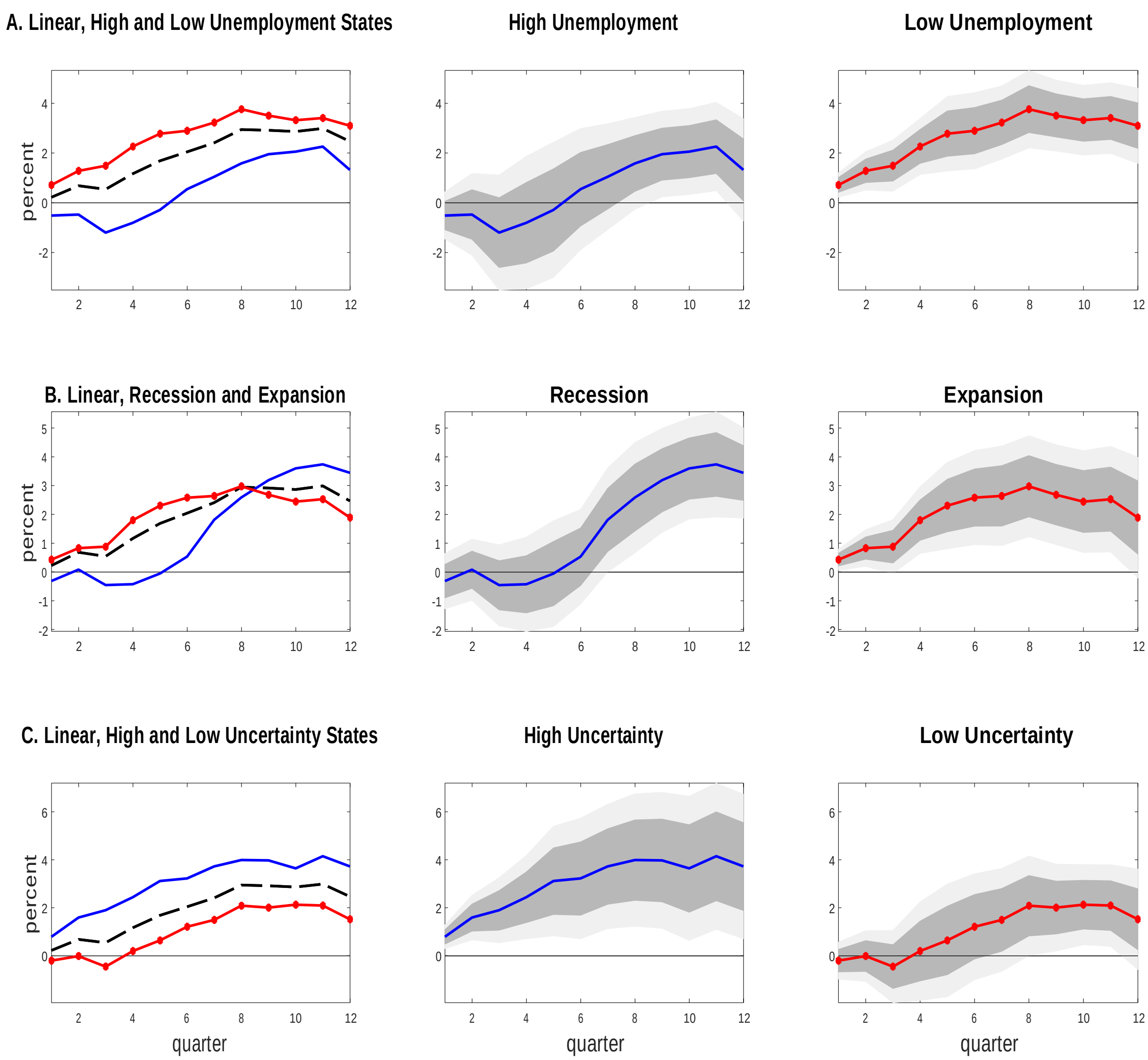
Note: Black lines indicate our state variables (all the state variables are HP detrended, λ = 1600), red lines represent the corresponding thresholds for each state variable, and shaded areas shows recessions as defined by the NBER.

Figure 3: Response of GDP to a tax shock: linear model



Note: Dashed black line indicates output response in the linear model. Light and dark shaded areas represent 95% and 68% confidence intervals, respectively.

Figure 4: Response of GDP to a tax shock: linear and state-dependent models



Note: Dashed black line indicates output response in the linear model. Solid blue lines show output responses in bad times (high unemployment states or recessionary regimes) and uncertain. Solid red lines with circle show output responses in good times (low unemployment states or expansionary regimes) and tranquil. Light and dark shaded areas represent 95% and 68% confidence intervals, respectively.

Figure 5: Response of GDP to a tax shock (robustness to different state variables)

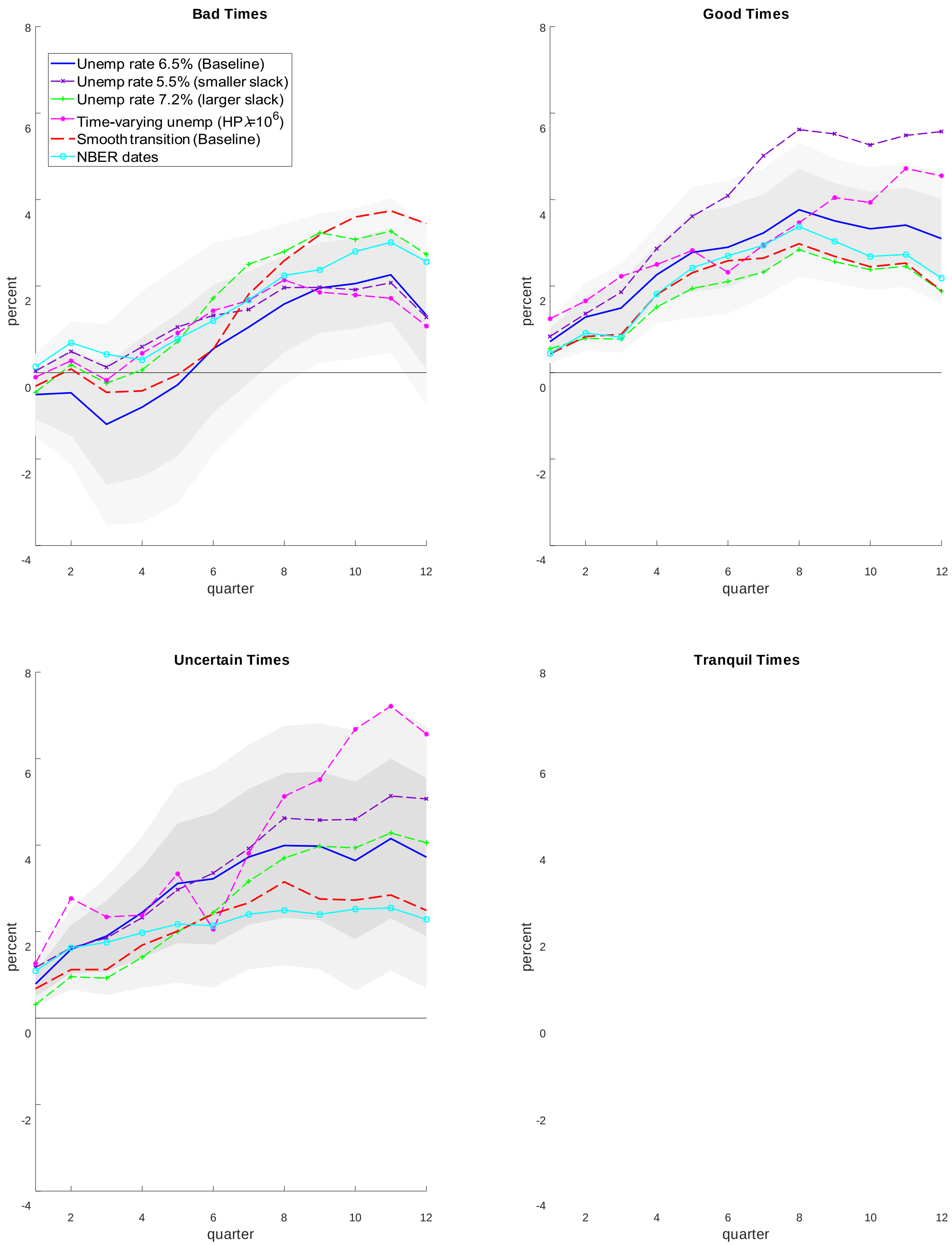


Figure 6: Response of GDP to a tax shock (robustness to control variables)

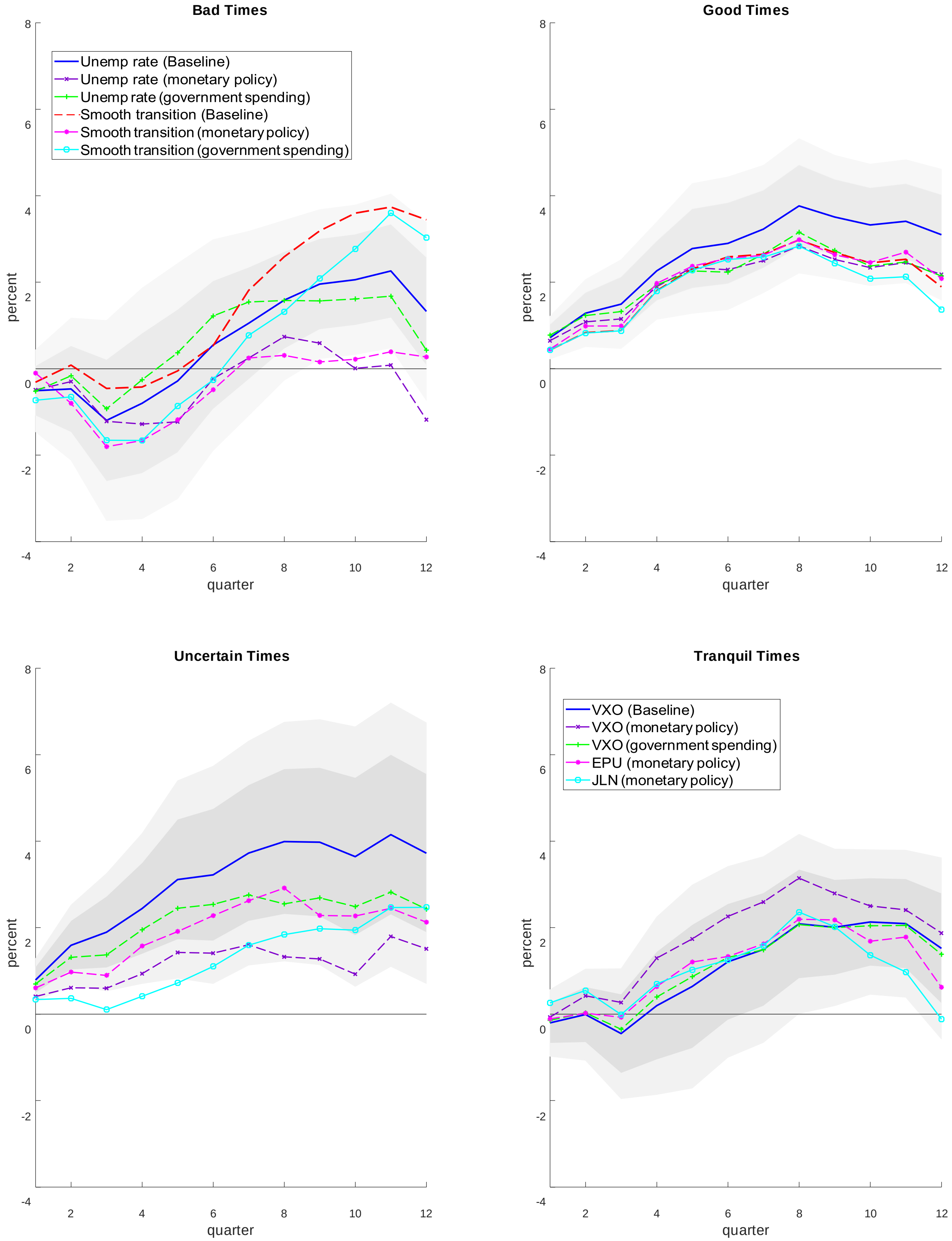


Figure 7: Response of GDP to a tax shock (robustness to unanticipated tax shock)

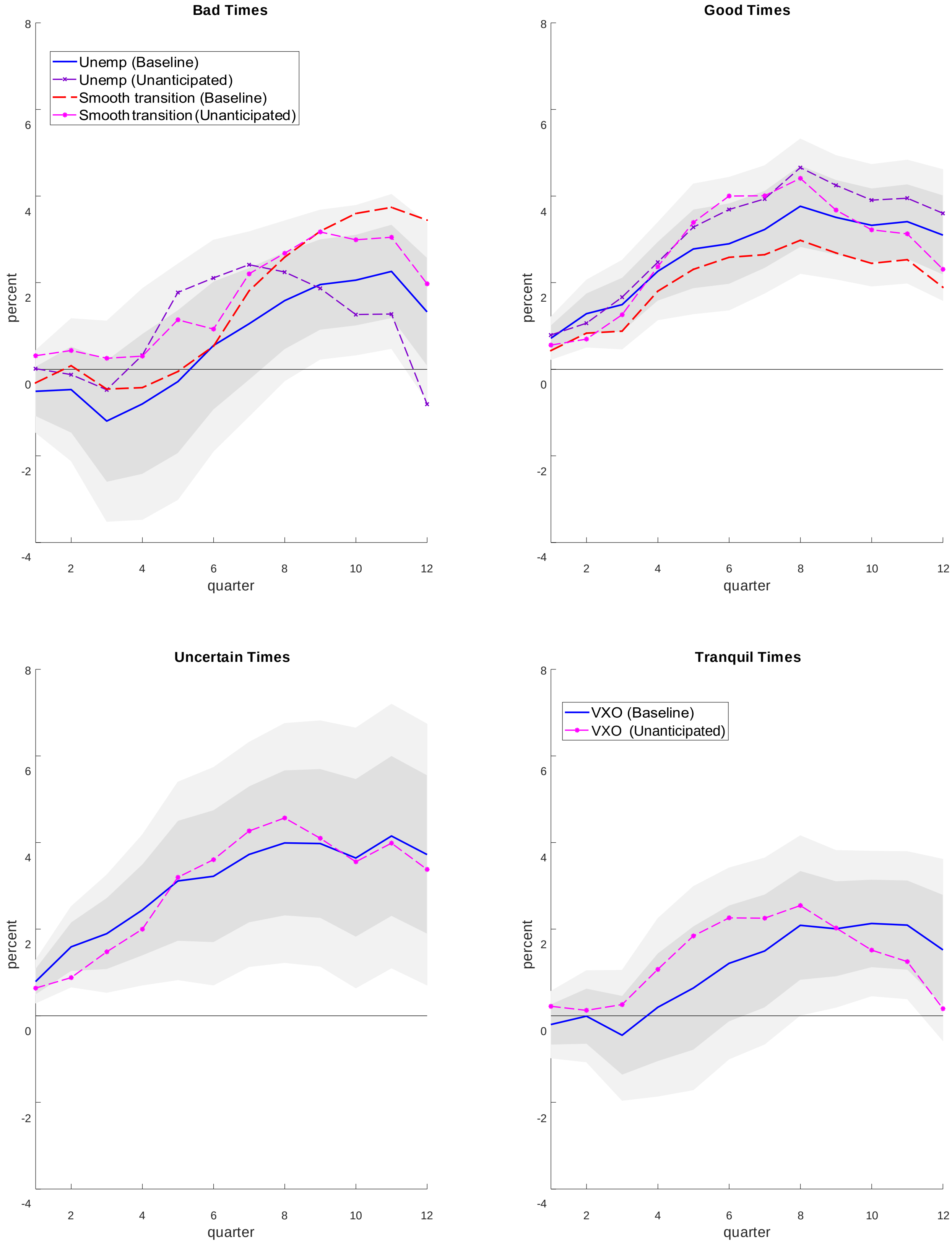
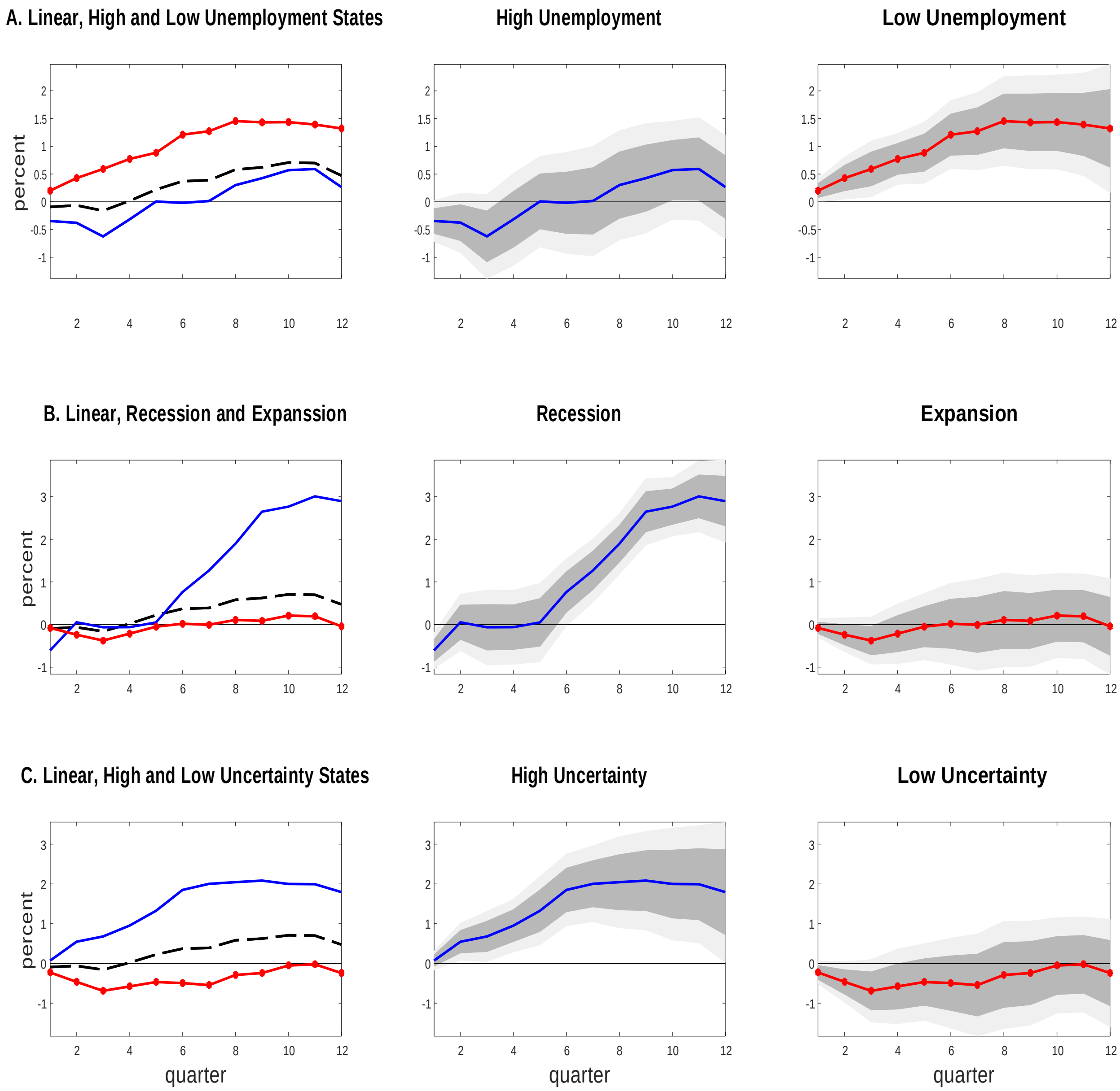
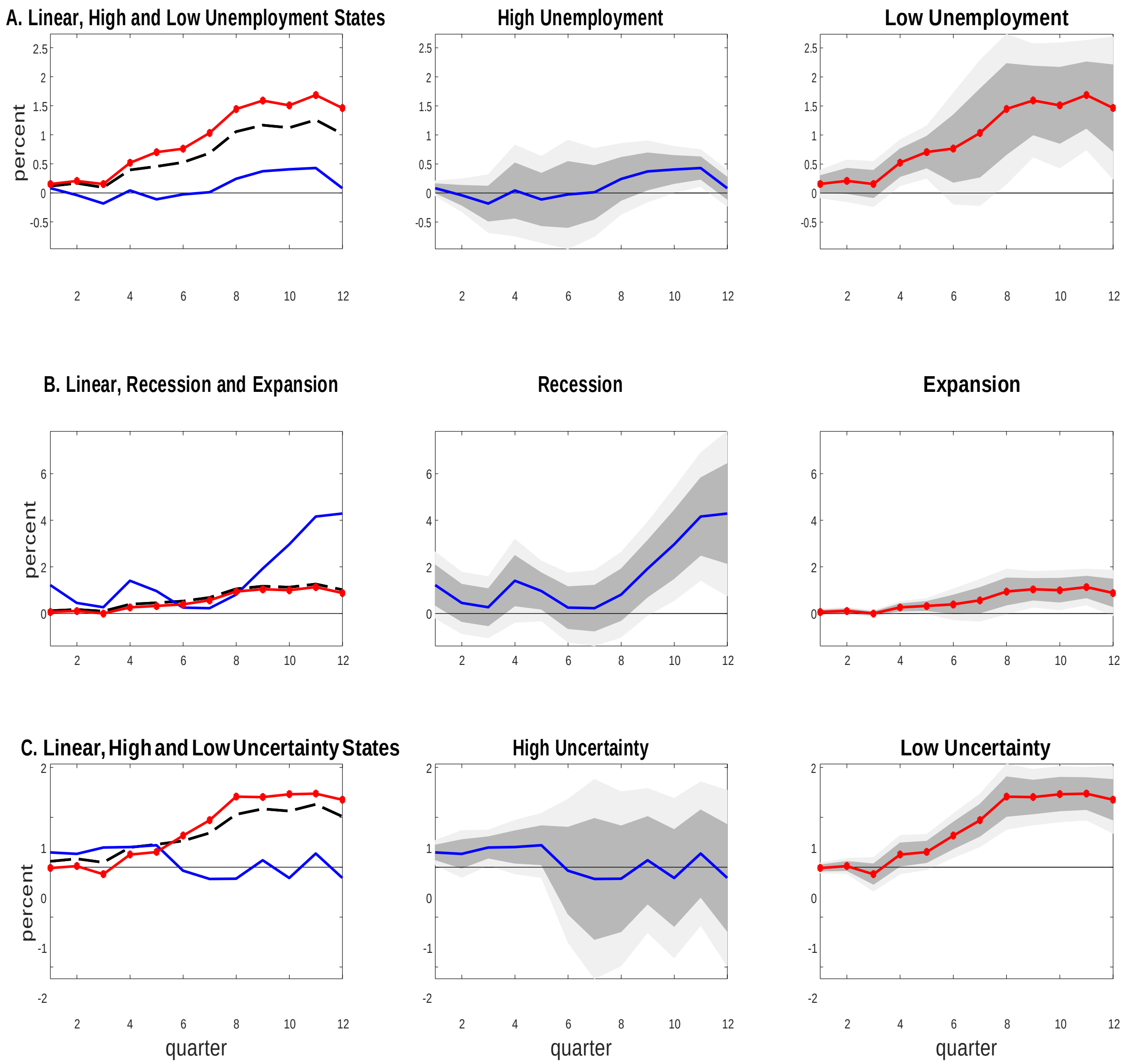


Figure 8: Response of GDP to a tax shock (robustness to Barro and Redlick (2011) marginal tax shock)



Note: Dashed black line indicates output response in the linear model. Solid blue lines show output responses in bad times (high unemployment states or recessionary regimes) and uncertain. Solid red lines with circle show output responses in good times (low unemployment states or expansionary regimes) and tranquil. Light and dark shaded areas represent 95% and 68% confidence intervals, respectively.

Figure 9: Response of GDP to a tax shock (robustness to Mertens and Montiel Olea (2018) marginal tax shock)



Note: Dashed black line indicates output response in the linear model. Solid blue lines show output responses in bad times (high unemployment states or recessionary regimes) and uncertain. Solid red lines with circle show output responses in good times (low unemployment states or expansionary regimes) and tranquil. Light and dark shaded areas represent 95% and 68% confidence intervals, respectively.

Figure 10: Response of the Components of GDP to a tax shock

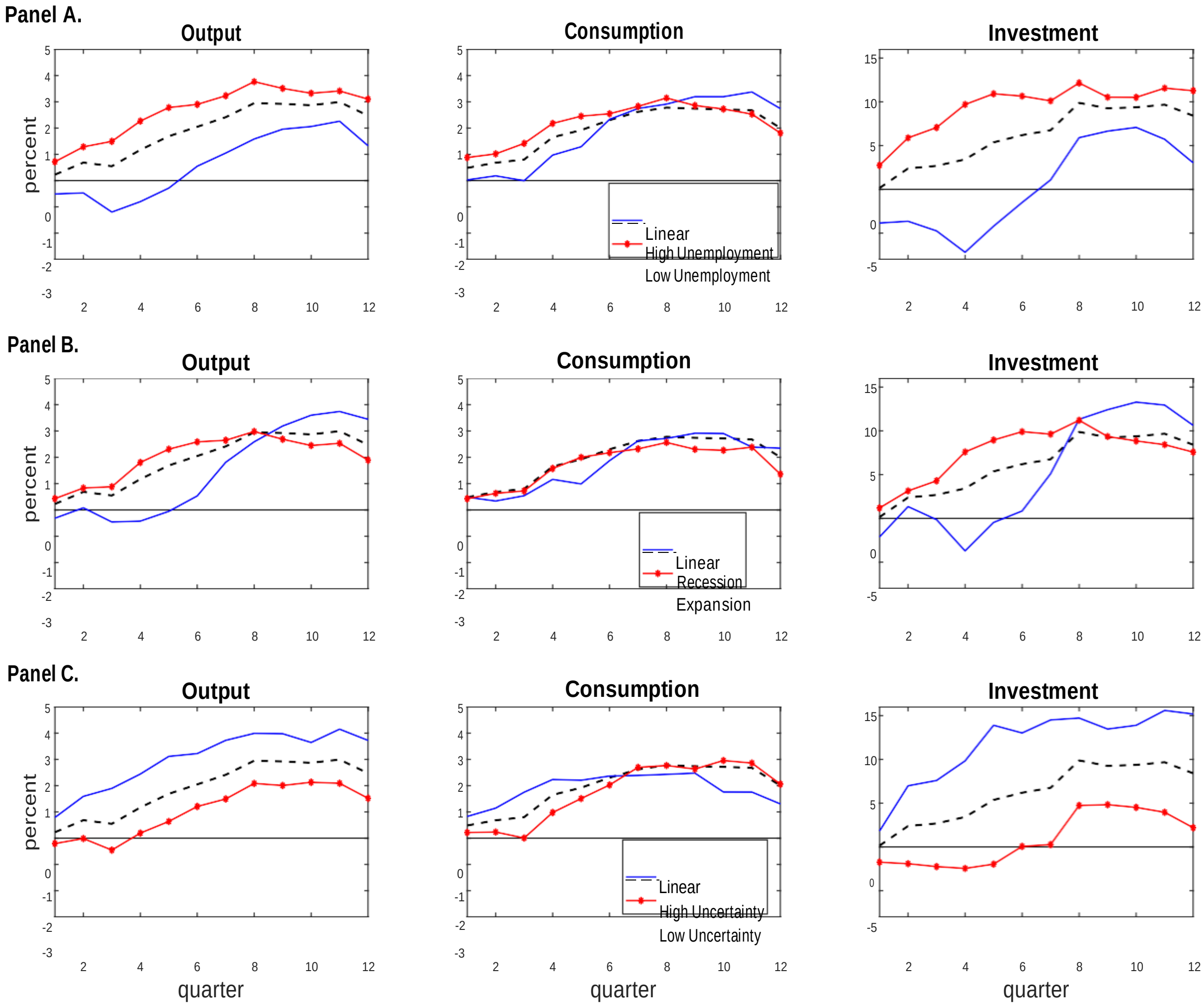


Figure 11: Response of the Components of investment to a tax shock

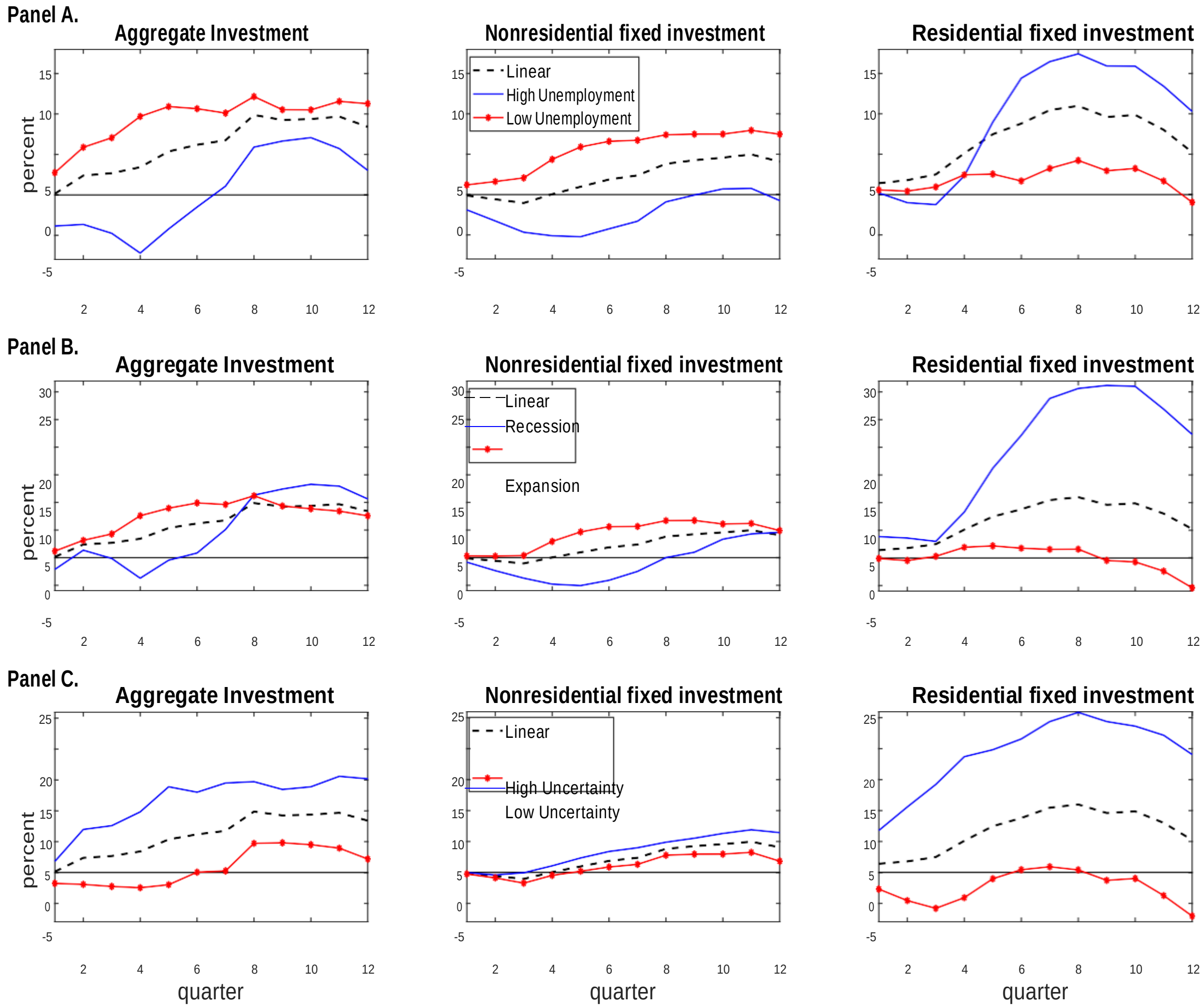


Figure 12: Estimates of the Cumulative Impact on Real GDP Growth of TCJA