

Working Paper Series
Congressional Budget Office
Washington, D.C.

Labor Market Effects of Tax Changes in Times of High and Low Unemployment

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Working Paper 2020-05

August 2020

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I have greatly benefited from comments provided by Wendy Edelberg, formerly of CBO, and Valerie A. Ramey of the University of California, San Diego, and the National Bureau of Economic Research. I would also like to thank John Kitchen, Jeffrey Kling, and Jeffrey Werling of CBO for helpful comments, and Loretta Lettner for editing. In addition, for other valuable comments and suggestions, I would like to thank the session participants at the 2018 meetings of the National Tax Association, the Society for Computational Economics, the Southern Economic Association, and the 2019 Biennial Conference of the Georgetown Center for Economic Research.

Abstract

This paper examines how the effects of legislated tax changes on labor market outcomes vary with the amount of slack in the economy, as measured by the rate of unemployment. I find that effects on hours worked, employment, and the unemployment rate become smaller in times of higher unemployment. I then develop a theoretical model in which changes in taxes on labor income directly affect the demand for labor by changing the costs that firms incur for employing workers. In the model, tax changes have smaller effects in times of higher unemployment because overall employee costs become less sensitive to after-tax wages when there is slack in the labor market. A calibrated version of the model is fairly successful in reproducing the estimated differences in the effects of tax changes across periods of high and low unemployment.

Keywords: tax policy, fiscal policy, state dependence, labor market frictions, nonlinear dynamics

JEL Classification: E2, E6, H2

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1 Introduction

The degree to which tax changes affect labor market outcomes has long been a central issue in macroeconomic policy analysis. Although many studies have examined the effects of tax changes on employment and output (see Ramey, 2019, for a recent survey) and how pretax incomes react to changes in tax rates (see, for example, Saez, Slemrod, and Giertz, 2012), little is known about how those effects might vary across different states of the economy—a phenomenon known as state dependence. Are tax cuts more effective in boosting employment in an expansion than in a recession? Do tax changes have asymmetric effects on hours worked over the business cycle? The answers have key implications for the timing and composition of fiscal stabilization policies and provide insights into the channels through which tax changes affect macroeconomic outcomes.

This paper explores the issue of state dependence by examining how the effects of legislated tax changes on labor market outcomes vary with the amount of slack in the economy, as measured by the rate of unemployment at the time of a tax change. I examine the effects of tax changes on hours worked, employment, and the unemployment rate and find evidence that effects differ considerably across periods of high and low unemployment. I then propose a structural model that can successfully reproduce the pattern of state dependence indicated by the evidence.

In the empirical section of the paper, I estimate the effects of legislated tax changes on labor market variables by drawing heavily on the narrative analysis of Romer and Romer (2010). Perusing the documentation accompanying the major pieces of tax legislation enacted in the post–World War II period, Romer and Romer separate the tax changes implemented in response to macroeconomic fluctuations or changes in government spending from those that are enacted for more exogenous reasons, such as policymakers’ beliefs about the effects of taxes on long-term economic growth. Using Romer and Romer’s narratively identified exogenous tax changes as an instrumental variable, I find that tax changes have less of an effect on hours worked, employment, and the unemployment rate in periods of high unemployment. That result remains largely unchanged under a series of checks for robustness involving additional control variables and alternative specifications of the empirical model.

In the theoretical section of the paper, I construct a model with labor search and matching frictions in which changes in income tax rates directly alter firms’ demand for labor by affecting the cost of employing workers. In the model, workers decide whether to put forth or withhold effort in each period, and firms engage in costly monitoring activities to elicit effort from their employees. In times of high unemployment, workers’ incentives to put forth effort become stronger and less sensitive to changes in after-tax wages because the value of an employment relationship is high relative to the immediate payoff to work (as measured by after-tax wages), and workers’ decisions about effort have first-order consequences for continued employment. As a result, in a state of high unemployment, tax changes matter less for workers’ decisions about effort and, consequently, have a smaller effect on employee costs and hiring than in a state of low unemployment.

In recent years, a number of studies have examined whether the macroeconomic effects of fiscal policy changes are state dependent. Most studies (including Jorda and Taylor, 2016; Fazzari, Morley, and Panovska, 2015; Auerbach and Gorodnichenko, 2013, 2012; Bachmann and Sims, 2012; and Mitnik and Semmler, 2012) have found evidence of larger effects in recessions than in expansions. (In contrast, Ramey and Zubairy, 2018, and Owyang, Ramey, and Zubairy, 2013, find no evidence of state-dependent effects.) Those studies, however, focus on the effects of government purchases on output. The empirical literature examining the state-dependent effects of tax changes on output is much smaller and reaches different conclusions than most studies examining

the effects of government purchases. Ziegenbein (2018), Demirel (2020, 2016), and Eskandari (2015) all find that tax changes have smaller effects on output in times of high unemployment.

This paper contributes to the empirical literature in various ways. First, I examine the state-dependent effects of tax changes on hours worked, employment, and the unemployment rate separately—rather than focusing on real gross domestic product (GDP) and its components. That approach offers a detailed view of labor market effects of tax changes along both the internal and external margin. Second, I carefully evaluate the validity of Romer and Romer’s narrative tax changes as an instrumental variable at different time horizons under various alternative specifications of the empirical model. Third, I assess whether the evidence for state dependence holds when only personal income taxes are considered and find evidence of larger effects in times of lower unemployment. That finding provides insights into the underlying causes of state dependence, which I take up subsequently in the theoretical part of the paper.

Although most empirical studies find evidence of different effects from fiscal policy changes in different states of the economy, there has been little theoretical research on the potential causes of state dependence. The limited theoretical literature on state-dependent effects of government purchases includes Canzoneri and others (2016) and Michaillat (2014). Both papers construct models that produce larger government spending multipliers in recessions. On the tax policy side, Sims and Wolff (2018) assess how the effects of tax shocks vary over the business cycle in a dynamic-stochastic general equilibrium model and find larger effects when output is relatively high. Ziegenbein (2018) shows that the effects of tax changes tend to become larger in times of lower unemployment because changes in overall job-search effort (caused by changes in after-tax wages) do not affect employment much when vacancies are low relative to the number of people searching for jobs.

This paper contributes to the theoretical literature by investigating the role of labor market slack in driving state-dependent responses to tax changes. In the proposed model, such slack stems from labor search and matching frictions as in Ziegenbein’s framework. The distinguishing feature of the model is that it incorporates on-the-job decisions by workers about effort and monitoring decisions on the part of firms. Those elements play a key role in driving empirically plausible state-dependent responses to tax changes because workers’ and firms’ responses to taxes—as they relate to decisions about effort and employee costs, respectively—vary across high- and low-unemployment states. I conduct quantitative analysis by calibrating the model to U.S. data. The calibrated version of the model is successful in reproducing the estimated differences between the effects of tax changes in times of high and low unemployment.

The remainder of the paper is organized as follows: Section 2 discusses the empirical method and the identification approach adopted to estimate the effects of tax changes in high- and low-unemployment states. Section 3 lays out the theoretical model and describes the calibration and solution strategies. Section 4 presents a series of simulations from the calibrated model, discusses the key elements that give rise to smaller effects in times of slack, and compares the simulated effects of tax changes with those estimated in the empirical part. Section 5 provides concluding remarks.

2 Empirical Analysis

Estimating the effects of tax changes on macroeconomic variables presents a series of methodological challenges. One important difficulty stems from the fact that changes in tax policy often aim to stabilize macroeconomic fluctuations or are primarily driven by changes in spending. That simultaneity invalidates any strictly causal

interpretation of the correlation between tax changes and subsequent economic activity. In addition, tax revenues are correlated with a host of economic processes, many of which are not directly related to policy actions—for example, revenues rise and fall automatically as the tax base fluctuates over the business cycle or as the distribution of taxpayers across different income brackets changes.

In the empirical analysis, I address those challenges by drawing heavily on Romer and Romer’s (2010) narrative account of tax policy changes in the United States. Combining information from various sources, Romer and Romer examine the major tax bills enacted in the post–World War II period and determine their effects on tax liabilities as well as the motivation underlying each piece of legislation.¹ In particular, they identify the tax changes that are motivated by policymakers’ views on the determinants of long-term economic growth or by inherited budget deficits (as opposed to deficits incurred during a policymaker’s term). Those tax changes are considered exogenous because there is no evidence in the historical record suggesting that they were enacted in response to macroeconomic developments or changes in government spending. Moreover, because the identified changes arise entirely from independent policy actions, they are effectively separated from movements in revenues that are not driven by policy changes. The estimates presented in this analysis are based on Romer and Romer’s narrative measure; therefore, they do not reflect the effects of tax changes that are implemented in response to economic fluctuations or that occur automatically over the business cycle.

Figure 1 shows cyclically adjusted revenues and the tax changes that Romer and Romer’s narrative account classifies as exogenous.² The two series are positively correlated over the sample period. But, the distribution of exogenous tax events is uneven across periods of high and low unemployment—defined as quarters in which the average rate of unemployment is higher and lower than 6.5 percent, respectively—with more changes occurring in periods of lower unemployment. Nonetheless, the number of observations in high- and low-unemployment periods are sufficiently large to enable meaningful comparison.

2.1 The Method

Using Romer and Romer’s (2010) narrative tax changes, the labor market effects of tax changes over a specified horizon can be examined by estimating a series of equations of the form:

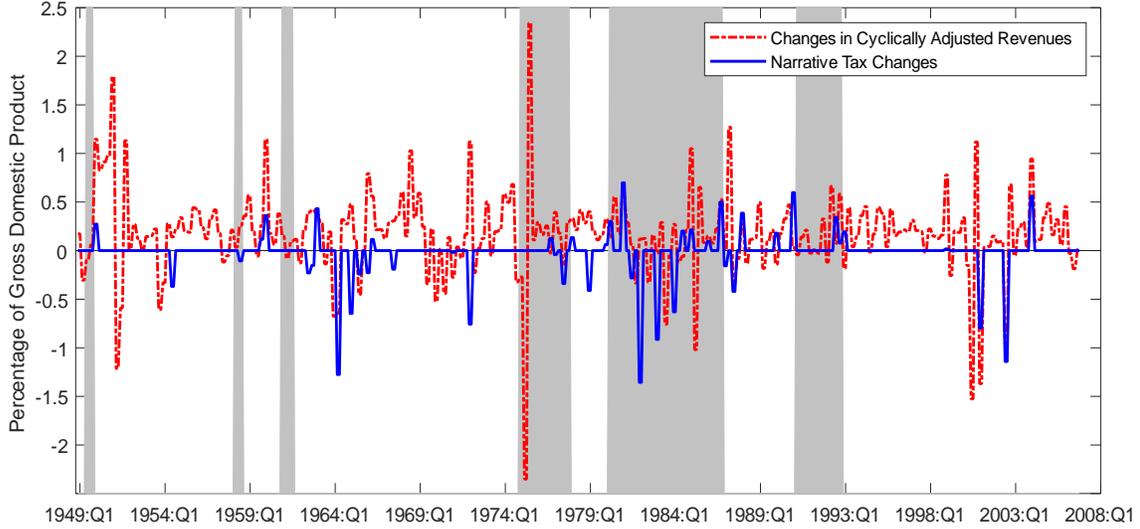
$$y_{t+k} = \mu_k + [1 - h(d_{t-1})] \left[\phi_{H,k} z_t + \sum_{i=1}^q A_{H,i} X_{t-i} \right] + h(d_{t-1}) \left[\phi_{L,k} z_t + \sum_{i=1}^q A_{L,i} X_{t-i} \right] + \varepsilon_{t+k}. \quad (1)$$

The dependent variable y_{t+k} represents a labor market outcome—hours worked, employment, and the unemployment rate—in quarter $t+k$. The variable z_t is Romer and Romer’s narrative measure of exogenous changes in tax liabilities in quarter t (expressed as a percentage of GDP), X_t is a vector of control variables (which may include past values of the dependent variable), and μ_k is a vector of constants. The variable ε_{t+k} denotes a potentially heteroskedastic and autocorrelated error term (that is, its variance can depend on the control variables and it can

¹ For a detailed description of those tax bills, see Christina D. Romer and David H. Romer, *A Narrative Analysis of Postwar Tax Changes* (University of California, Berkeley, June 2009), <http://eml.berkeley.edu/~dromer/papers/nadraft609.pdf> (529 KB).

² The Congressional Budget Office constructs the series for cyclically adjusted revenues by removing the effects of business-cycle fluctuations so that the adjusted series do not incorporate automatic movements generated during ups and downs in the business cycle.

Figure 1. Narratively Identified Exogenous Tax Changes and Cyclically Adjusted Revenues



Sources: Congressional Budget Office; Romer and Romer (2010).
 Shaded areas indicate periods in which the unemployment rate is above 6.5 percent.

be correlated with its past values).

Variable d_t denotes the rate of unemployment in quarter t . The function $h(d_{t-1})$ —hereafter referred to as the transition function—introduces state dependence to the otherwise linear specification in (1) by allowing the responses of y_t to tax changes to differ across periods of high and low unemployment. In the benchmark case, it is specified as

$$h(d_{t-1}) = \begin{cases} 1 & \text{if } d_{t-1} < \bar{d} \\ 0 & \text{if otherwise.} \end{cases} \quad (2)$$

Following Ramey and Zubairy (2018), I set the threshold unemployment rate \bar{d} to 6.5 percent. Therefore, the coefficients $\phi_{H,k}$ and $\phi_{L,k}$ give the effects of a tax change on the dependent variable when the rate of unemployment is, respectively, above and below 6.5 percent at the time of the tax change. Given estimates for those coefficients, the change in the dependent variable in quarter $t + k$ in response to a dollar change in tax liabilities occurring in quarter t can be found as

$$\phi(d)_k = [1 - h(d)]\phi_{H,k} + h(d)\phi_{L,k}. \quad (3)$$

Using (3), the responses of the dependent variable over a horizon T can be characterized as a sequence of $\phi(d)_k$'s (for $k = 1, 2, \dots, T$) each derived from a separate regression of the form (1).

However, a key policy question is how much labor market variables respond to a given change in tax revenues. The estimated impulse response functions—characterized by the sequence of $\phi(d)_k$'s—do not directly address that question because they show the responses to a shock to tax liabilities. One alternative is to estimate a second set of equations of the form (1) with revenues introduced as the dependent variable and Romer and Romer's

narrative changes as exogenous shocks to revenues. The effect per dollar of revenues then can be calculated as the change in the labor market variable over a period divided by the change in cumulative revenues over that period. That approach works reasonably well if narrative tax changes are indeed precise measurements of exogenous revenue shocks. But potential measurement error in the narrative account suggests reason for caution in treating narrative tax changes as direct observations of exogenous shocks to revenues.

A more straightforward approach is to directly estimate the effects from an exogenous change in revenues by estimating

$$y_{t+k}^k = \alpha_k + [1 - h(d_{t-1})] \left[\eta_{H,k} \tau_t^k + \sum_{i=1}^q T_{H,i} X_{t-1} \right] + h(d_{t-1}) \left[\eta_{L,k} \tau_t^k + \sum_{i=1}^q T_{H,i} X_{t-i} \right] + \xi_{t+k}, \quad (4)$$

where the endogenous regressor τ_t^k denotes the cumulative revenues over $k + 1$ quarters expressed as a share of GDP. That is,

$$\tau_t^k = \frac{\sum_{i=0}^k \tau_{t+i}}{\text{GDP}_t}, \quad (5)$$

where τ_t denotes the revenues in period t . I estimate the coefficients $\eta_{H,k}$ and $\eta_{L,k}$ in (4) by using the narrative tax changes as an instrumental variable. Specifically, I use $[1 - h(d_{t-1})]z_{t-i}$ and $h(d_{t-1})z_{t-i}$ to instrument for $[1 - h(d_{t-1})]\tau_t^k$ and $h(d_{t-1})\tau_t^k$, respectively. That approach yields more robust estimates in the presence of measurement error in narrative tax changes or in revenues than the approach based on estimated impulse responses to narrative tax changes. Moreover, defining the endogenous regressor as the total cumulative revenues over a given number of quarters (as opposed to revenues in a given quarter) helps account for the fact that the effects of narrative tax changes on actual revenues show up gradually over time (because new policies are often implemented slowly and take effect over a period of many years), thus rendering the results less sensitive to the exact timing of the relationship between the narrative series and revenues.

Because hours worked, employment, and the unemployment rate are expressed in different units, I define y_{t+k}^k differently for the three dependent variables to address the most relevant policy question in each case. In the case of hours, I define y_{t+k}^k as the total hours worked between periods t and $t + k$ expressed as a ratio of hours worked in period t —that is, $y_{t+k}^k = \sum_{i=0}^k y_{t+i} / y_t$. That specification leads to a direct estimate of the cumulative effect on hours over a fixed period ($k + 1$ quarters), therefore yielding an estimate of how many hours in total are gained or lost from a dollar change in revenues.³ In the case of employment, the variable in question is the number of employed individuals, so I define y_{t+k}^k as the average number of employees between t and $t + k$ expressed as a ratio of the number of employees in period t —that is, $y_{t+k}^k = \left(\frac{1}{k+1} \sum_{i=0}^k y_{t+i} \right) / y_t$. That specification leads to a direct estimate of the change in the number of employees in response to a dollar change in revenues, thereby allowing the effect on total hours to be broken into adjustments in internal and external margins. In the case of unemployment, the dependent variable is a rate. Thus, I define y_{t+k}^k as the average unemployment rate between periods t and $t + k$ —that is, $y_{t+k}^k = \frac{1}{k+1} \sum_{i=0}^k y_{t+i}$.

³ If the dependent variable is GDP (thus defined in the same units as revenues), that specification yields a direct estimate of the tax multiplier, which is defined as the total cumulative dollar change in real GDP resulting from a dollar change in revenues.

With the dependent variables and the endogenous regressor defined as described above, and given estimates for the coefficients $\eta_{H,k}$ and $\eta_{L,k}$ for each dependent variable, the percentage change in hours worked and average employment and the percentage-point change in the average unemployment rate in response to a change in revenues of 1 percent of GDP are found as

$$\eta(d)_k = [1 - h(d)]\eta_{H,k} + h(d)\eta_{L,k}. \quad (6)$$

2.2 Instrument Strength

Romer and Romer’s (2010) detailed historical account of legislated tax changes and careful analyses by other researchers (including Mertens and Ravn, 2013, and Perotti, 2012) provide ample evidence of the exogeneity of the narratively identified tax changes. To determine whether those changes also meet the relevance criterion for instrument validity, I next examine the strength of narrative tax changes as an instrumental variable.

I compute the Newey and West (1987) robust F -statistics for the first-stage regressions of the endogenous revenue variables $[1 - h(d_{t-1})]\tau_t^k$ and $h(d_{t-1})\tau_t^k$ on the instruments $[1 - h(d_{t-1})]z_t$ and $h(d_{t-1})z_t$, and the other control variables for different values of k . A commonly adopted rule of thumb is to reject the null hypothesis of weak instruments if the F -statistic exceeds a threshold value of 10 (Staiger and Stock, 1997). However, Olea and Pflueger (2013) show that the threshold can vary considerably if errors display serial correlation. They propose an alternative criterion, called the effective F -statistic, that is more robust to heteroskedasticity and serial correlation. To have a more complete assessment, I also compute Olea and Pflueger’s effective F -statistics and thresholds for the benchmark case.⁴

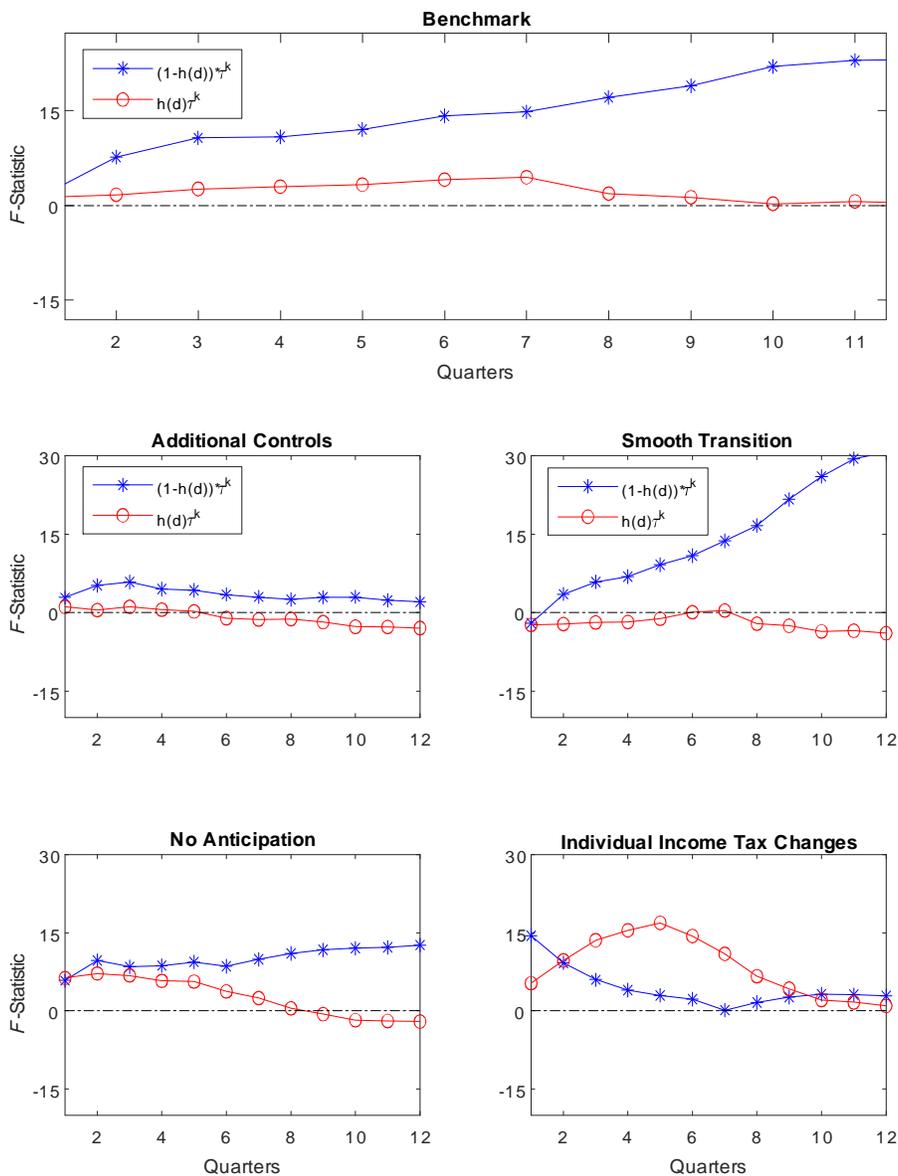
Figure 2 shows the differences between the F -statistics and the corresponding critical values for different horizons (for $k = 0, 1, \dots$) and under alternative specifications of the empirical model (discussed in the next section). A negative value means that the computed F -statistic is below the threshold and, therefore, indicates a potential problem with instrument strength for that particular horizon. As Figure 2 attests, in the benchmark case and under all but one of the alternative specifications, robust F -statistics exceed the threshold value for horizons shorter than eight quarters. In addition, Olea and Pflueger’s effective F -statistics (computed using the simplified conservative version of their procedure) also exceed the relevant threshold for $3 < k < 8$ under the benchmark specification. For longer horizons, the differences between the F -statistics and the threshold values are negative for $h(d_{t-1})z_t$ —that is, the instrument for the endogenous regressor $h(d_{t-1})\tau_t^k$ —in the majority of cases. Those results indicate a potential problem with instrument relevance for periods longer than two years. Consequently, in the following analysis, I estimate the responses of labor market variables over a 1-year horizon (for $k = 4$) and a 2-year horizon ($k = 8$).

3 Estimation and Results

The next step is to quantify the effects of tax changes on three major labor market variables—hours worked, employment, and the unemployment rate. All three variables are from the Current Population Survey conducted

⁴ Computation of robust and effective F -statistics requires an estimate of the asymptotic covariance matrix of the reduced form coefficients. Because the error term in (4) can be heteroskedastic and display serial correlation, I use a nonparametric HAC estimate for that matrix. I set the bandwidth of that nonparametric estimator by using the data-dependent automatic selection criterion proposed in Newey and West (1994).

Figure 2. Instrument Strength



Source: Author's estimates.

The lines show the differences between the robust F -statistics and the threshold value of 10. The robust F -statistics are from the first-stage regression of the endogenous regressors $[1 - h(d_{t-1})]\tau_t^k$ and $h(d_{t-1})\tau_t^k$ on the instruments $[1 - h(d_{t-1})]z_t$ and $h(d_{t-1})z_t$ and other control variables for horizons $k = 1, 2, \dots, 12$. Negative values indicate a potential problem with instrument relevance for the corresponding value of k .

by the Bureau of Labor Statistics, and the sample period runs from the first quarter of 1950 to the fourth quarter of 2006.⁵ I first evaluate a benchmark case including a core set of control variables and then consider other specifications involving additional controls and alternative forms for the transition function $h(d)$.

In all cases, I estimate the percentage change in hours and employment, and the percentage-point change in the unemployment rate in response to a tax change that raises revenues by 1 percent of GDP. I evaluate the effects over a 1-year and a 2-year horizon by computing (6) for $k = 4$ and 8. Then, I assess the differences between the effects of tax changes across different states by examining how results vary when the rate of unemployment at the time of the tax change is above and below the threshold level of 6.5 percent.

3.1 Benchmark Specification

In the benchmark case, the vector of control variables, X , includes six lags of the growth rate of total hours, the unemployment rate, and the narratively identified tax changes, which control for a multitude of factors that drive labor market dynamics. Table 1 shows the estimated effects under the benchmark specification: The effects on all three variables are found to be larger in the lower-unemployment state. Over a 1-year horizon, an increase in taxes of 1 percent of GDP is estimated to reduce hours by 0.79 percent in the lower-unemployment state and by 0.38 percent in the higher-unemployment state, suggesting a roughly 50 percent difference in the size of the estimated effect between the two states. The estimated effects on employment and the unemployment rate are also about 50 percent larger in the lower-unemployment state. Over a 2-year horizon, the effects likewise become larger in the lower-unemployment state, albeit by smaller percentages than they do when they are estimated over a 1-year horizon.

To examine whether the differences across high- and low-unemployment states are statistically significant, I compute p -values for the null hypothesis $\eta_{H,k} = \eta_{L,k}$. As (6) suggests, rejection of that null would indicate different responses in the two states. Table 1 shows that the differences across high- and low-unemployment states are statistically significant over a 1-year horizon: The null $\eta_{H,k} = \eta_{L,k}$ is rejected at the 5 percent level of significance for all three variables. Over the 2-year horizon, the effects are again uniformly larger in the low-unemployment state, but the null $\eta_{H,k} = \eta_{L,k}$ cannot be rejected at the 10 percent level. Taken together, those results indicate strong evidence of different effects from tax changes in low- and high-unemployment states over at least a 1-year horizon.

3.2 Sensitivity of the Benchmark Results

In this section, I assess the robustness of the benchmark results by considering a series of alternative specifications. First, I include additional variables in the control vector X . Second, I consider an alternative form for the transition function $h(d)$. Third, I assess whether anticipation effects play an important role in driving the key results by excluding from the sample the tax changes that are legislated more than 90 days in advance of their implementation dates. Finally, I separate out personal income tax changes in Romer and Romer's (2010) narrative measure to assess whether the evidence of state dependence holds for a more disaggregated measure of tax

⁵ Hours represent the total number of hours worked in the nonfarm business sector. Employment is defined as the number of employed civilians 16 years of age and older. The unemployment rate is the number of unemployed as a percentage of the labor force calculated as employment divided by the number of people in the civilian labor force. (Source: Office of Productivity and Technology, U.S. Bureau of Labor Statistics, December 6, 2018.) Data are downloaded from the personal web page of Valerie A. Ramey (<https://econweb.ucsd.edu/~vramey/research.html#data>).

Table 1. Benchmark Specification

	Low UR	High UR	<i>p</i> -Value
1-Year Horizon			
Hours	-0.79	-0.38	0.04
Employment	-0.56	-0.22	0.01
Unemployment Rate	0.39	0.21	0.01
2-Year Horizon			
Hours	-1.91	-1.46	0.28
Employment	-0.77	-0.51	0.11
Unemployment Rate	0.43	0.32	0.30

Source: Author's estimates.

This table shows the estimated percentage changes in hours worked and employment and percentage-point changes in the unemployment rate (UR) in response to a reduction in revenues of 1 percent of gross domestic product. "Low UR" and "High UR" respectively indicate states in which the rate of unemployment is lower and higher than 6.5 percent.

changes. Although the quantitative results under those specifications exhibit some notable differences, the main findings are qualitatively similar to those that emerge under the benchmark case.

3.2.1 Additional Control Variables

I next extend the control vector by including real GDP, real government purchases, and the interest rate on 3-month U.S. Treasury bills.⁶ That specification is a natural extension of the benchmark case: Including the short-term interest rate helps control for the role of monetary policy (see Rossi and Zubairy, 2011); including real government purchases helps capture potential interactions between revenues and spending; and including real GDP (alongside hours worked and the unemployment rate) may help control for a broader range of factors that drive normal labor market dynamics.

Table 2 shows that the main findings are insensitive to including those variables in the vector of controls. The estimated effects of a tax change on all three variables are larger in the lower-unemployment state. Moreover, the reported *p*-values indicate that the differences between the effects in high- and low-unemployment states are statistically significant for all three variables over the 1-year horizon and for the unemployment rate over the 2-year horizon despite the fact that including multiple lags of additional controls significantly increases the number of estimated parameters.

3.2.2 A Smooth Transition Specification

The benchmark transition function (2) offers a simple and intuitive way of incorporating state dependence into an otherwise linear model. But, it also suggests that the state of the economy shifts very abruptly at a fixed threshold unemployment rate. A natural alternative is a specification in which the state-to-state transition of the economy is gradual as in the smooth transition autoregressive model developed in Granger and Terasvirta (1993).⁷ That

⁶ All of those variables are entered as percentage changes from the previous quarter. Real government purchases are defined as federal government consumption and gross investment chained in 2009 dollars. (Source: Bureau of Economic Analysis, National Income and Product Accounts.) The series for quarterly 3-month Treasury bill rates are calculated by averaging monthly series. (Source: Federal Reserve Bank of St. Louis, FRED database.)

⁷ See Demirel (2016) and Auerbach and Gorodnichenko (2012) for adaptations of that approach to vector autoregressive models.

Table 2. The Specification With Additional Control Variables

	Low UR	High UR	<i>p</i> -Value
1-Year Horizon			
Hours	-0.50	-0.10	0.06
Employment	-0.46	-0.20	0.06
Unemployment Rate	0.28	0.03	0.01
2-Year Horizon			
Hours	-1.43	-1.16	0.44
Employment	-0.66	-0.52	0.27
Unemployment Rate	0.32	0.21	0.05

Source: Author's estimates.

This table shows the estimated percentage changes in hours worked and employment and percentage-point changes in the unemployment rate (UR) in response to a reduction in revenues of 1 percent of gross domestic product. "Low UR" and "High UR" respectively indicate states in which the rate of unemployment is lower and higher than 6.5 percent.

structure can be incorporated into (4) through a transition function of the form

$$h(\hat{d}_t) = \frac{\exp\{-\varphi\hat{d}_t\}}{1 + \exp\{-\varphi\hat{d}_t\}}, \quad (7)$$

where $\varphi > 0$ and $\hat{d}_t = d_t - \bar{d}$ denotes the difference between the actual rate of unemployment and a benchmark unemployment rate, \bar{d} , of 6.5 percent. Thus, a large positive value for \hat{d}_t indicates a state of high cyclical unemployment.

The function $h(\hat{d}_t)$ has the properties $\lim_{\hat{d}_t \rightarrow \infty} h(\hat{d}_t) = 0$ and $\lim_{\hat{d}_t \rightarrow -\infty} h(\hat{d}_t) = 1$. Therefore, the coefficients $\eta_{H,k}$ and $\eta_{L,k}$ in (6) now describe the effects of a tax change in two limiting states with very high and very low unemployment, respectively. Moreover, the effect in any given state is characterized as a weighted average of the coefficients $\eta_{H,k}$ and $\eta_{L,k}$. Thus, unlike the benchmark specification (2) in which transition dynamics are governed by a step function, (7) allows the weights placed on $\eta_{H,k}$ and $\eta_{L,k}$ to vary smoothly with the state of the economy, thereby facilitating a gradual transition from one state to another.

The parameter φ in (7) controls how fast the weights on $\eta_{H,k}$ and $\eta_{L,k}$ change with \hat{d}_t . I set the value of that parameter so that the economy is in a state of high unemployment roughly 26 percent of the time, which matches the frequency of high-unemployment episodes in the United States during the postwar period.⁸

Table 3 shows the estimated effects when the unemployment rate is 5 percent and 8 percent. (Both values lie well within the range of historical experience.) The result that the effects from tax changes are smaller in the lower-unemployment state is insensitive to adopting the smooth transition form (7). That pattern remains statistically significant as most of the reported *p*-values indicate. The main findings are also insensitive to varying the value of φ within a fairly wide range (although those results are not reported here for brevity).

3.2.3 Controlling for Anticipation

A number of tax changes included in Romer and Romer's (2010) narrative analysis are implemented well after they are signed into law and, therefore, are anticipated prior to their implementation dates. As many researchers

⁸ Here, a high-unemployment episode is defined as a period in which d_t exceeds 6.5 percent.

Table 3. The Smooth Transition Specification

	Low UR	High UR	<i>p</i> -Value
1-Year Horizon			
Hours	-0.85	-0.33	0.02
Employment	-0.63	-0.18	0.01
Unemployment Rate	0.39	0.17	0.01
2-Year Horizon			
Hours	-1.90	-1.38	0.21
Employment	-0.80	-0.48	0.06
Unemployment Rate	0.41	0.30	0.23

Source: Author's estimates.

This table shows the estimated percentage changes in hours worked and employment and percentage-point changes in the unemployment rate (UR) in response to a reduction in revenues of 1 percent of gross domestic product. "Low UR" and "High UR" indicate states in which the rate of unemployment is 5 percent and 8 percent, respectively.

Table 4. Excluding Tax Changes That Are Legislated More Than 90 Days in Advance of Their Implementation Dates

	Low UR	High UR	<i>p</i> -Value
1-Year Horizon			
Hours	-0.68	-0.40	0.12
Employment	-0.39	-0.26	0.30
Unemployment Rate	0.27	0.17	0.06
2-Year Horizon			
Hours	-1.86	-1.37	0.16
Employment	-0.65	-0.48	0.22
Unemployment Rate	0.35	0.23	0.04

Source: Author's estimates.

This table shows the estimated percentage changes in hours worked and employment and percentage-point changes in the unemployment rate (UR) in response to a reduction in revenues of 1 percent of gross domestic product. "Low UR" and "High UR" respectively indicate states in which the rate of unemployment is lower and higher than 6.2 percent.

(including Leeper, Walker, and Yang, 2013; Mertens and Ravn, 2012; and Ramey, 2011) argue, the effects of anticipated tax changes can be quite different from those of unanticipated ones. To examine whether anticipation effects play an important role in driving the key results, I follow Mertens and Ravn (2013) in excluding from the sample the tax changes that are legislated more than 90 days in advance of their scheduled implementation dates, and retain only those with shorter implementation lags.

As Table 4 shows, the results are qualitatively similar to those of the benchmark case—that is, the estimated effects are larger in the lower-unemployment state. With roughly half of the tax changes dropped from the sample, however, the effects are less precisely estimated than in the benchmark case, and *p*-values for differences across states are generally larger. Nevertheless, the differences across states for the unemployment rate are statistically significant over both horizons.

Table 5. Including Individual Income Tax Changes Only

	Low UR	High UR	<i>p</i> -Value
1-Year Horizon			
Hours	-0.73	-0.24	0.06
Employment	-0.38	-0.26	0.48
Unemployment Rate	0.26	0.19	0.57
2-Year Horizon			
Hours	-1.62	-0.65	0.03
Employment	-0.55	-0.33	0.20
Unemployment Rate	0.30	0.16	0.19

Source: Author's estimates.

This table shows the estimated percentage changes in hours worked and employment and percentage-point changes in the unemployment rate (UR) in response to a reduction in revenues of 1 percent of gross domestic product. "Low UR" and "High UR" respectively indicate states in which the rate of unemployment is lower and higher than 6.2 percent.

3.2.4 Personal Income Tax Changes

Romer and Romer's (2010) narrative measure comprises a broad array of tax changes including those in personal, corporate, Social Security, and excise taxes. Because different types of taxes affect the economy in different ways, the pattern of state dependence may vary across different taxes. To assess whether the evidence for state dependence holds for a more disaggregated measure of tax changes, I next separate out personal tax changes in Romer and Romer's narrative measure by using Mertens and Ravn's (2013) narratively identified changes in personal income taxes. I also control for anticipation effects by considering only the personal income tax changes that were implemented no later than 90 days after they were legislated.

As Table 5 shows, the effects of personal income tax changes exhibit the same pattern of state dependence as those from the full sample of narrative tax changes, with larger effects on all three variables in the lower-unemployment state. Moreover, the differences across states are statistically significant for hours over both horizons. However, *p*-values for differences across states are generally larger because the sample of unanticipated personal income tax changes includes considerably fewer observations than the full sample of narrative tax changes.

3.3 A Comparison With Previous Research

Previous empirical research that investigates the effects of marginal rates on pretax incomes by examining tax-return data (surveyed in Saez, Slemrod, and Giertz, 2012) finds only small effects from tax changes on the supply of labor. In contrast, macroeconomic studies find large effects on employment and output from narratively identified tax changes. For example, Romer and Romer (2010) estimate that a reduction in tax liabilities of 1 percent of GDP can boost GDP by 3 percent over 12 quarters. In a more recent study, Demirel (2016) finds that, after 8 quarters, a cut in revenues of 1 percent of GDP can increase employment by about three-quarters of a percent in times of high unemployment and by as much as 1.7 percent in times of low unemployment.

This paper's estimates (as summarized in Table 1 for the benchmark case) are larger than those found in most studies that use tax-return data, but they are smaller than those suggested by previous narrative-based analyses,

including Demirel (2020, 2016). Those differences stem, in large part, from one important feature of this analysis: Specifically, I estimate the effects of tax changes in a single step (as in Ramey and Zubairy, 2018) using an instrumental variable approach instead of treating Romer and Romer’s narratively identified changes in tax liabilities as contemporaneous observations on exogenous shocks to revenues. That innovation not only results in a smaller central estimate for the effects on employment than those reported in Demirel (2016), but also yields a direct estimate for the standard errors of the effects in different states of the economy.

The results presented in this paper are also more in line with the general view of tax changes that often prevails among policy analysts than are the estimates of the previous narrative-based studies (which are often considered implausibly large). For example, the Congressional Budget Office estimates that a 1 percent change in total after-tax wages, all else being equal, changes the supply of labor by about 0.19 percent.⁹ Given that the share of wages and salaries in GDP averaged roughly 48 percent during the sample period (between 1950 and 2006), a linear extrapolation suggests that a change in wage income taxes of 1 percent of GDP would change labor supply by about $0.19 \div 0.48 \approx 0.4$ percent. Indeed, 0.4 percent roughly corresponds to the average of the estimated percentage responses of employment in high- and low-unemployment states to a change in taxes of 1 percent of GDP under the benchmark specification. However, if—in the absence of economic slack—elasticity of the labor supply more closely reflects the response of employment to changes in after-tax wages, it would be more informative to compare CBO’s central estimate of 0.4 percent with this paper’s benchmark estimate in the low-unemployment state, which is 0.56 percent. That estimate is well within the range CBO uses to characterize the uncertainty of the effects from tax changes, and the difference between the two estimates is most likely attributable to the fact that the benchmark estimate of 0.56 percent also captures the demand-side effects of tax changes in addition to the effects that arise from changes in the labor supply.

4 The Model

In this section, I construct a theoretical model that can reproduce the pattern of state dependence found in the empirical part of the analysis. The model extends the costly search-and-matching framework of Arseneau and Chugh (2012), Hall (2005), and Shimer (2005) by incorporating decisions by workers about on-the-job effort and monitoring decisions by firms, which play an important role in inducing state-dependent responses to tax changes.

In the model, workers decide whether to put forth or withhold effort at work in each period, and to elicit effort from workers, firms engage in costly monitoring activities. Although putting forth effort in any given period ensures continued employment in that period, withholding effort increases the probability of dismissal. Higher tax rates, all else being equal, make employees more likely to withhold effort by lowering the after-tax return to work, thereby increasing employers’ monitoring costs and weakening their hiring incentives. (Lower tax rates have the opposite effect on workers’ willingness to put forth effort and employers’ hiring incentives.) But, in periods of high unemployment, workers’ choices about effort become less sensitive to tax changes because after-tax wages matter less for workers’ decisions about whether to put forth or withhold effort when the value of an existing employment relationship is higher. That causes firms’ employee costs to become less sensitive

⁹ That figure is calculated as the sum of an estimated substitution elasticity of 0.24 and an estimated income elasticity of -0.05. For a detailed description of how CBO estimates the responsiveness of the labor supply to changes in the after-tax wage rate, see Congressional Budget Office, *How the Supply of Labor Responds to Changes in Fiscal Policy* (October 2012), www.cbo.gov/publication/43674.

to changes in after-tax wages. As a result, vacancies, employment, and the unemployment rate respond to tax changes by smaller amounts when unemployment is higher.

4.1 The Labor Market

The model economy is inhabited by a large number of individuals and identical firms, both of which are of measure one. At the beginning of each period, a fraction $s_t \in [0, 1]$ of individuals randomly apply for jobs, and firms recruit workers by posting a measure $v_t \in [0, 1]$ of new vacancies. The number of new employment relationships, m_t , that result from search and recruiting activities, s_t and v_t , is determined by a standard constant-returns matching technology given by

$$m_t = \bar{m} s_t^\psi v_t^{1-\psi}, \quad (8)$$

where $\bar{m} > 0$ measures the efficiency of the matching process and $\psi \in [0, 1]$ gives the elasticity of the matching function with respect to the measure of job seekers. Upon a successful match, a newly employed job seeker starts working immediately. Also, at the beginning of each period, a fraction ρ of existing employment relationships separate. Thus, aggregate employment, n_t , evolves according to the rule

$$n_t = (1 - \rho)n_{t-1} + m_t. \quad (9)$$

Given the matching technology (8), the probability that a searching individual finds a job is given by $p_t = m_t/s_t = \bar{m}(v_t/s_t)^{1-\psi}$, where the ratio v_t/s_t gives labor market tightness. Similarly, the probability that a vacancy is filled can be found as $q_t = \bar{m}(v_t/s_t)^{-\psi}$. Because there are a large number of individuals and firms, the probabilities p_t and q_t correspond to the actual job-finding and job-filling rates in period t , respectively.

4.2 Households

Each individual belongs to a large household that consists of a continuum of individuals (or members). In any given period, each member of a household belongs to one of the following three categories: 1) Employed, 2) unemployed, or 3) not in the labor force. An individual is employed if he or she is matched with a firm and earns wage income, unemployed if he or she is not matched with a firm but is actively searching for a match, and not in the labor force if he or she is solely engaged in production of home services. Because households are large, they are able to perfectly insure their members against idiosyncratic job risk.¹⁰ As a result, an individual's consumption level does not depend on his or her employment status.

At the beginning of each period, households choose search activity s_t , employment n_t^s , home services x_t , consumption c_t , and government bond holdings b_t to maximize the expectation of a discounted sum of utilities given by

$$E_0 \sum_{t=0}^{\infty} \beta^t \{U(c_t, x_t) - z_t n_t^s\}, \quad (10)$$

subject to

$$c_t + b_t = (1 - \tau_t)w_t n_t^s + \pi_t + tr_t + (1 + r_{t-1})b_{t-1}, \quad (11)$$

¹⁰ The simplifying assumption of large households and perfect risk sharing among the members of a household is common in the labor search and matching literature (see, for example, Andolfatto, 1996, and Merz, 1995) and is of no consequence for the purposes of this analysis.

where $\beta \in (0, 1)$ is a discount factor, the utility function $U(\cdot)$ is strictly increasing and concave in both arguments, and π_t and tr_t , respectively, stand for firms' profits and government transfers. The variable $z_t > 0$ denotes the disutility from an additional individual's work effort, w_t and r_t are the real wage and the net real interest rate, respectively, and τ_t is the marginal tax rate on wage income.

Home services are produced using a linear technology of the form

$$x_t = 1 - \xi_t, \quad (12)$$

where ξ_t stands for labor force participation and is defined as

$$\xi_t = (1 - \rho)n_{t-1}^s + s_t. \quad (13)$$

Individuals outside of the labor force are all engaged in the production of home services. Thus, the total benefit to the household from not employing an individual in market production includes a marginal increase in the production of home services as well as a marginal decrease in the total disutility from market work.

In each period, the job-finding rate, p_t , gives the fraction of searches that result in new employment relationships. Thus, households' employment evolves according to the rule

$$n_t^s = (1 - \rho)n_{t-1}^s + p_t s_t, \quad (14)$$

where $p_t s_t$ gives the measure of individuals who find jobs and start working in period t . Note that some of those individuals may come from outside of the labor force and some may have been separated from their jobs at the start of period t and successfully searched in the same period immediately after becoming unemployed.

4.2.1 Individuals' Decisions About Work Effort

Households' decisions regarding job searches and home services (or, equivalently, labor force participation) are made in the beginning of each period. After labor market matching takes place and individuals' employment status is determined, those individuals who are matched with firms decide whether to put forth or withhold the customary level of effort at work as in the efficiency wage model of Shapiro and Stiglitz (1984). If an individual puts forth the due work effort, the individual receives a wage, w_t , and the employment relationship continues into the next period (subject to the possibility that an exogenous event may cause separation, with probability ρ , at the beginning of the next period). If an individual chooses not to expend any effort (that is, in the event of shirking), the individual avoids the disutility of work, z_t , but also faces a higher probability of job separation. That is because, if a worker shirks and is monitored, an employer's optimal policy is to dismiss the worker.¹¹

Individuals' decisions about effort are based on a comparison of the expected utilities H_t^E and H_t^S that result from putting forth the routine work effort and shirking, respectively. Let δ_t denote employers' monitoring probability (which is taken as given by workers) and T_{t+1} represent the value to the household from starting

¹¹ Alexopoulos (2004) and Ramey and Watson (1997) use similar approaches to modeling workers' decisions about on-the-job effort. Unlike Alexopoulos, however, I build on a framework with search-and-matching frictions and explicitly model the continuation value of an existing employment relationship. The effect of tax changes on that value relative to that on the immediate payoff to work plays an important role in driving state dependence in the model. Ramey and Watson explore how incentives governing workers' effort and firms' specific investment decisions change in response to aggregate productivity shocks. I instead focus on the effects of tax shocks on workers' incentive to put forth effort over the business cycle.

period $t + 1$ with an additional employment relationship. Then, we have

$$H_t^E = (1 - \tau_t)w_t U_{c,t} - z_t + \beta E_t(T_{t+1}), \quad (15)$$

$$H_t^S = \delta_t \kappa (1 - \tau_t)w_t U_{c,t} + (1 - \delta_t) [(1 - \tau_t)w_t U_{c,t} + \beta E_t(T_{t+1})], \quad (16)$$

where $U_{c,t}$ denotes the marginal utility of consumption in period t .

Equation (15) defines the expected value of an individual's effort to the household as the difference between the utility gain from the after-tax wage income, $(1 - \tau_t)w_t U_{c,t}$, and the disutility z_t , plus the discounted continuation value, $\beta E_t(T_{t+1})$. Equation (16) describes the expected value from shirking: If an individual shirks and is monitored (which happens with probability δ_t), the individual avoids the disutility z_t , loses the continuation value T_{t+1} , but retains a fraction, $\kappa \in [0, 1]$, of that period's wage income.¹² If an individual shirks and is not monitored (which happens with probability $1 - \delta_t$), the individual avoids the disutility z_t and keeps both the continuation value and the full wage income for the period.

Because of perfect intrahousehold risk sharing, marginal utilities of consumption and home services are the same for all members of a household. Also, individuals' choices and employers' monitoring activity are perfectly observable and thus there is no scope for strategic interactions within households.

Because all employed individuals are identical, the following condition must be satisfied to ensure positive work effort in equilibrium:

$$H_t^E \geq H_t^S \quad (17)$$

As (15) and (16) suggest, that condition requires

$$\delta_t \geq d_t = \frac{z_t}{(1 - \kappa)(1 - \tau_t)w_t U_{c,t} + \beta E_t[T_{t+1}]} \quad (18)$$

The variable d_t represents the critical monitoring intensity that leaves an individual indifferent about putting forth work effort and shirking. Therefore, it gives the minimum amount of monitoring an employer must practice to maintain a functioning work environment. Naturally, that amount increases in the disutility of market work, z_t , but decreases in the expected continuation value of an employment relationship $E_t[T_{t+1}]$. It also decreases in $(1 - \kappa)(1 - \tau_t)w_t U_{c,t}$, which is the utility value of the after-tax wage that a worker loses in the event of shirking and dismissal. As a result, changes in the marginal tax rate have a direct effect on the minimum amount of monitoring an employer must practice. As will be discussed later in greater detail, that effect plays a key role in inducing the pattern identified in the empirical analysis.

4.2.2 Households' Problem

Having examined individuals' choices about effort, I now return to household decisions regarding search activity, employment, home services, and consumption. Households take as given the job-finding probability, the wage level, and the interest rate. Given that (18) holds, households' problem can be formulated recursively as follows:

$$V(n_{t-1}^s, b_{t-1}, S_t) = \max_{c_t, x_t, n_t^s, s_t, b_t} \{U(c_t, x_t) - z_t n_t^s + \beta E_t[V(n_t^s, b_t, S_{t+1})]\}$$

¹² Retained wage income can be interpreted as severance payments or partial wages for the fraction of the period the worker remains employed prior to dismissal.

subject to (11) – (14),

where $V(\cdot)$ denotes a value function and S_t is a vector containing the aggregate state variables. Defining $V_{n,t} = \partial V(\cdot)/\partial n_{t-1}^s$ and using the envelope condition $V_{n,t} = (1 - \rho)U_{x,t}(1 - p_t)/p_t$, the household's optimal work decision can be expressed as

$$z_t + \frac{U_{x,t}}{p_t} = (1 - \tau_t)w_t U_{c,t} + \beta(1 - \rho)E_t \left[U_{x,t+1} \frac{1 - p_{t+1}}{p_{t+1}} \right]. \quad (19)$$

The left-hand side of (19) is the disutility from an additional member's work effort plus the utility value of the home services lost because of the extra search activity needed to establish an additional employment relationship. (To form a new employment relationship, the household needs to increase search activity by $1/p_t$ units.) The right-hand side of (19) is the utility from the after-tax wage plus the discounted value of starting the next period with an additional match. Thus, the optimal work decision equalizes the marginal cost of employment (the left-hand side) to the marginal benefit (the right-hand side).

In an equilibrium with positive work effort—that is, when employers' monitoring intensity satisfies (18)—the value of starting period $t + 1$ with an additional employment relationship, $V_{n,t+1}$, corresponds to T_{t+1} . Thus, the envelope condition $V_{n,t} = (1 - \rho)U_{x,t}(1 - p_t)/p_t$ can be incorporated into (18) to have

$$d_t = \frac{z_t}{(1 - \kappa)(1 - \tau_t)w_t U_{c,t} + \beta(1 - \rho)E_t \left[U_{x,t+1} \frac{1 - p_{t+1}}{p_{t+1}} \right]}, \quad (20)$$

which describes a lower bound on employers' monitoring intensity. As discussed next, firms take that lower bound as given when deciding how many workers to hire and how intensely they should monitor their employees.

4.3 Firms

Firms enter period t with employment level n_{t-1}^d . Because attrition of existing employees occurs over time (at the rate of ρ), at the beginning of each period, firms post vacancies (v_t) to establish new matches. The job-filling rate, q_t , gives the fraction of vacancies that a firm is able to fill at the start of period t . Thus, firms' employment stock evolves according to the rule

$$n_t^d = (1 - \rho)n_{t-1}^d + q_t v_t. \quad (21)$$

Firms assign their employees to one of two tasks—production and supervision. Production employees use the constant-returns technology $y_t = a_t h_t$ to produce a homogenous consumption good (y_t), where a_t is a stochastic productivity parameter of the form

$$a_t = a_{T,t} a_{G,t}, \quad (22)$$

and the variables $a_{T,t}$ and $a_{G,t}$ represent the permanent and the transitory (mean-reverting) components of productivity, respectively. The variable h_t denotes the effective labor input from production employees. An employee contributes one unit of effective labor if he or she chooses not to shirk and contributes nothing otherwise. Supervisory employees monitor production workers' performance to deter shirking and maintain routine workflow. Supervisory services are needed because worker-specific measures of output are not available and thus firms

cannot directly monitor production workers' effort by observing output.¹³

To monitor the fraction δ_t of its production workers—that is, $\delta_t h_t$ workers—a firm needs $\mu \delta_t h_t$ supervisory employees, where the parameter $\mu > 0$ measures supervision efficiency. (Because firms hire a large number of workers, δ_t also corresponds to the production employees' perceived probability of being monitored.) Thus, the total number of employees a firm hires, n_t^d , is given by the sum of production and supervisory employees:

$$n_t^d = (1 + \mu \delta_t) h_t. \quad (23)$$

Firms take the job-filling probability q_t , the lower bound on monitoring intensity (20), and the wage rate w_t as given and maximize the expectation of the discounted sum of profits by choosing the total number of employees n_t^d , vacancies v_t , and the monitoring probability δ_t (which pins down the shares of supervisory and production employees in total employment). Incorporating (23) into $y_t = a_t h_t$, firms' problem can be formulated recursively as follows:

$$J(n_{t-1}^d, S_t) = \max_{n_t^d, v_t, \delta_t} \left\{ \frac{a_t n_t^d}{1 + \mu \delta_t} - w_t n_t^d - \theta_t v_t + E_t[\Theta_{t+1} J(n_t^d, S_{t+1})] \right\}$$

subject to (21) and $\delta_t \geq d_t$,

where $J(\cdot)$ denotes a value function, $\Theta_{t+1} = \beta \frac{U_{c,t+1}}{U_{c,t}}$ is a stochastic discount factor with which firms value future random profits, and θ_t is the cost of posting a vacancy. To ensure the existence of a balanced growth path, I assume that vacancy costs and labor productivity share the same stochastic trend, that is $\theta_t = \bar{\theta} a_{T,t}$ where $\bar{\theta} > 0$.

Define $J_{n,t} = \partial J(\cdot) / \partial n_{t-1}^d$ as the value of an additional employment relationship to the firm at the start of period t . Using the envelope condition $J_{n,t} = (1 - \rho) \theta_t / q_t$ and incorporating the definition for the stochastic discount factor, the first-order optimality condition for firms' employment decisions can be found as

$$w_t + \frac{\theta_t}{q_t} = \frac{a_t}{1 + \mu d_t} + \beta(1 - \rho) E_t \left[\frac{U_{c,t+1}}{U_{c,t}} \frac{\theta_{t+1}}{q_{t+1}} \right]. \quad (24)$$

Equation (24) states that firms expand recruiting effort until the cost of an additional worker (the real wage plus the recruiting cost) is equated to the contemporaneous marginal product of the worker, adjusted for monitoring costs, plus the discounted continuation value of an additional employment relationship (that is, the option value of starting period $t + 1$ with a preexisting match). In addition, the constraint $\delta_t \geq d_t$ holds with equality because there is no payoff to the firm from increasing its monitoring intensity beyond the minimum level required to deter shirking. Also, for future reference, note that taxes on wage income have a direct effect on firms' demand for labor because, as (18) suggests, changes in the marginal tax rate directly influence the lower bound d_t , thereby altering the amount of monitoring the firm must practice to elicit work effort from its employees.

4.4 Wage Determination

Because of matching frictions, established employment relationships are valuable to workers and firms. An existing match is associated with a positive surplus because the marginal product of labor is always greater than the nonmatch value that would otherwise be received by the household, and wages determine how that surplus is shared between the two parties. But, as discussed in Hall (2005), there is no single dominant theory of wage

¹³ For simplicity, I assume that firms are able to observe the effort of supervisory employees directly and, therefore, those employees do not require any additional supervision.

determination in the presence of matching frictions because there are many wage paths that result in privately efficient outcomes in the sense of delivering positive surpluses to both parties.

To see this more clearly, it will be useful to define the bargaining-relevant surplus of an employment relationship to the household and the firm. Immediately after labor market matching in period t , the value of an employed individual to the household is

$$\Omega_t^H = (1 - \tau_t)w_t - \frac{z_t}{U_{c,t}} + E_t \left[\Theta_{t+1} \frac{V_{n,t+1}}{U_{c,t+1}} \right], \quad (25)$$

which is the sum of the after-tax wage and the discounted continuation value of the match to the household minus the disutility from the individual's work effort, all of which are defined in terms of the consumption good. The household's surplus from an established employment relationship is given by (25) because, as in Arseneau and Chugh (2012), there is no continuation value to the household from a member who unsuccessfully searched for a job (the household reoptimizes labor force participation at the start of each period), and searching individuals do not contribute to the production of home services. A comparison of (25) with (19) reveals that $\Omega_t^H = U_{x,t}/U_{c,t}p_t$.

Similarly, the value of an additional employee to the firm is defined as

$$\Omega_t^F = \frac{a_t}{1 + \mu d_t} - w_t + E_t [\Theta_{t+1} J_{n,t+1}], \quad (26)$$

which is the sum of the marginal product of labor (adjusted for supervision costs) and the discounted continuation value of the match to the firm minus the real wage. Comparing (26) and (24), we find $\Omega_t^F = \theta_t/q_t$.

The reservation wage of the household, w_t^H , equates the household's surplus from employment to zero (that is, the nonmatch value to the household). Thus, using (25), it can be found as

$$w_t^H = \frac{(z_t/U_{c,t}) - E_t [\Theta_{t+1} V_{n,t+1}/U_{c,t+1}]}{1 - \tau_t}.$$

The reservation wage of the firm, w_t^F , is the expected current and future (discounted) profits from the match and, given (26), it is found as

$$w_t^F = \frac{a_t}{1 + \mu d_t} + E_t [\Theta_{t+1} J_{n,t+1}],$$

where d_t is defined as in (20).

Any sequence of wages $\{w_t\}_{t=0}^{\infty}$ satisfying $w_t^F \geq w_t \geq w_t^H$ for all t is privately efficient for the household and the firm because both receive a positive surplus from the match. One such sequence is given by the outcome of a Nash bargain in which the real wage is determined so that $\Omega_t^F = \epsilon \Omega_t^H$, where $\epsilon > 0$ measures the relative bargaining power of firms. As emphasized by Shimer (2005), however, under the generalized Nash bargaining solution, the standard search and matching setting implies implausibly large movements in wages (and thus small movements in unemployment and vacancies) in response to changes in productivity. One way to address this issue involves introducing some form of real wage rigidity, as many researchers have done, to generate smaller movements in wages. To that end, I follow Michailat (2014) and Blanchard and Gali (2010) in assuming that the real wage fluctuates around a long-term level in response to changes in productivity.

Specifically, I characterize the wage path as

$$w_t = \tilde{w}_t a_{G,t}^\lambda, \quad (27)$$

where \tilde{w}_t is a reference wage that would obtain along a nonstochastic balanced growth path in which the surplus from matching is shared according to the Nash bargaining solution and $a_{G,t}$ is the mean-reverting component of the productivity process (22).¹⁴ The parameter $\lambda \in [0, 1]$ represents an index of real wage rigidities because it measures how much the real wage adjusts when productivity deviates from its trend level. In the case of $\lambda = 0$, the real wage follows a trend that reflects the long-term outcome under Nash bargaining. When $\lambda > 0$, the real wage fluctuates around that long-term trend in response to transitory shocks to productivity. I also assume that wage equals w_t^H if, in any given period t , the schedule (27) results in a wage that is smaller than w_t^H and equals w_t^F if (27) results in a wage that is greater than w_t^F . As a result, the equilibrium wage always remains in the bargaining set $[w_t^H, w_t^F]$.

4.5 Equilibrium

In equilibrium, the household and the firm are representative, the measure of household members who successfully search for jobs equals the measure of vacancies filled by the firm, the condition (18) holds with equality, and $n_t^d = n_t^s = n_t$. The equilibrium consists of the exogenous processes $\{a_{T,t}, a_{G,t}, \tau_t\}_{t=0}^\infty$ and the endogenous sequences $\{c_t, n_t, d_t, w_t, r_t, b_t, v_t, s_t\}_{t=0}^\infty$ that satisfy the household's optimal participation and the firm's optimal hiring decisions described by (19) and (24), and the wage schedule (27). In equilibrium, the variables also satisfy a government budget constraint (equating the sum of tax revenues and additional borrowing to the sum of spending and interest payments),

$$\tau_t w_t n_t + b_t - b_{t-1} = t r_t + r_{t-1} b_{t-1}, \quad (28)$$

and the aggregate resource constraint

$$a_t n_t = c_t + \theta_t v_t. \quad (29)$$

4.6 Calibration

Table 6 lists the values assigned to the parameters of the model and the target statistics. The model period corresponds to one quarter. I calibrate the model so that, along the balanced growth path, the unemployment rate is 5.6 percent, the labor force participation rate is 63 percent, and production and nonsupervisory employees constitute 82 percent of total employment. Those figures are sample averages for the period used in the empirical part of the analysis. To match those targets, I set the recruiting cost parameter $\bar{\theta}$ to 0.086, the matching efficiency parameter \bar{m} to 0.807, and the monitoring technology parameter μ to 0.242.

I specify the permanent component of the productivity parameter (22) as a random walk with drift and the

¹⁴ More specifically, $\tilde{w}_t = \arg \max_{w_t} \Omega_{H,t}^\eta \Omega_{F,t}^{1-\eta}$, where $\eta \in (0, 1)$ is the Nash bargaining weight of the household, and $\Omega_{H,t}$ and $\Omega_{F,t}$ respectively denote the household's and the firm's surplus from a match along a nonstochastic balanced growth path—that is, in the absence of random shocks to the marginal tax rate τ_t and the permanent and transitory components of the productivity parameter a_t .

Table 6. Calibration of the Theoretical Model

	Value	Source	
<i>Balanced Growth Path Targets</i>			
Unemployment rate	5.6 Percent	BLS, sample average	
Labor force participation rate	63 Percent	BLS, sample average	
Labor market tightness	0.72	Pissarides (2009)	
Share of nonsupervisory employees in total employment	0.82	BLS, sample average	
<i>Parameters</i>			
β	Discount rate	0.99	4 percent real interest rate
σ	Substitution elasticity, home services	0.18	Arseneau and Chugh (2012)
α	Habit formation parameter	0.95	Matches participation volatility
ψ	Elasticity of matching function to searches	0.235	Hall (2005)
η	Households' Nash bargaining weight	0.50	Pissarides (2009)
κ	Share of wages retained in the event of dismissal	0.25	
\bar{z}	Work effort disutility parameter	1	Normalization
ρ	Job-separation rate	0.10	JOLTS
$\bar{\tau}$	Average labor income tax rate	0.20	BEA NIPAs, sample average
λ	Elasticity of real wage to productivity	0.50	Michaillat (2014)
g	Average productivity growth	0.0074	Estimated
ρ_G	Autoregressive parameter, productivity	0.782	Estimated
ρ_τ	Autoregressive parameter, tax rate	0.780	Estimated
$\sigma_{\varepsilon,a}$	Standard deviation, growth rate shock	0.0015	Estimated
$\sigma_{\varepsilon,\gamma}$	Standard deviation, transitory productivity shock	0.0072	Estimated
$\sigma_{\varepsilon,\tau}$	Standard deviation, tax shock	0.0240	Estimated
U_x	Marginal utility of home services	0.266	Matches targets
$\bar{\theta}$	Recruiting cost parameter	0.086	Matches targets
μ	Monitoring technology parameter	0.242	Matches targets
\bar{m}	Matching efficiency parameter	0.807	Matches targets

BEA = Bureau of Economic Analysis; BLS = Bureau of Labor Statistics; JOLTS = Job Openings and Labor Turnover Survey; NIPAs = national income and product accounts.

transitory component as a stationary autoregressive process. That is,

$$\log(a_{T,t}/a_{T,t-1}) = g + \varepsilon_{T,t}, \quad (30)$$

$$\log a_{G,t} = \rho_G \log a_{G,t-1} + \varepsilon_{G,t}, \quad (31)$$

where $g > 0$ is the trend growth rate of the economy, $\rho_G \in [0, 1)$ and the shocks $\varepsilon_{T,t}$ and $\varepsilon_{G,t}$ are distributed $N(0, \sigma_{\varepsilon_T}^2)$ and $N(0, \sigma_{\varepsilon_G}^2)$. To calibrate the parameters of those processes, I first construct the model-consistent productivity series as $\log a_t = \log(y_t/n_t)$, where y_t is the real value added of the private sector and n_t denotes total private nonsupervisory employment.¹⁵ Then, I identify $\log a_{T,t}$ and $\log a_{G,t}$ by decomposing $\log a_t$ into trend and cycle components using a Hodrick-Prescott (HP) filter with a smoothing parameter 1600. Fitting an AR(1) process to the cycle series and averaging the growth rate of the trend series, I estimate $\rho_G = 0.782$ and $\sigma_{\varepsilon_G} = 0.0072$ for the transitory component, and $g = 0.0074$ and $\sigma_{\varepsilon_T} = 0.0015$ for the trend component.

I specify the tax rate on labor income also as an autoregressive process:

$$\log(\tau_t/\bar{\tau}) = \rho_\tau \log(\tau_{t-1}/\bar{\tau}) + \varepsilon_{\tau,t}, \quad (32)$$

where $\bar{\tau} > 0$ is the average tax rate, $\rho_\tau \in [0, 1)$ and $\varepsilon_{\tau,t}$ is distributed $N(0, \sigma_{\varepsilon_\tau}^2)$. I construct the series for the tax rate using the procedure described in Jones (2002).¹⁶ I find that the average labor income tax rate is roughly 20 percent in the sample period, and so I set $\bar{\tau} = 0.20$.¹⁷ Then, I identify the percentage deviation of the tax rate from its trend level by applying the HP filter to the constructed series. Fitting an AR(1) process to the filtered series, I estimate $\rho_\tau = 0.78$ and $\sigma_{\varepsilon_\tau} = 0.024$.

For the utility function, I use the form

$$U(c_t, x_t) = \log c_t + \phi_t \frac{(x_t - \alpha \tilde{x}_{t-1})^{1-1/\sigma}}{1 - 1/\sigma},$$

which allows for external habit formation in labor force participation. The term \tilde{x}_{t-1} represents the habit stock (defined in terms of aggregate home services). The parameter $\alpha \in [0, 1)$ measures the degree of habit formation and σ determines the elasticity of home services with respect to the real wage. Following Arseneau and Chugh (2012), I set $\sigma = 0.18$. I set the degree of habit formation to match the volatility of labor force participation in the United States since the early 1960s. Also, to make sure that a balanced growth path exists, I specify the preference shifter ϕ_t and the work effort disutility parameter z_t as $\phi_t = \bar{\phi} a_{T,t}$ and $z_t = \bar{z} a_{T,t}$. I normalize \bar{z} to unity and set $\bar{\phi}$ so that labor market tightness (that is, the ratio v/s) is 0.72, as in Pissarides (2009), along the model's balanced growth path. I also assume that workers retain 25 percent of their quarterly wages in the event of shirking and dismissal and thus set $\kappa = 0.25$.

The remaining parameter values are fairly standard in search and matching models. I set a quarterly job separation rate $\rho = 0.1$, which is consistent with the evidence in Davis, Faberman, and Haltiwanger (2006). The elasticity of the matching function with respect to searches is $\psi = 0.235$, as in Hall (2005). The subjective

¹⁵ The sample period runs from the first quarter of 1964 to the last quarter of 2015. (Source: Federal Reserve Bank of St. Louis, FRED database.)

¹⁶ That procedure uses data from the national income and product accounts of the Bureau of Economic Analysis. See Appendix B of Jones (2002) for a detailed description.

¹⁷ The sample period runs from the first quarter of 1947 to the first quarter of 2015.

discount $\beta = 0.99$ implies a real interest rate of roughly 4 percent in the balanced growth path. Following Michailat (2014), I set the elasticity of real wages with respect to productivity, λ , to 0.5.¹⁸

4.7 Numerical Solution

The dynamic general equilibrium model laid out thus far does not allow for an exact analytical solution, and so I compute an approximate solution using a numerical approach. However, the common practice of computing a linear approximation to the exact solution is not useful for assessing how the effects of tax changes vary across high- and low-unemployment states—that is, examining state dependence requires a nonlinear approach.

I capture the nonlinearity of the model using the parameterized expectations method discussed in Den Haan and Marcet (1990).¹⁹ That method approximates the conditional expectation operator $E_t(\cdot)$ —which appears in the households’ and the firms’ first-order conditions (19) and (24) and in the lower bound for employers’ monitoring intensity (20)—using a flexible functional form $\varphi(\gamma; S_t)$ where, as defined earlier, S_t is a vector that collects the state variables. The term γ denotes a k -dimensional vector of parameters such that, as k approaches infinity, the function $\varphi(\gamma; S_t)$ approximates $E_t(\cdot)$ arbitrarily well. Conditional expectations are then parameterized by choosing γ so that, for a given k , the function $\varphi(\gamma; S_t)$ is as close as possible to $E_t(\cdot)$.²⁰

5 Results

The next step is to examine the responses of the model economy to tax changes. Using a series of simulations from the calibrated model, I first evaluate the effects of a tax shock on labor market variables and assess how those effects vary across periods of high and low unemployment. Then, I compare the results that emerge from the simulated model with those estimated in the empirical part of the analysis.

5.1 Responses to a Tax Change

Figure 3 shows the responses of the labor market variables to a shock that increases the tax rate τ_t by 1 percentage point in the initial period. The tax rate then gradually reverts back to its balanced growth path level following the law of motion (32). The responses of the unemployment and labor force participation rates are expressed as percentage-point changes from their balanced growth path levels, and those of the remaining variables are expressed as percentage changes.

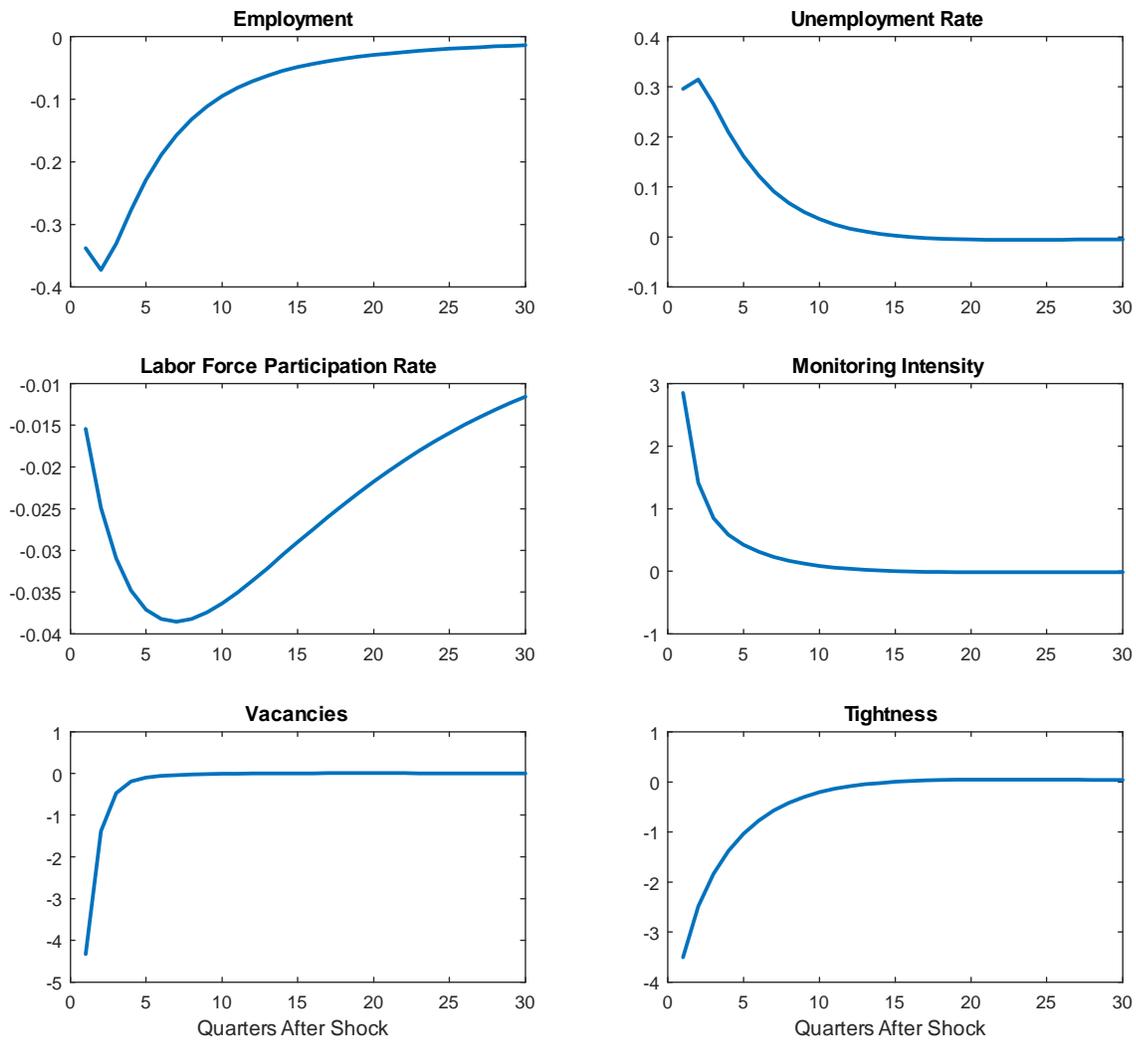
The increase in the tax rate reduces the return to work. Facing lower after-tax wages, households reduce search activity in the initial period, and labor force participation decreases slightly. Lower after-tax wages also result in a smaller loss of utility for workers in the event of shirking and dismissal, thereby weakening their incentives to put forth effort at work and increasing the amount of monitoring a firm must practice to elicit effort from its employees, as (18) suggests. Because additional monitoring increases employee costs, firms cut their demand for labor. The resulting drop in vacancies reduces labor market tightness (despite the initial decrease in households’ search activity) and causes employment to be lower and the unemployment rate to be higher than what would

¹⁸ As discussed in Michailat (2014), that value is roughly in the middle of the range of estimates reported in Haefke, Sonntag, and Van Rens (2008) and Pissarides (2009).

¹⁹ Also see Marcet and Marshall (1994) for a formal discussion of the method.

²⁰ A detailed description of the computational algorithm is available from the author upon request.

Figure 3. Responses of Labor Market Variables to a Shock That Increases the Tax Rate on Labor Income by 1 Percentage Point in the Initial Period



Source: Author's calculations.

The responses of the unemployment and labor force participation rates are percentage-point changes, and those of the remaining variables are percentage changes from balanced growth path values.

occur in the absence of the tax increase. Labor force participation also declines very gradually (because of habit formation in home services) in tandem with the drop in the return to work.

Figure 3 highlights a key channel through which changes in the marginal tax rate affect labor market outcomes in the model—by directly affecting firms’ demand for labor. In addition to influencing the supply of labor by affecting households’ decisions regarding job searches and labor force participation, changes in the marginal tax rate alter employees’ incentives to put forth effort. As discussed earlier, the strength of those incentives directly determines the amount of monitoring an employer must implement to deter shirking. Higher tax rates result in lower labor demand because the weaker effort incentives that result from lower after-tax wages call for more intensive monitoring on the part of employers, thereby increasing labor costs. Moreover, the size of the effect on employees’ effort incentives depends critically on the probability of finding a job and thus on the amount of existing slack in the labor market at the time of the tax change. Next, I discuss how that relationship underlies the state-dependent effects of tax changes in the model.

5.2 Effects of Tax Changes in States of High and Low Unemployment

Figure 4 illustrates the responses to a 1 percentage-point increase in the marginal tax rate when the unemployment rate at the time of the tax change is 2.5 percentage points higher and 2.5 percentage points lower than 6.5 percent (that is, the threshold unemployment rate used in the empirical analysis). I simulate the high-unemployment scenario by subjecting the economy to a sequence of shocks to the mean-reverting component of labor productivity that gradually raises the rate of unemployment from the long-term rate of 5.6 percent to about 9 percent within six quarters. To simulate the low-unemployment scenario, I introduce a sequence of shocks that reduces the rate of unemployment from 5.6 percent to roughly 4 percent within the same period. Then, for each scenario, I consider two alternative paths, one in which the productivity shocks are followed by a tax shock that raises τ_t by 1 percentage point in Quarter 6, and another in which the tax rate remains unchanged throughout the simulation horizon. The responses shown in Figure 4 are the differences between those two paths and, therefore, illustrate how the tax change implemented in Quarter 6 affects each variable in relation to what would occur without any changes in the tax rate.

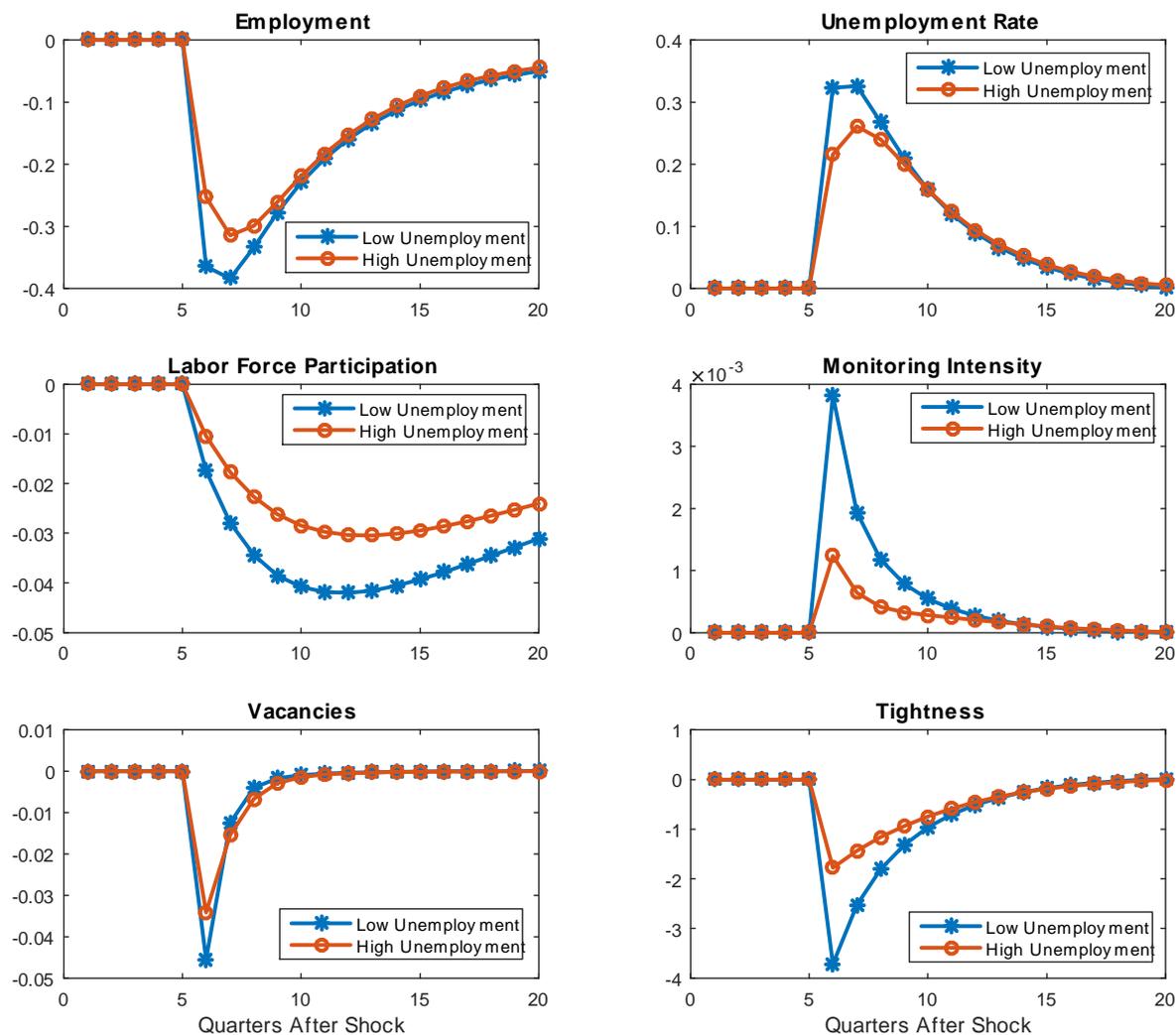
In both states of unemployment, the tax increase raises the intensity with which firms monitor their employees because lower after-tax wages weaken workers’ incentives to put forth effort. But, in the high-unemployment state, the increase in monitoring intensity is much less pronounced. That is because, in response to a given increase in the tax rate, workers are much less likely to withhold effort and face increased risk of job loss when it is highly difficult to find a new job. As a result, the amount of monitoring an employer must practice to maintain a functioning work environment does not increase in the slack state as much as it does in the low-unemployment state.

To further clarify this key mechanism, Figure 5 shows the relationship in the balanced growth path between the elasticity of firms’ monitoring intensity (d_t) with respect to the tax rate (τ_t) and the rate of unemployment. From (20), that elasticity (denoted Δ) is found as

$$\Delta = \frac{(1 - \kappa)wU_c\bar{z}}{\left\{ (1 - \kappa)(1 - \tau)wU_c + \beta(1 - \rho)E \left[U_x \frac{1-p}{p} \right] \right\}^2} \frac{\tau}{\bar{d}},$$

where all variables without time subscripts denote balanced growth path values after they are rendered stationary

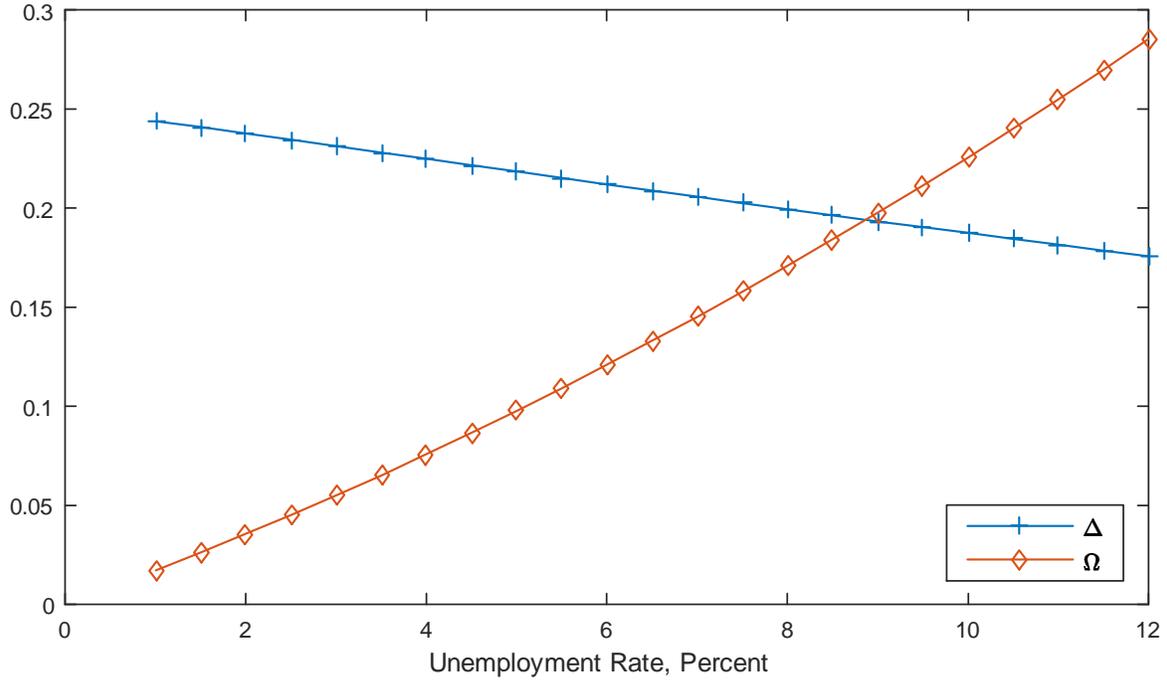
Figure 4. Responses of Labor Market Variables to a 1 Percentage-Point Increase in the Labor Income Tax Rate in High- and Low-Unemployment States



Source: Author's calculations.

The responses of the unemployment and labor force participation rates are percentage-point changes, and those of the remaining variables are percentage changes from what would occur in the absence of the tax change. "Low Unemployment" and "High Unemployment" indicate states in which the rate of unemployment at the time of the tax change equals 4.1 percent and 8.6 percent, respectively.

Figure 5. The Elasticity of Firms' Monitoring Intensity With Respect to the Tax Rate as a Function of the Unemployment Rate



Source: Author's calculations.

The term Δ stands for the elasticity of firms' monitoring intensity with respect to the tax rate, and Ω denotes the continuation value of an employment relationship relative to the immediate payoff to work.

using an appropriate transformation.²¹ Firms' monitoring intensity is less responsive to changes in the tax rate in times of high unemployment because the continuation value of an employment relationship, $E \left[U_x \frac{1-p}{p} \right]$, relative to the immediate payoff to work, wU_c , defined as

$$\Omega = \frac{E \left[U_x \frac{1-p}{p} \right]}{wU_c}$$

becomes larger when unemployment is higher. Because the option value of starting the next period with a pre-existing match is higher when the probability of finding a job is lower, a tax hike increases workers' tendency to withhold effort by a much smaller amount in a state of high unemployment. As a result, firms are able to deter shirking by increasing their monitoring activity less than they would in a state of low unemployment, which results in a less pronounced increase in employee costs. Accordingly, vacancies and employment drop and the rate of unemployment increases less in the slack state than in the low-unemployment state. The decline in labor force participation is also more limited in the slack state mainly because the tax change has a smaller effect on the probability of finding a job.

In addition to analyzing the effects of a tax increase, I also examine the responses to a tax cut. The reason

²¹ For example, w is the balanced growth path value of the stationary variable $\widehat{w}_t = w_t/a_{T,t}$.

Table 7. Simulated Versus Estimated Effects of Tax Changes

	Calibrated Model		Empirical Estimates	
	Low UR	High UR	Low UR	High UR
Employment	-0.52	-0.39	-0.56	-0.22
Unemployment Rate	0.42	0.31	0.39	0.21

Source: Author's calculations.

This table shows the simulated percentage responses of employment and percentage-point responses of the unemployment rate to an increase in taxes of 1 percent of gross domestic product in the model compared with the benchmark empirical estimates.

is that, in the model, the effects from tax cuts need not be symmetrical to those from increases because the relationship between taxes and macroeconomic variables is nonlinear in the model. Figure 6 shows the simulated effects of a 1 percentage-point cut in the tax rate in high- and low-unemployment states. A comparison with Figure 4 reveals that the responses to the tax increase and cut are not exactly symmetrical, but the effects from a tax cut on all three variables are larger in the low-unemployment state, as are the effects from a tax increase.

5.3 Comparison of Simulated and Estimated Effects

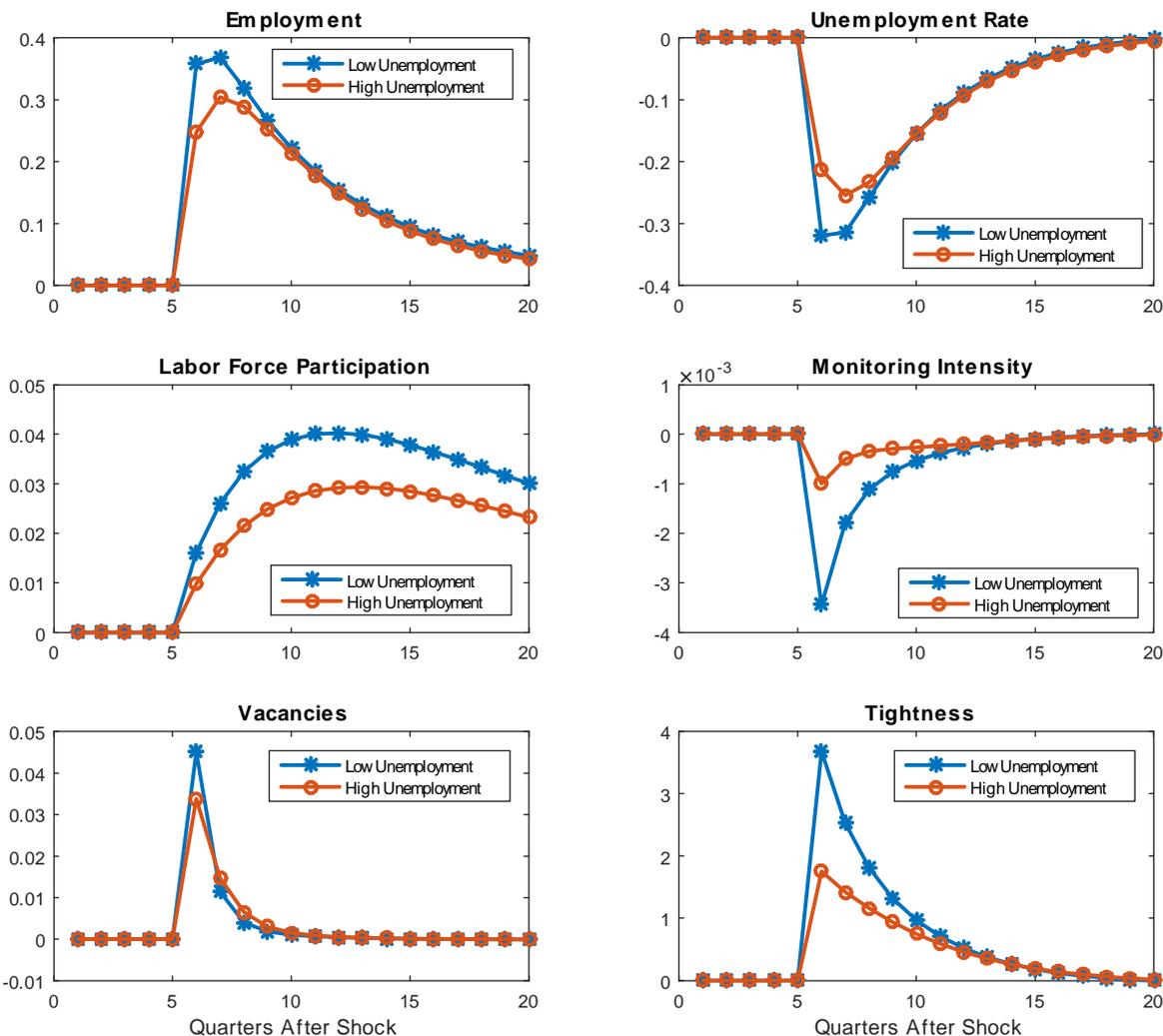
Table 7 compares the effects of a tax change in the calibrated model with those estimated using the benchmark empirical specification. Estimated effects and those from the calibrated model are both defined as in (5). That is, both sets of effects are calculated as percentage changes in employment and percentage-point changes in the unemployment rate over four quarters in response to an increase in taxes of 1 percent of GDP over the same period.

The model is quite successful in matching the estimated effects. Recall that the parameter values underlying model simulations are not picked to generate specifically the estimated effects of tax changes in high- and low-unemployment states but are set to replicate primarily the sample averages of a small number of labor market variables along the model's balanced growth path. And yet, the responses from the calibrated model are fairly close to the benchmark empirical estimates in both states.

6 Conclusion

Taken together with the findings of the previous research, the results of this analysis indicate that tax changes have significant effects on labor market outcomes, but those effects also vary depending on the state of the economy at the time a tax change is implemented. In the empirical part of the analysis, I find that the effects of a tax change on total hours worked, employment, and the unemployment rate become smaller in times of higher unemployment. That pattern remains largely intact under a series of alternative specifications of the empirical model. In the theoretical part, I construct a structural model in which tax changes have smaller effects on labor market variables in times of high unemployment because workers' decisions about effort and, ultimately, firms' overall employee costs become less sensitive to changes in after-tax wages in the presence of slack in the labor market. A calibrated version of the model is fairly successful in replicating the differences in the effects of tax changes on employment and the unemployment rate across periods of high and low unemployment.

Figure 6. Responses of Labor Market Variables to a 1 Percentage-Point Cut in the Labor Income Tax Rate in High- and Low-Unemployment States



Source: Author's calculations.

The responses of the unemployment and labor force participation rates are percentage-point changes and those of the remaining variables are percentage changes from what would occur in the absence of the tax change. "Low Unemployment" and "High Unemployment" indicate states in which the rate of unemployment at the time of the tax change equals 4.1 percent and 8.6 percent, respectively.

The results of this analysis show the effects of exogenous changes in tax policy; they do not reflect the effects of tax changes that are implemented in response to macroeconomic developments or that occur automatically over the business cycle. The proposed empirical approach is most useful for examining the effects of tax changes that are of moderate size, and the estimated differences across high- and low-unemployment states are most informative when those states are well within historical experience. Using the reported estimates to examine the effects of tax changes that do not satisfy those criteria requires a large degree of extrapolation, which can be problematic given the evidence of nonlinear effects from tax changes. In addition, the estimates presented in this paper should not be used to infer the effects of particular tax policy proposals because the paper's estimates are based on broad legislated tax changes that include many policy provisions. Given those limitations, one direction for future research is to extend the historical narrative analysis of Romer and Romer (2010) to construct more disaggregated measures of exogenous tax changes.

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