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# Household Indebtedness and the Macroeconomic Effects of Tax Changes


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**Keywords**

Tax policy, Household debt, Borrowing constraints, Marginal propensity to consume, Nonlinearity, Local projections

**JEL Classification**

E32, E62, G51, H30

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# Household Indebtedness and the Macroeconomic Effects of Tax Changes*

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# I. INTRODUCTION

The effects of fiscal policy on the macroeconomy have long been a crucial feature of macroeconomic research and policy discussion. Given its importance, the size of the fiscal multiplier has been extensively studied both theoretically and empirically (e.g., Blanchard and Perotti, 2002; Mountford and Uhlig, 2009; Christiano et al., 2011; Ramey, 2011; Woodford, 2011). However, recent studies suggest that the effects of fiscal policy on the macroeconomy are nonlinear and vary across the states of the economy. For example, empirical studies such as Auerbach and Gorodnichenko (2012a), Bachmann and Sims (2012), Baum et al. (2012), Mittnik and Semmler (2012), and Fazzari et al. (2015) suggest that government spending policy is more effective during recessions than expansions.[1]

Although most studies on the state-dependent fiscal multipliers were in the context of a phase of business cycles, constrained monetary policy and rising public debt after the global financial crisis have brought a theoretical and empirical appeal that the effects of fiscal policy may also depend on the stance of the monetary policy (e.g., Eggertson and Krugman, 2012; Miyamoto et al., 2018) or the level of government debt (e.g., Ilzetzki et al., 2013; Fotiou et al., 2020; Huidrom et al., 2020).[2] In addition, following the rapidly-expanding literature on household finance, household debt has become a crucial factor in understanding the transmission of fiscal policy (e.g., Andrés et al., 2015; Klein, 2017; Bernardini and Peersman, 2018; Bernardini et al., 2020; Alpanda et al., 2021; McManus et al., 2021; Klein et al., 2022).

However, most of these studies focused on government spending, not tax policy, although there is a good reason to extend such a mechanism to the latter. For example, the higher marginal propensity to consume (MPC) of indebted households driving heterogeneous consumption responses can be stronger for tax policy that directly affects household current disposable income than government spending. This is especially true because many empirical studies instrument changes in government expenditure using military spending due

[1] However, studies on state-dependent fiscal multipliers do not necessarily come to the same conclusion. For example, Ramey and Zubairy (2018) use the unemployment rate as a state variable and find that the size of the U.S. government spending multipliers is below unity irrespective of the level of slack in the economy. When it comes to tax policy, Ziegenbein (2017), Eskandari (2019), and Demirel (2021) use a similar state variable to find that the short-term impact of tax changes on output and employment is indeed smaller during bad times characterized by slower growth or higher unemployment.

[2] For example, Eggertsson and Krugman (2012) develop a theoretical framework to illustrate the effect of fiscal policy under the zero nominal interest rate. Fotiou et al. (2020) and Huidrom et al. (2020) use a nonlinear Vector Autoregression (VAR) model to show that fiscal multipliers are smaller when government debt is higher.

to its exogeneity to economic conditions. We contribute to this growing literature by providing the first kind of systematic analysis of whether the impact of tax policy varies with the indebtedness of households at the U.S. aggregate level. We adopt the state-dependent local projection method proposed by Ramey and Zubairy (2018), which is a nonlinear extension of Jordà (2005) to answer this question.

The aforementioned studies have focused on a different MPC between debtors and savers through the lens of heterogeneous agent models where fiscal policy is more effective when a larger proportion of households are borrowing-constrained. A common presumption behind these studies is that debtors are more subject to borrowing constraints, suggesting significant adjustments in their consumption in response to conditions that alter their income unexpectedly (Deaton, 1991; Agarwal et al., 2007). According to Hubbard et al. (1986) and Galí et al. (2007), even households with a positive net worth act on a rule of thumb to an extent to which their assets are illiquid.

Such a theoretical prediction has also gained strong empirical support from recent studies leveraging the micro-level consumption response. For example, Cloyne and Surico (2017) demonstrate that households with mortgage debt exhibit large and significant consumption responses to exogenous tax changes using household-level expenditure survey data. Using individual credit card balance data, Demyanyk et al. (2019) find that the Department of Defense spending facilitates consumption to a higher degree by more credit-constrained individuals than by less credit-constrained ones. Using the Consumer and Expenditure Survey, Ma (2019) finds heterogeneous consumption responses to government spending shocks between the poor and rich. While micro-level data strengthens the identification of the heterogeneous transmission channel of the fiscal policy, it does not tell much about its economy-wide effects, which deserve a comprehensive analysis in their own right.[3]

Using the U.S. data from 1955Q1 to 2011Q4, we provide strong empirical evidence that tax policy can be markedly effective when households are heavily indebted. To address the concern of endogeneity regarding the tax policy and macroeconomic variables, we use the narrative tax shock series by Romer and Romer (2010), which is largely exogenous to the state of the economy. Using an instrumental variable local

[3] To the best of our knowledge, the existing studies on the state-dependent effects of the tax policy have been limited compared with those of the government spending policy. For example, while several recent studies investigate the role of the phase of business cycles, the level of slack in the economy, financial conditions, and the degree of macroeconomic uncertainty (Biolsi, 2017; Ziegenbein, 2017; Bertolotti et al., 2019; Eskandari, 2019; Demirel, 2021), only Klein (2017) focuses on private debt including household debt.

projection approach suggested by Ramey and Zubairy (2018), we find the two-year cumulative tax multiplier of 1.29 when household debt is high.[4] In contrast, the multiplier is only -0.40 and not statistically significant when household debt is low. By conducting comprehensive empirical exercises guided by the existing theoretical models, we argue that a higher MPC and higher labor supply elasticity of indebted households are the key mechanisms for generating larger tax multipliers.

When investigating the response of each component of GDP, state dependence is primarily driven by private consumption, which is directly affected by the household current disposable income in the presence of borrowing constraints. The response of private investment does not vary significantly between the states for most specifications, supporting the relevance of household borrowing constraints in understanding our findings. Our finding is different from the literature on the interaction between private debt and fiscal policy and, therefore, provides further insight. For example, Bernardini and Peersman (2018) find a stronger state dependence of investment than consumption in response to government spending, particularly when a narrative measure by Ramey (2011) is used to identify the government spending shock. Our finding is also in contrast to Eskandari (2019), who finds that the state-dependent tax multipliers are driven by investment, not consumption when conditioned on the unemployment rate, economic growth, or uncertainty.

These findings are robust to controlling for subsequent government spending policy actions or tax revenue changes, monetary policy stance, fiscal foresight, and additional state classifications considered in the existing literature, such as the phase of business cycles, the slack of labor markets, and financial market conditions that may confound the household debt-dependent effects of the tax policy. Furthermore, they are robust to using alternative criteria for identifying a period of household indebtedness, using an alternative measure of tax shocks, and correcting potential bias in computing impulse response functions (IRFs) using local projections (Teulings and Zubanov, 2014). Importantly, the documented state-dependent effects of tax changes still hold when only using changes in a personal income tax, lending further support to our interpretation.

We analyze the impact on labor markets and find a strong state dependence in the response of both extensive and intensive margins of labor (i.e., employment and average hours worked). The absence of expansionary effects of a tax cut during the low-debt state can be attributed to the positive income effect

[4] The multiplier is normalized, so a positive (negative) number indicates an increase (decrease) in GDP following a tax cut.

from a tax cut partially offsetting the substitution effect, resulting in an insignificant response of labor supply. In contrast, such an income effect is dominated by the substitution effect when households are heavily indebted, thereby increasing household labor supply significantly, which is consistent with micro-level evidence found in the literature. This additional labor market effect further contributes to a larger tax multiplier during a high-debt state.

As the macroeconomic effect of tax policy is not necessarily symmetric between a tax cut and tax rise, the household-dependent effects of tax policy could also be sign-dependent. We investigate this possibility by considering a tax cut and tax rise separately. We find that the sign-dependent effects of tax policy do not mask the state-dependent effects we documented, but the state-dependent effects are stronger for a tax cut than the same size of a tax increase. Importantly, against the re-accelerating household debt accumulation driven by housing market imbalances since the COVID-19 pandemic and recent strong inflationary pressure worldwide, our findings suggest that tax-based expansion could still stimulate consumption and output without creating housing price appreciation or strong inflation.

The remainder of the paper is organized as follows. Section II provides the theoretical argument for household debt-dependent tax multipliers in a nutshell. In Section III, the empirical methods adopted in the study are outlined with a brief review of the data. In Section IV, we present the main findings with a series of robustness checks. We also employ additional exercises to shed light on mechanisms. Section V presents the conclusion.

## II. The Argument in a Nutshell

This section presents the theoretical argument for household debt-dependent tax multipliers in a nutshell. See, for example, Andrés et al. (2015), McManus et al. (2021), and Klein et al. (2022) for a formal derivation of the argument, which share endogenously binding borrowing constraints as the key to generating the link between the size of government spending multipliers and private indebtedness. Suppose that the household sector consists of two types of agents, patient and impatient households. Both types of households supply differentiated labor services, set wages in a Calvo framework, and demand consumption goods and housing. The production sector is standard (i.e., producing goods—used for investment, consumption, and government spending—in a monopolistic competitive market and subject to a fixed probability of setting new prices). The central bank sets the policy rate according to the Taylor rule, whereas the government finances its expenditures by collecting income taxes and issuing bonds.

In equilibrium, patient households will be savers and impatient ones borrowers, whose borrowing is collateralized by housing due to costly enforcement.[5] The supply of housing is fixed. Importantly, borrowing constraints bind endogenously rather than at all times, which implies that the transmission of economic shocks depends on the degree of borrowing constraints. While it is well known that the distinction between financially constrained and unconstrained agents is important for the transmission of fiscal and monetary policy (e.g., Galí et al., 2007; Bilbiie, 2008), "occasionally" binding constraints become the key to understanding state-dependent fiscal multipliers because the share of constrained (rule-of-thumb) agents is constant in the earlier models.

In this class of heterogeneous agent models, the shock propagation crucially depends on the tightness of borrowing constraints. When borrowing constraints bind, the two household types have different MPCs out of their current disposable incomes. Constrained agents (borrowers) have a higher MPC and unconstrained agents (savers) have a lower MPC. Since borrowing constraints are tighter when households are more indebted, the average (i.e., economy-wide) MPC is also higher at this time.[6] On the contrary, if borrowing constraints are slack, there are no significant differences in MPCs between borrowers and savers, as both households are at their unconstrained optimum, and Ricardian equivalence holds. Thus, an increase in current disposable income following a tax cut is more effective in stimulating consumption when households are, on average, more indebted.

Note that this mechanism does not require a disproportionate increase in disposable income for (constrained) high-MPC households, which is necessary to generate a stronger crowding-in effect of government spending on consumption found in the literature. Moreover, although household borrowing constraints are tied to the value of housing in this class of models, housing prices, *per se*, do not have to respond to tax policy to generate the debt-dependent effects on consumption. To the extent that tax changes

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[5] Borrowing constraints do not necessarily have to be tied to the value of housing to rationalize our empirical findings. The household debt-dependent effect of tax policy arises as long as indebted households are borrowing constrained. Given the empirical orientation of our work, we simply borrow the commonly used framework to account for occasionally-binding borrowing constraints.

[6] Indeed, Klein et al. (2022) demonstrate that episodes of binding borrowing constraints coincide with periods of above-average household indebtedness.

directly affect the disposable income of constrained households, tax cuts could have a first-order effect on consumption even without the appreciation of housing prices. These are what make tax policy distinct from government spending policy when interacting with household debt.

Instead, we highlight the household debt-dependent labor market responses to a tax shock—motivated by micro-level evidence—as an additional mechanism explaining our findings. Compared with government spending policy, tax policy also has a direct effect on household labor supply decisions, as an income tax cut would increase labor supply via the substitution effect. The income effect, which is an opposite force reducing labor supply, is largely absent when households are borrowing-constrained, resulting in a stronger increase in labor supply, and therefore output. Despite the clarity of this argument, empirical studies thus far focused mostly on the role of household indebtedness in determining the size of spending, not tax multipliers. We fill this gap in the literature by providing the first kind of systematic analysis of whether the impact of tax policy also varies with the indebtedness of households.

## III. EMPIRICAL FRAMEWORK

### A. State-dependent local projection method

In this section, we describe the main empirical framework used in the analysis. We employ the methodology of Jordà (2005) for estimating the response of various macroeconomic variables to the identified tax shock. We estimate the following regression for each horizon to calculate Jórda's impulse response function:

$$y_{t+h} = \alpha_h + \beta_h shock_t + \Phi_h(L) X_t + \varepsilon_{t+h}, \quad for\ h = 0, 1, 2, \cdots , \tag{1}$$

where $y_t$ is the dependent variable whose response is our ultimate interest; $shock_t$ is an exogenous tax shock that will be explained in greater detail; $\Phi_h(L)$ is a lag polynomial; and $X_t$ is a set of control variables.

In Equation (1), $\beta_h$ shows the response of the dependent variable after $h$ quarters from the shock. Therefore, a series of $\beta_h$ illustrates the dependent variable's impulse response function to the shock. In our analysis, $\beta_h$ implies the effect of tax changes on dependent variables after $h$ quarters. One of the potential problems of Jórda's method is the serial correlation of the error terms, and in our case, the extent of the persistence of the dependent variable. To handle this problem, we adopt Newey-West heteroskedasticity and autocorrelation corrected (HAC) standard errors from Newey and West (1987).

This model can be conveniently transformed into a state-dependent model to test whether the effects of tax shocks depend on the state of the economy. We closely follow the state-dependent model used by Ramey and Zubairy (2018) and Demirel (2021) in terms of its implementation. The nonlinear version of the regression model can be specified as follows:

$$y_{t+h} = I(z_{t-1})[\alpha_{H,h} + \beta_{H,h} shock_t + \Phi_{H,h}(L)X_t] + \big(1 - I(z_{t-1})\big)[\alpha_{L,h} + \beta_{L,h} shock_t + \Phi_{L,h}(L)X_t] + \varepsilon_{t+h}. \quad (2)$$

In this model, we allow variation in coefficients according to the levels of household indebtedness to acquire a state-dependent impulse response function. Specifically, the first part of Equation (2) accounts for the high-debt state, and the second part captures the low-debt state, where $I(z_t)$ is a dummy variable indicating that the economy falls into a state of high household indebtedness, which will be defined in the following section. Thus, a series of $\beta_{H,h}$ for $h = 1, 2, ...$ denotes the impulse response to tax shocks in a state of high debt, whereas a series of $\beta_{L,h}$ describes the same in a low-debt state.[7]

## B. Identifying household indebtedness

We closely follow Bernardini and Peersman (2018) and Alpanda and Zubairy (2019) for measuring the state of household indebtedness, focusing on the debt gap, which is the deviation of the household debt-to-GDP ratio from its trend.[8] They use the cyclical position of household debt instead of its level to isolate the role of financial development in driving long-term household debt. This is because an accumulation of debt, driven by long-term financial deepening, does not necessarily provide useful information about households' indebtedness.

[7] While the estimated responses obtained from the nonlinear VAR models are based on the assumption that the state of the economy remains constant over the impulse-response horizons, this assumption may not be a good approximation if the underlying states are only short-lived. As extensively discussed in Ramey and Zubairy (2018), in this direct regression approach compared to VAR models, if the average shock changes the state of household indebtedness, it will be absorbed into the impulse response estimate. The state-dependent control variables should capture natural transitions between states that are independent of the shock. Thus, the coefficients on the state-dependent constant terms and control variables will capture information on the average behavior of the economy to transition to the other state at future horizons. Notably, we bias our estimates toward not finding the differential effects of the tax shock across states to the extent that we estimate the properties of a given state by partially using the dynamics of a system in another state.

[8] The main findings in the paper are robust to using the household debt to income ratio, as the correlation between the two measures exceeds 0.9.

The long-term trend is defined using the Hodrick and Prescott (HP) filter with a smoothing parameter of $\lambda = 10^4$, as in Alpanda and Zubairy (2019).[9] We handle the so-called endpoint problem of the two-sided HP filter by filtering the household debt to GDP data from 1951Q4 to 2015Q4 and only including the data from 1955Q1 to 2011Q4 in our main analysis. The availability of the narrative tax shock series restricts the sample period.[10] Figure A.1 in Appendix A presents the household debt gap with the recession period defined by the National Bureau of Economic Research.

We identify the state of household indebtedness by defining a high (low) debt state as periods with positive (negative) deviations of the household debt to GDP ratio from its trend. In addition, we impose that each state lasts at least four consecutive periods to rule out frequent transitions between states, thereby enhancing estimation precision. As a result, about half (48.7 percent) of the observations belong to the high debt state. We still check whether our results are robust to defining a high debt state with positive deviations for any quarter.

We prefer this binary indicator over an alternative of the continuous transition between states, such as the smooth transition function used by Auerbach and Gorodnichenko (2012a), to yield a straightforward economic interpretation.[11] The smooth transition function allows the impact of tax policy to shift smoothly between the states by considering a continuum of states to compute the impact, resulting in more precise estimates. However, the estimates are often implausibly large, as they are measured by the effects of a tax cut during the extreme states (corresponding to $F(z_t) = 0$ or 1), which are rare in the data. Nevertheless, we still employ the smooth transition function to separate the states as a robustness check. In so doing, we replace $I(z_t)$ in Equation (2) with $F(z_t) = \frac{exp\ (\gamma \tilde{z}_t)}{1+exp\ (\gamma \tilde{z}_t)}$, where $\tilde{z}_t$ is the standardized (i.e., normalized to have zero mean and unit variance) measure of the household debt gap $z_t$ defined above.[12]

[9] The choice of $\lambda = 10^4$ implies twice the typical business cycle. Such a relatively high smoothing parameter ensures that even the lowest frequency variations in the household debt to GDP ratio are removed. There is minimal change in our findings when using $\lambda = 10^6$, as in Bernardini and Peersman (2018). We also use a band-pass filter of Baxter and King (1999) for checking robustness.

[10] Although Romer and Romer's narrative tax shock series is only available until 2007Q4, the local projection method does not require the same sample size of dependent and independent variables. Since the horizon for impulse response functions is 20 quarters, we can evaluate the effect of the exogenous tax shock up to 2011Q4.

[11] The original state variable in Auerbach and Gorodnichenko (2012) is a moving average of the GDP growth rate.

[12] The smooth transition function transforms the household debt gap measure into a probability between zero and one. The transformed value would be close to one when the debt gap is higher and close to zero if the debt gap is lower. The parameter $\gamma$ governs the speed of

Following Gordon and Krenn (2010) and Ramey and Zubairy (2018), we divide all national account variables such as output, private consumption, private fixed investment, and tax revenues with the potential GDP calculated by the Congressional Budget Office. In other words, before estimations, we transform each variable as follows: $y_{t+h} = \frac{Y_{t+h} - Y_{t-1}}{PGDP_{t-1}}$, where $Y_t$ is the real GDP or its components, and $PGDP_t$ is the potential GDP. This normalization ensures that all the coefficients are in the same unit, thereby allowing for the direct construction of the tax multipliers. We always include four lags of the dependent variables of interest, real GDP growth, the government spending to GDP ratio, and the exogenous series of tax changes as controls to deal with any possible serial correlation of the variables and omitted variable bias (Montiel Olea and Plagborg-Møller, 2021).[13]

### C. Identifying narrative tax shocks

The fundamental challenge in identifying the effects of tax changes on the macroeconomy is that tax policy can change in response to the underlying economic conditions. We mitigate the endogeneity concerns using the exogenous tax changes identified through a narrative approach by Romer and Romer (2010). They create an exogenous measure of tax shocks by using narrative records such as presidential speeches and Congressional reports. Their narrative shock series identifies the size, timing, and principal motivation for all the crucial post-war tax policy actions. They classify legislated changes into those taken for reasons related to prospective economic conditions and for more exogenous reasons. We use this sequence of tax shock series to identify the exogenous tax policy in our analysis.

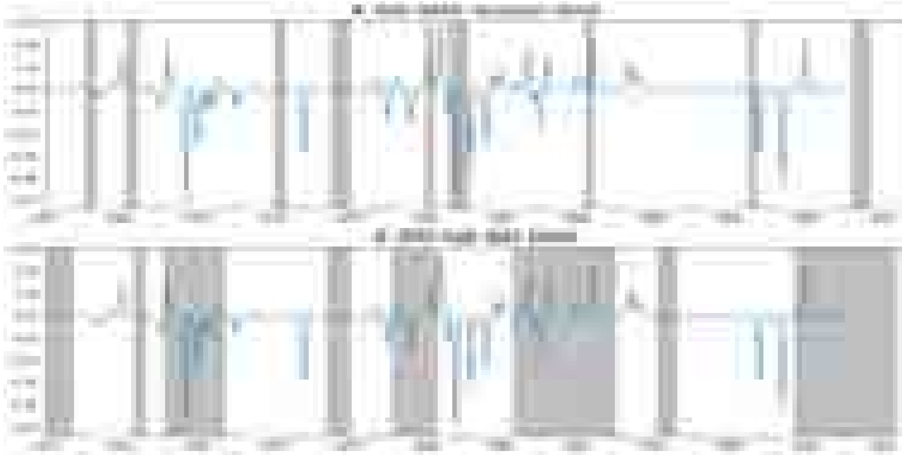
Figure 1 shows Romer and Romer's narrative tax shock as a share of the potential GDP, together with NBER recession dates in Panel A and with high debt states defined above in Panel B. On average, there are more stimulus episodes than consolidation ones in our sample, but there seems no concentration of exogenous tax shocks in a particular debt state, which will be further scrutinized. In Figure A.2 in Appendix

transition between the two states; hence the smooth transition function converges to a binary indicator when $\gamma \to \infty$. Following Auerbach and Gorodnichencko (2012a), we choose $\gamma = 1.5$, but our key findings are not sensitive to the choice of $\gamma$. The probability of being in the high debt state is plotted in the right panel of Figure A.1 in Appendix A.

[13] It is possible that future government spending varies with current tax policy systematically. For example, Romer and Romer (2007), using their narrative exogenous tax shocks, show that a current tax cut tends to be followed by a government spending increase, not a decrease. In unreported analysis, we confirm that government spending indeed increases after a tax cut using a linear model. However, the responses of government spending are not statistically different between the states, suggesting that our findings are not driven by systematic responses of government spending to tax shocks. We appreciate an anonymous reviewer's suggestion to explore this possibility.

A, we plot the distribution of exogenous tax shocks between alternatively defined states, which will be used as a robustness check.

**Figure 1.** Evolution of narrative exogenous tax shocks across states



Note: This graph plots measures of exogenous tax changes, which is narrative tax shock series from Romer and Romer (2010) as a share of the potential GDP. The shaded area in Panel A (Panel B) is NBER recession dates (high debt states).

In Table 1, we report how exogenous tax changes are distributed across household debt states, both using the baseline binary definition and the alternative definition using a smooth transition function. Using the baseline definition, the high debt state accounts for 48.7% of the sample period, while 45.3% of tax shocks occur in this state. This statistic implies that tax shocks are evenly distributed between the states, suggesting that the effect of tax changes estimated below is unlikely to be originated from a particular state. We also show that the sign of tax shocks is fairly evenly distributed in each state.

We then repeat the same exercise for other states used as a robustness check. Among the three additional states of the economy, we observe that tax shocks are far more frequent during the period of labor market slack considered in Ramey and Zubairy (2018). In Table A.1 in Appendix A, we further present the correlation among the states defined by the same variables. The low correlation coefficients in the table demonstrate that the state defined by household indebtedness is largely independent of the state considered in the existing literature. Finally, in Table A.2 in Appendix A, we summarize the description and source of the key variables used in the empirical analysis.

**Table 1.** Distribution of tax shocks across states

| | Debt (binary) | Debt (smooth) | Unemployment rate | Real GDP growth | Credit spread |
|---|---|---|---|---|---|
| **High state** | | | | | |
| Frequency (%) | 48.68% | 46.49% | 49.56% | 51.32% | 42.11% |
| Tax shocks (%) | 45.34% | 45.24% | 69.05% | 57.14% | 45.24% |
| Share of positive shocks (%) | 57.89% | 52.63% | 51.72% | 56.67% | 47.37% |
| **Low state** | | | | | |
| Frequency (%) | 51.32% | 53.51% | 50.44% | 48.68% | 57.89% |
| Tax shocks (%) | 54.66% | 54.76% | 30.95% | 42.86% | 54.76% |
| Share of positive shocks (%) | 43.48% | 47.83% | 46.15% | 47.50% | 52.17% |

**Note:** This table shows the frequency of each state in the sample period and the distribution of tax shock between the two states.

# IV. EMPIRICAL FINDINGS

## A. Main results

Before presenting the main results, Figure B.1 in Appendix B shows the response of the real GDP, consumption, and investment to an exogenous tax cut from the linear model.[14] The qualitative findings are consistent with those of the previous studies, such as Romer and Romer (2010), Mertens and Ravn (2014), and Demirel (2021) that use the same narrative tax shocks, and a tax cut leads to increased output in the short and medium run.[15] Moreover, the size and the timing of the maximum effect are consistent with Demirel (2021), recording a maximum increase of 2.1% in real GDP after eight quarters using essentially the same methodology and a similar sample period.

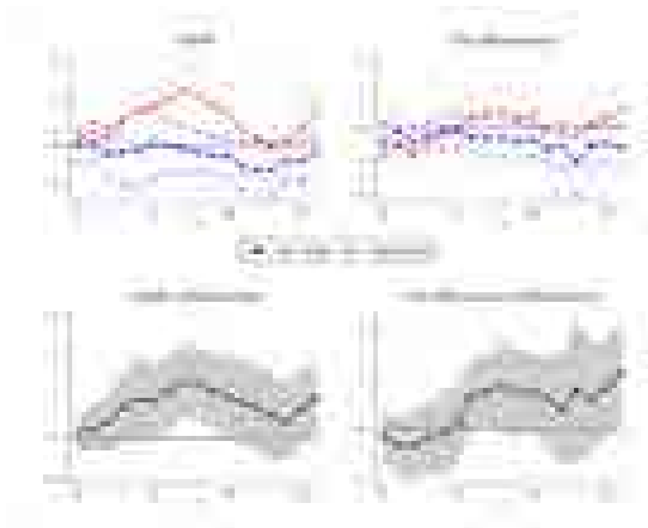
Figure 2 presents the state-dependent effect of an exogenous tax cut on real GDP, which is the focus of the paper, together with the state-dependent responses of real tax revenues. In the left panel, the output responses in two different states indicate a marked difference. An exogenous tax cut stimulates the output only during a high household debt state. The same size of the tax cut does not have a statistically significant

[14] Throughout the paper, we normalize the sign of the coefficient on tax shocks so that all responses correspond to a tax cut.

[15] While the maximum effect of an exogenous tax cut corresponding to one percent of the GDP on output is smaller than that of Romer and Romer (2010) (1.7% vs. 2.9%), this difference is a result of different estimation techniques (local projection vs. autoregressive distributed lag model). See Favero and Giavazzi (2012) and Mertens and Ravn (2014) for how to reconcile the difference in the magnitude of tax multipliers found in the literature. However, our primary concern is not the size of multipliers, *per se*, but whether it varies systematically depending on the state of household indebtedness.

effect on output when household indebtedness is low. In the bottom panel, we also report the statistical difference in the response of output between the states with a 90% confidence interval.

**Figure 2.** State-dependent effect of an exogenous tax cut on output and tax revenues



Note: The top panel of this graph shows the state-dependent response of output (left) and tax revenues (right) with a 90% confidence interval to an exogenous tax cut estimated using the sample from 1955Q1 to 2011Q4. The bottom panel reports the statistical difference in the estimated IRFs between the states. Output, tax revenues, and tax shocks are normalized by the potential GDP estimated by the Congressional Budget Office. Heteroskedasticity and autocorrelation consistent (HAC) standard errors of Newey and West (1987) are used.

An important concern for this finding is that the nature of tax policy might depend on household indebtedness. Remember that the measure of exogenous tax shocks is based on a narrative account, and each tax change has various motivations. Our findings might simply illustrate this difference if the motivation behind tax changes systematically depends on the state of household indebtedness. For example, the stronger expansion in output during the high debt state could be simply driven by the fact that a cumulative tax cut itself is larger during the same state. We guard against this possibility by checking whether the response of tax revenues to an exogenous tax shock systematically varies depending on the state of household debt.[16]

The right panel of Figure 2 shows that no significant distinction appears in the responses between the two states, especially for the horizon in which differences in the output response arise.[17] This finding

[16] Following Ramey and Zubairy (2018), we use federal current receipts from the National Income and Product Accounts data to measure government tax revenues. Since tax revenues are also normalized by the potential GDP, they can be seen as a proxy for the average tax rate.

[17] If anything, the magnitude of cumulative tax cuts is smaller during the high debt state, which goes against finding our results.

indicates an absence of inherent asymmetry in the type of tax policy based on the state of household debt, and therefore household debt-dependent tax multipliers documented in Figure 3 are unlikely to be driven by the endogenous response of tax revenues alone.[18] Nevertheless, we control for the lags in the share of the federal current revenues in GDP as a robustness check.

*State-dependent tax multipliers.* The tax multiplier is defined as the dollar change in GDP over a specified period resulting from a dollar change in tax revenues during the same period. In the empirical literature, it is common to estimate multipliers indirectly: first estimate the elasticity of output in terms of government expenditure or tax revenue, then transform it by multiplying with the inverse of the average government expenditure or tax revenue share of output (e.g., Blanchard and Perotti, 2002). However, such a naive approach has been criticized recently. For example, Mountford and Uhlig (2009) argue that multipliers should be calculated as the integral of the output response divided by the integral of the government expenditure or tax revenue response. In addition, Ramey and Zubairy (2018) posit that the share of government spending on GDP has changed substantially in the historical sample, causing a bias. Sims and Wolff (2018) also argue that this conventional approach is particularly misleading when calculating state-dependent tax multipliers, as in ours.

Following Ramey and Zubairy (2018), we compute the cumulative tax multiplier for a state-dependent model in one step, which is equivalent to the result from the following three steps but has several advantages:[19] (i) estimate Equation (2) for the GDP of each horizon $j$ up to $h$ and sum the $\beta_j$ for each state ; (ii) estimate Equation (2) for tax revenues of each horizon $j$ up to $h$ and sum those $\beta_j$ for each state; (iii) compute the multiplier as the answer to step (i) divided by the answer to step (ii). Instead, the one-step model is given by

$$\begin{aligned}\textstyle\sum_{j=0}^{h} y_{t+j} = I(z_{t-1})\left[\alpha_{H,h} + m_{H,h}\sum_{j=0}^{h} y_{t+j} + \Phi_{H,h}(L)X_t\right] + \\ \left(1 - I(z_{t-1})\right)\left[\alpha_{L,h} + m_{L,h}\sum_{j=0}^{h} tr_{t+j} + \Phi_{L,h}(L)X_t\right] + \varepsilon_{t+h}, \qquad (3)\end{aligned}$$

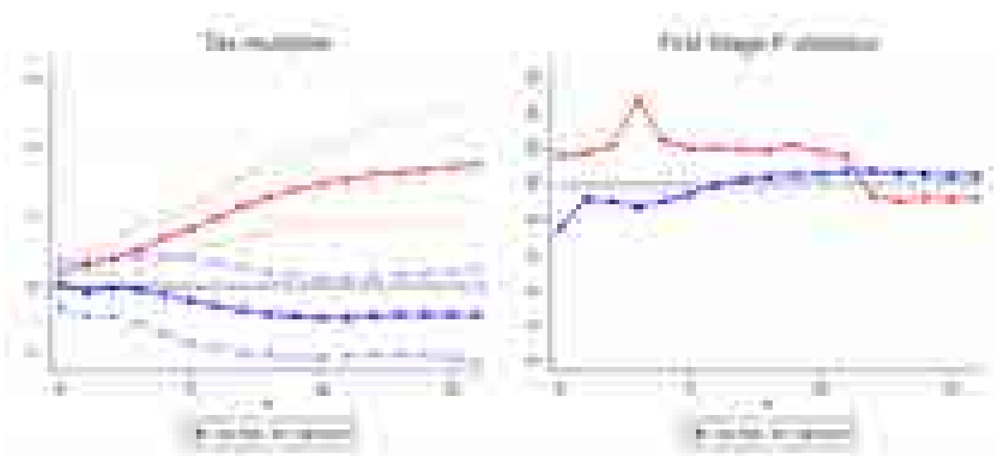
[18] Although our theoretical argument in Section II does not require any assumption on tax regressivity, our finding might still be driven by different tax regressivity given the non-distinct tax revenue responses between the states. By employing the average marginal tax rate series from Mertens and Montiel Olea (2018) as a dependent variable, we confirm that the response of the average marginal tax rate to exogenous tax shocks is not statistically different between the states.

[19] According to Ramey and Zubairy (2018), the one-step IV method allows for (i) direct computation of standard errors of the multiplier; (ii) measurement errors in the tax shock and the tax revenue variable as long as their measurement errors are uncorrelated; (iii) testing the importance of instrument relevance condition.

where $m_{H,h}$ and $m_{L,h}$ are tax multipliers for high and low-debt states, respectively. $I(z_{t-1}) \times shock_t$ and $(1 - I(z_{t-1})) \times shock_t$ are used as instruments for the respective interaction of cumulative tax revenues with the state indicators.

Figure 3 shows the state-dependent multipliers with a 90% confidence interval over estimation horizons. The multipliers are also normalized so that a positive value indicates an increase in output following a tax cut. Consistent with the evidence reported in Figure 2, the tax multiplier is positive and statistically significant in the high-debt state, while it is small and statistically insignificant in the low-debt state. The values of baseline state-dependent multipliers are also summarized in the top panel of Table 2, reporting the one-year (two-year) multiplier of 0.70 (1.29) and -0.12 (-0.40) for high and low debt states, respectively. We also present the state-dependent multipliers by using an alternative definition of the high debt state as a robustness check. We confirm that the household-debt dependent tax multiplier still holds in any case.

**Figure 3.** State-dependent cumulative tax multipliers and test of weak instruments



Note: This graph shows the state-dependent tax multipliers with a 90% confidence interval (left) and the corresponding first-stage effective F-statistic (right) using the sample from 1955Q1 to 2011Q4. Heteroskedasticity and autocorrelation consistent (HAC) standard errors of Newey and West (1987) are used for estimating the tax multipliers.

We further plot the first-stage effective F-statistic by Montiel Olea and Pflueger (2013) to check whether exogenous tax shocks by Romer and Romer (2010) are a relevant instrument for tax revenues in both states. Although the effective F-statistic does not always exceed the rule-of-thumb threshold of 10 (Staiger and Stock, 1997), it is typically larger than 10 for the high-debt state and it is very close to 10 for the low-debt state.

**Table 2.** Estimates of tax multiplier across the state of household indebtedness

| | | High debt | Low debt |
|---|---|---|---|
| Baseline | | | |
| | On impact | 0.20 (0.33, 0.07) | 0.03 (0.37, -0.32) |
| | 1-year | 0.70 (1.02, 0.38) | -0.12 (0.44, -0.69) |
| | 2-year | 1.29 (1.78, 0.79) | -0.40 (0.20, -1.00) |
| Immediate switch | | | |
| | On impact | 0.33 (0.73, -0.06) | 0.12 (0.53, -0.28) |
| | 1-year | 1.13 (2.12, 0.15) | -0.17 (0.54, -0.87) |
| | 2-year | 2.08 (3.47, 0.69) | -0.60 (0.13, -1.33) |
| Smooth transition function | | | |
| | On impact | 0.96 (2.67, -0.75) | 0.04 (2.75, -2.66) |
| | 1-year | 4.96 (8.15, 1.77) | -2.53 (5.07, -10.13) |
| | 2-year | 9.55 (15.10, 4.01) | -8.10 (4.63, -20.84) |

Note: Reported numbers are the estimates of tax multipliers at certain estimation horizons in different states of the economy. The numbers in parentheses denote a 90% confidence interval.

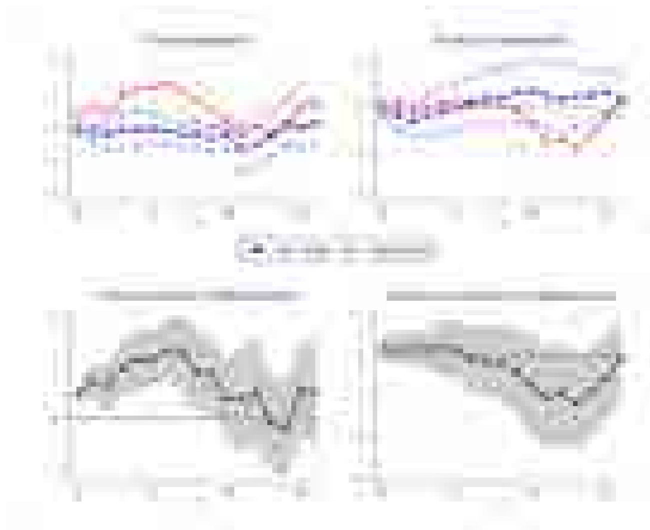
Previous studies, such as Ziegenbein (2017), Sims and Wolff (2018), Eskandari (2019), and Demirel (2021), provide theoretical and empirical evidence that tax multipliers are smaller during periods of slack or recessions, which is dramatically opposite to the majority of studies on government spending multipliers.[20] Our findings suggest that the state of household debt is also critical in understanding the effectiveness of tax policy, along with the state of business cycles measured by output growth or unemployment.[21]

*Response of consumption and investment.* We consider the state-dependent responses of consumption and investment to the same shock for understanding the source of household debt dependency in output responses. Figure 4 depicts the state-dependent responses of private consumption and private fixed investment to an exogenous tax cut. Importantly, we find that the consumption response primarily drives the state-dependent output response. While the state-dependent consumption response is qualitatively similar to that of the real GDP and indeed even stronger, investment responses are not statistically different between the states. This stark difference suggests that underlying household indebtedness is closely linked to consumption decisions (Mian et al., 2017), validating our conjecture on the role of household borrowing constraints.

**Figure 4.** State-dependent effect of an exogenous tax cut on consumption and investment

[20] For example, Ziegenbein (2017) and Demirel (2021), using a search model of unemployment, argue that an increased labor market slack or tighter credit conditions in contractionary periods can reduce the responsiveness of labor supply to changes in labor income taxes, resulting in smaller effects on output from tax changes.

[21] The robustness checks conducted later demonstrate that the high-household debt condition does not necessarily pick up the expansionary phase of the economy, suggesting that the household debt channel is independent of other mechanisms studied in the literature.



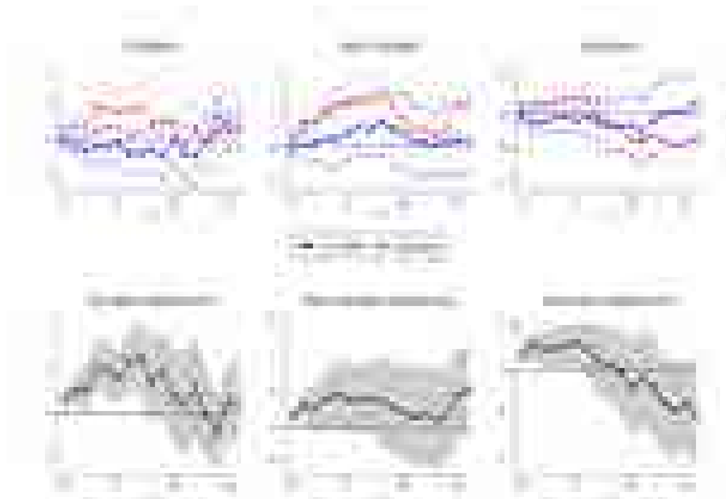
Note: This graph shows the state-dependent response of private consumption (left) and private fixed investment (right) with a 90% confidence interval to an exogenous tax cut estimated using the sample from 1955Q1 to 2011Q4. The bottom panel reports the statistical difference in the estimated IRFs between the states. The dependent variable and the tax shock are normalized by the potential GDP estimated by the Congressional Budget Office. Heteroskedasticity and autocorrelation consistent (HAC) standard errors of Newey and West (1987) are used.

Our findings are also distinct from Eskandari (2019), who uses the unemployment rate, GDP growth, and uncertainty as a state variable and finds that the state dependency of tax multipliers is primarily driven by investment, not consumption. Thus, household indebtedness appears as an independent transmission channel of tax policy from those previously considered in the literature. We further strengthen this claim by considering household indebtedness jointly with other state variables in Section IV.B.

Figures 5 and 6 present the state-dependent effects of an exogenous tax shock on the subcomponents of private consumption and private fixed investment.[22] First, the strong state-dependent consumption response is largely preserved for each component, but the difference between the states is most pronounced for durable goods. However, in the case of investment, only the response of non-residential investment is consistent with the pattern of the state-dependent effect of tax shocks on output. The different responses between residential and non-residential investment to tax shocks offer further insight into the transmission channel of tax policy via household indebtedness.

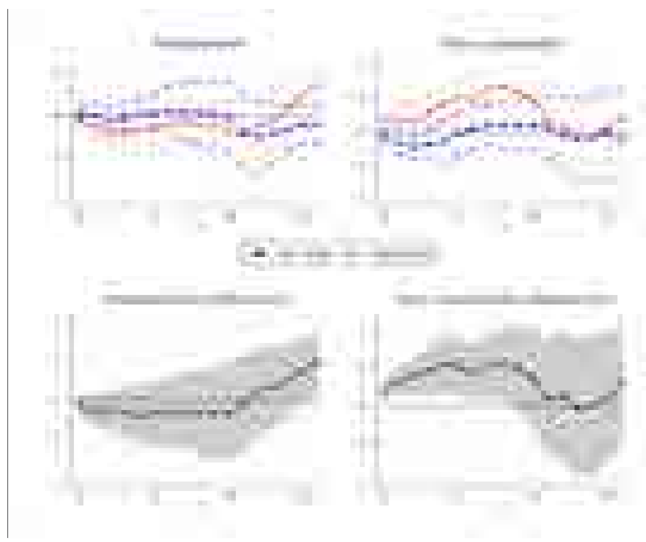
**Figure 5.** State-dependent effect of an exogenous tax cut on the components of consumption

[22] Figures B.2 and B.3 in Appendix B provide the linear effect of exogenous tax shocks on these variables.



Note: This graph shows the state-dependent response of durable (left), non-durable (middle), and service consumption (right) with a 90% confidence interval to an exogenous tax cut estimated using the sample from 1955Q1 to 2011Q4. The bottom panel reports the statistical difference in the estimated IRFs between the states. The dependent variable and the tax shock are normalized by the potential GDP estimated by the Congressional Budget Office. Heteroskedasticity and autocorrelation consistent (HAC) standard errors of Newey and West (1987) are used.

**Figure 6.** State-dependent effect of an exogenous tax cut on components of investment



Note: Note: This graph shows the state-dependent response of residential (left) and non-residential investment (right) with a 90% confidence interval to an exogenous tax cut estimated using the sample from 1955Q1 to 2011Q4. The bottom panel reports the statistical difference in the estimated IRFs between the states. The dependent variable and the tax shock are normalized by the potential GDP estimated by the Congressional Budget Office. Heteroskedasticity and autocorrelation consistent (HAC) standard errors of Newey and West (1987) are used.

On the one hand, the response of residential investment is statistically insignificant in both states, which indicates that expansionary tax policy does not have a first-order effect on the supply side of the U.S. housing markets in either condition. We further investigate the state-dependent effects of tax policy on housing prices in the following section to shed light on the implication of the interaction between housing cycles and tax policy. On the other hand, the response of non-residential investment is compatible with the implication of state-dependent tax policy on labor markets studied in the following section: labor supply increases much more in the high-debt state than in the low-debt state. Given the stronger household consumption demand and the higher marginal product of capital due to increased labor supply, firms are encouraged to invest and hire more when household debt is high. However, it is notable that this mechanism is the consequence of household inter and intra-temporal decisions under borrowing constraints rather than a direct consequence of tax policy on relaxing the financial constraints of a firm.

## B. Robustness checks

We provide several sensitivity tests in this subsection to ensure that our primary finding, which states that (i) an exogenous tax reduction has a significant expansionary effect only during the period of high household indebtedness and (ii) this effect works mainly through changes in private consumption, not investment, is robust to various alternative specifications.[23]

*Controlling for tax revenues.* As discussed earlier, the nature of tax policy may be also state-dependent, generating a mechanical state-dependent response of key macroeconomic variables. Although the evidence presented in Figure 2 largely alleviated this concern, we still control for the lags in the share of the federal current revenue in GDP to confirm that the response of tax revenues is still irrelevant to our findings. The first panel in Table A.3 in Appendix A confirms that the state-dependent effects of tax shocks are largely preserved.

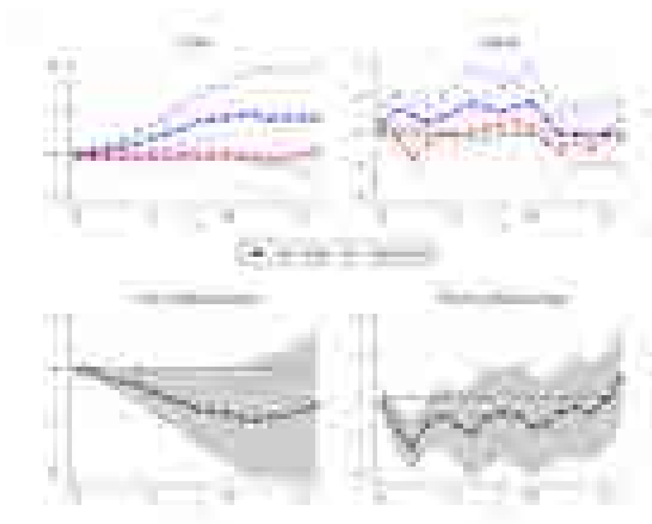
*Fiscal-monetary policy interaction.* The interaction between fiscal and monetary policy can also influence the sign and the size of the impact of fiscal policy on the macroeconomy. To the extent that fiscal policy affects the macroeconomy through inter and intra-temporal substitution effects and an income effect, the ultimate effect on the economy also hinges on current and future monetary policy behavior (Christiano et al., 2011; Davig and Leeper, 2011). For example, if the monetary policy is more expansionary when households are heavily indebted, it could mask the expansionary effect of tax policy during a high debt state. In particular, Favero and Giavazzi (2012) and Bertolotti et al. (2019), using the same narrative tax shock series from Romer

[23] Throughout this section, we only provide the difference in the state-dependent IRF coefficients for output, consumption, and output, and the corresponding p-values for selected horizons to save space. The state-dependent IRFs for every exercise is available upon request.

and Romer (2010), show that controlling for monetary policy in fiscal VARs is important to avoid omitted variable bias. Thus, to isolate the role of household indebtedness, we should investigate whether the stance of monetary policy in response to the tax cut systematically varies between the states.

We use the effective federal funds rate to measure the stance of monetary policy. We also look at the response of the log CPI for a comprehensive understanding of the state-dependent effects of tax policy. Figure 7 shows the state-dependent response of both the CPI and the federal funds rate.[24] Despite the stronger increase in private consumption during the high-debt state, an expansionary tax shock is less inflationary during this state, implying that the supply side of the economy also reacts differently depending on household indebtedness. In Section IV.D, we further discuss this issue by investigating the state-dependent effects of tax policy on the labor market.

**Figure 7.** State-dependent effect of an exogenous tax cut on the CPI and policy rate



Note: This graph shows the state-dependent response of the CPI (left) and federal funds rate (right) with a 90% confidence interval to an exogenous tax cut estimated using the sample from 1955Q1 to 2011Q4. The bottom panel reports the statistical difference in the estimated IRFs between the states. The tax shock is normalized by the potential GDP estimated by the Congressional Budget Office. The CPI and the federal funds rate are incorporated in logged value and level, respectively. Heteroskedasticity and autocorrelation consistent (HAC) standard errors of Newey and West (1987) are used.

Consistent with the weaker inflationary response during the high debt state, we find that monetary policy is somewhat more accommodative after an exogenous tax cut when households are heavily indebted, which might confound our findings. Thus, we estimate the effects of the tax shock after controlling for the

[24] See Figure B.4 in Appendix B for the linear response of these variables.

federal funds rate and its four lags to verify this claim. The second panel in Table A.3 confirms that the dynamics of GDP, consumption, and investment hardly change from the baseline model.

*Alternative definition of states.* In defining a state, we have used a binary indicator because of its simple interpretation. Here, we test the robustness of our findings using a probabilistic framework (i.e., smooth transition function) defined in the previous section. In Equation (2), the probability function $F(z_t)$ replaces $I(z_t)$ and also enters with a lag. The third panel in Table A.3 illustrates that the results remain qualitatively similar, but the state-dependent effects are more extreme than the baseline analysis, as expected. We further confirm that our key findings hold when we employ the Baxter and King (1999) band-pass filter to detrend the household debt to GDP variable. The fourth panel in Table A.3 confirms that the baseline findings hardly change when using the band-pass filter for isolating the frequencies between 4 and 64 quarters to define the measure of the household debt gap. Lastly, we allow for an immediate switch between states by relaxing the assumption on the minimum of four consecutive periods for each state and confirm that our findings still hold (the fifth panel in Table A.3).

*Accounting for potential bias in the estimates.* Teulings and Zubanov (2014) posit a potential bias in the local projections estimator when estimating the effect of the banking crisis on the loss of future output in the context of many zero observations (i.e., no crisis year), and suggest controlling for the forward values of the crisis dummy over the forecast horizons to correct this bias. Following the same, we control for the future value of tax shocks occurring over the estimation horizons (between periods $t$ and $t + k - 1$). The sixth panel in Table A.3 shows that the baseline results barely change, suggesting that the bias is unlikely an issue here.

*Great Recession and the ZLB.* Our baseline sample runs until 2011Q4, although the narrative shock series is available until 2007Q4. The flexible nature of local projections does not require balanced data but extreme behavior during the Great Recession and the subsequent ZLB might be seen as an outlier, rather than the average response of the economy to tax changes. To guard against this possibility, we re-estimate Equation (2) using the data up to 2007Q4 only. The last panel in Table A.3 confirms that our results are not driven by this outlier event.

*Omitted variable bias.* Despite the evidence of the strong state-dependent effects of tax shocks on the macroeconomy, the state of household debt may overlap with the state of other economic variables that could confound the documented state-dependent effects. Since the literature has already identified different kinds of state-dependent effects of tax policy, addressing this possibility is crucial for establishing new empirical findings. First, we investigate whether our definition of the high-debt state simply captures economic expansions during which tax multipliers are known to be larger (Ziegenbein, 2017; Sims and Wolff, 2018; Eskandari, 2019; Demirel, 2021).

As shown in Table A.1 in Appendix A, the correlation between the state defined by the household debt gap and the one defined by real GDP is near zero (0.03), implying that the role of business cycles is unlikely to mask the role of household debt in driving our findings. Nevertheless, it would still be an interesting exercise to see the relative importance of the two in generating state-dependent tax multipliers. To answer this question, following Bernardini and Peersman (2018), we estimate Equation (4), where the additional state variable captured by a binary indicator $I^S(w_t)$ is augmented to the original local projections:

$$\begin{aligned} y_{t+h} = & [\alpha_{N,h} + \beta_h^N shock_t + \Phi_{N,h}(L)X_t] + I(z_{t-1})[\alpha_{H,h} + \beta_h^H shock_t + \Phi_{H,h}(L)X_t] \\ & + I^S(w_{t-1})\left[\alpha_{S,H,h} + \beta_h^{S,H} shock_t + \Phi_{S,H,h}(L)X_t\right] + \varepsilon_{t+h}. \end{aligned} \tag{4}$$

Now the new indicator variable $I^s(w_t) = 1$ when the additional variable of concern $w_t$, such as output growth, is higher than its trend. The first bracket in Equation (4) captures the dynamics of macroeconomic variables during the baseline period outside both states (i.e., low household debt and low economic growth periods). As a result, $\beta_h^H$ in Equation (4) measures the additional effects of the identified tax shock during the high debt state, whereas $\beta_h^{S,H}$ measures the additional effects during the high growth state compared to the baseline.

Table A.4 in Appendix A summarizes the estimation results. On the one hand, we still find that the expansionary effects, especially on output and consumption, are larger during the high household debt state, even after controlling for the state of business cycles. They are also highly statistically significant, especially in the short run, lending further support to the independent role of household indebtedness in shaping the macroeconomic effects of tax changes. The interaction effects between tax shocks and the state of business cycles are still consistent with the existing studies (i.e., tax multipliers are larger during expansions).

We further confirm the robustness of our findings by augmenting the household debt state with the state capturing labor market slack, which is the original state variable considered in Ramey and Zubairy (2018). The slack of labor markets may provide additional information not captured by the phase of business cycles studied above. Following Ramey and Zubairy (2018), we define an economy as a slack state when the unemployment rate is above a certain threshold. Since our sample is shorter than Ramey and Zubairy (2018), we use the sample median of 5.7% as a threshold. As shown in the second panel of Table A.4, the household debt-dependent effect of tax changes still holds in this case.[25] We find no statistical difference in the effect of tax changes between the states defined by labor market slack.

The status of household debt may also overlap with the state of financial markets, which may influence the impact of tax policy through a different channel. We measure financial market conditions using a credit spread (spread between Aaa-grade corporate bonds and Baa-grade corporate bonds), as it is consistently available over a long period. We use the deviation of the credit spread from its trend using the HP filter, which is consistent with the definition of the debt gap measure. The last panel in Table A.4 confirms that the household debt-dependent effects of tax policy remain statistically significant after controlling for this additional state.

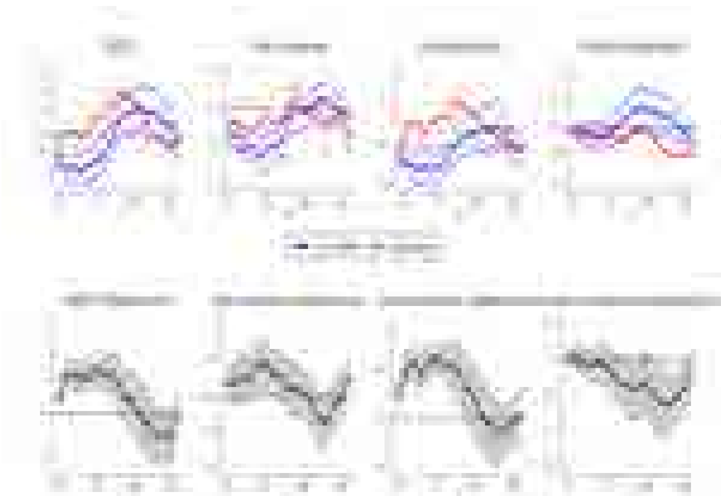
*Alternative measure of tax shock.* In this section, we use changes in the average marginal individual tax rate taken from Mertens and Montiel Olea (2018) as a tax shock and check whether the household debt-dependent effects of tax policy still hold when using this alternative measure. This robustness check is motivated by the fact that there are only infrequent exogeneous narrative tax changes in our sample, especially toward the end of the sample period. This raises a concern that our estimated effect might have been driven by a particular period rather than describing a general pattern in the data. As explained above, Romer and Romer's narrative tax shock series is also missing the 2008-10 tax stimulus acts and their consequence on the macroeconomy.

Figure 8 presents the estimation results using the data up to 2015Q4, which are largely consistent with the baseline. As shown in the linear case in Figure B.5 in Appendix B, the impact effect of tax changes is somewhat dwarfed compared to the baseline because tax cuts are often considered to combat the slowdown of the economy. This endogeneity issue explains the negative impact response of real GDP and it is precisely because we have used exogenous tax changes to answer the main question. Nevertheless, the pattern of state-dependent effect of tax changes remains the same. Other than the responses during both states being shifted downwards, tax cuts are still more effective in stimulating consumption and output during the high-debt state. Similar to the baseline, the greater effectiveness of tax policy during the high-debt state is not driven by larger cumulative tax cuts. To the extent that this exercise uses more frequent changes in the tax rate than the

[25] Our finding is robust to the alternative threshold using the mean of the unemployment rate in the sample (6%).

narrative series, it gives us further comfort in the relevance of household indebtedness in determining the effectiveness of tax policy.

**Figure 8.** State-dependent effect of the average marginal income tax rate changes



Note: This figure shows the state-dependent response of GDP (left), consumption (middle), and fixed investment (right) with a 90% confidence interval to a tax cut measured using changes in the average marginal tax rate from Mertens and Ravn (2018). The bottom panel reports the statistical difference in the estimated IRFs between the states. The sample runs from 1955Q1 to 2015Q4. Heteroskedasticity and autocorrelation consistent (HAC) standard errors of Newey and West (1987) are used.

*Fiscal foresight and types of tax shocks.* Lastly, it is well known that economic agents can respond to anticipated tax changes differently from unanticipated ones (e.g., Mertens and Ravn, 2011; Leeper et al., 2013). To guard against the concern of fiscal foresight, we only consider the unanticipated tax shock, which excludes tax policies where the delay between legislation and implementation is longer than a quarter.[26] To sharpen the identification even further, we focus on personal income tax changes only, which are directly linked to household disposable income.[27] If our measure of household indebtedness truly captures household

[26] Considering the concern about fiscal foresight, Mertens and Ravn (2011) separate the exogenous tax shock series of Romer and Romer (2010) into the one anticipated by economic agents and the one that is not (i.e., tax policies whose delay between legislation and implementation is shorter than a quarter).

[27] Mertens and Ravn (2013) further distinguish them into personal and corporate income tax changes. The disaggregation of exogenous tax changes into their subcomponents allows us to test the validity of our identifying assumption that the household debt gap proxies the degree of household borrowing constraints at the macro level. The literature has long recognized that personal income tax cuts stimulate the economy via the demand-side response, whereas corporate income tax cuts enhance the supply-side condition of the economy. Given our focus on household debt as a state variable, we analyze whether personal income tax shock actually generates the strong state dependence we documented.

borrowing constraints, the state-dependent effects should be pronounced in this most refined measure of tax shocks.

However, the disaggregation of the exogenous tax shocks raises new problems due to the correlation between legislated changes in personal and corporate taxes. We follow Mertens and Ravn (2013) to resolve this issue by incorporating both types of tax shocks and their lags in the estimation to capture the orthogonal component embedded in each type of tax shock. We estimate the following equation:

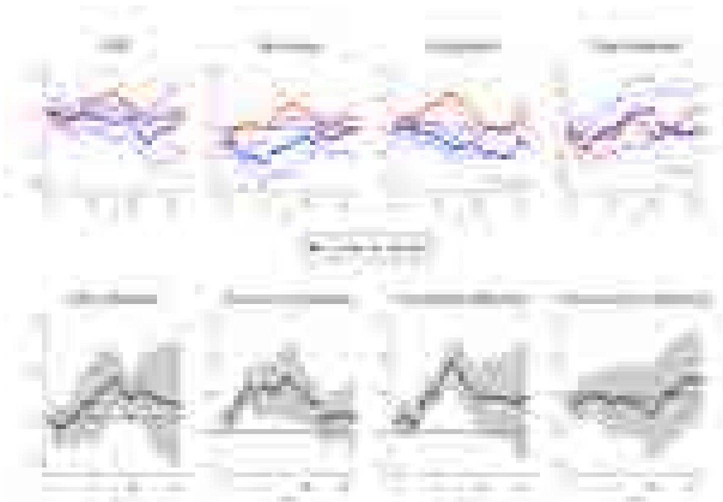
$$y_{t+h} = I(z_{t-1})\left[\alpha_{H,h} + \beta_{H,h}^{P} shock_t^{Personal} + \beta_{H,h}^{C} shock_t^{Corporate} + \Phi_{H,h}(L)X_t\right] + \left(1 - I(z_{t-1})\right)\left[\alpha_{L,h} + \beta_{L,h}^{P} shock_t^{Personal} + \beta_{L,h}^{C} shock_t^{Corporate} + \Phi_{L,h}(L)X_t\right] + \varepsilon_{t+h}, \quad (5)$$

where $shock_t^{Personal}$ and $shock_t^{Corporate}$ denote the surprise personal income tax shock and corporate income tax shock, respectively. The identifying assumption in Equation (5) is similar to the short-run identification used in the VAR model of Mertens and Ravn (2013), where the shock of interest is placed second in the Cholesky ordering, allowing for the contemporaneous effect of the other type of tax shocks, resulting in more conservative estimates.

Figure 9 shows the response of output, tax revenues, consumption, and fixed investment to the unanticipated exogenous reduction in personal income tax.[28] The response of output is somewhat less precisely estimated as compared with the baseline results probably due to the smaller number of refined shocks occurring in each state. However, the strong state-dependent consumption response suggests that our main results are robust to fiscal foresight and not driven by an alternative mechanism through the corporate income tax cut. Still, the investment response to the personal income tax shock is not strongly dependent on the state of household debt. This finding is indeed consistent with no plausible first-order effect of personal income tax changes on corporate balance sheet conditions. Nevertheless, one should take caution in taking these results given the reduced number of shocks during each state and the dominance of tax cuts over tax increases, which also applies to the following exercise on the asymmetry between positive and negative tax shocks.

**Figure 9.** State-dependent effect of an unanticipated personal tax cut

[28] See Figure B.6 in Appendix B for linear IRFs.



Note: This graph shows the state-dependent response of GDP (left), consumption (middle), and fixed investment (right) with a 90% confidence interval to an unanticipated personal income tax cut after controlling for a corporate income tax cut estimated using the sample from 1955Q1 to 2011Q4. The bottom panel reports the statistical difference in the estimated IRFs between the states. The dependent variable and the tax shock are normalized by the potential GDP estimated by the Congressional Budget Office. Heteroskedasticity and autocorrelation consistent (HAC) standard errors of Newey and West (1987) are used.

## C. Asymmetry between tax stimulus and consolidation

Because of the linear structure of the VARs used in the earlier empirical studies, the literature often overlooked the possible asymmetry between the macroeconomic impact of tax cuts and tax raises. Our estimated effect of a tax shock in the baseline analysis treats an increase and a decrease in tax symmetrically. However, a few studies investigate this potential asymmetry in the sign of tax changes (Jones et al., 2015; Hussain and Malik, 2016) and find that a tax cut has a significant expansionary impact on the U.S. economy, whereas the same size of a tax increase does not have a significant recessionary impact. Given that consumption response is key to our findings, the existing literature also points to an asymmetric consumption response to positive and negative transitory income shocks (Deaton, 1991; Bunn et al., 2018), further motivating this exercise.

If the sign of tax changes is systematically related to household indebtedness, the sign-dependent effects of tax policy documented in the existing studies may mask their state-dependent effects.[29] However, it appears that tax cuts are somewhat more frequent during the low-debt state than in the high-debt state, as

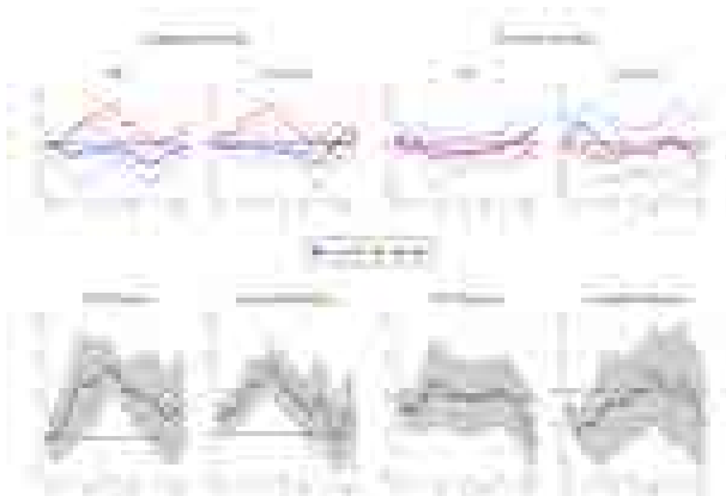
[29] See Barnichon and Matthes (2022) for a similar argument about the government spending policy.

shown in Table 1, working against finding our results. We still test these possibilities by estimating the following equation:

$$y_{t+h} = I(z_{t-1})\left[\alpha_{H,h} + \beta_{H,h}^{Pos} shock_t^{Pos} + \beta_{H,h}^{Neg} shock_t^{Neg} + \Phi_{H,h}(L)X_t\right] + \left(1 - I(z_{t-1})\right)\left[\alpha_{L,h} + \beta_{L,h}^{Pos} shock_t^{Pos} + \beta_{L,h}^{C} shock_t^{Neg} + \Phi_{L,h}(L)X_t\right] + \varepsilon_{t+h}, \quad (6)$$

where $shock_t^{Pos}$ denotes the exogenous tax increase, while $shock_t^{Neg}$ denotes the exogenous tax cut (i.e., $shock_t^{Pos} = max\ \{shock_t, 0\}$ and $shock_t^{Neg} = min\ \{shock_t, 0\}$).

**Figure 10.** State-dependent effect of the positive vs. negative tax shock



Note: This graph shows the state-dependent response of output and consumption with a 90% confidence interval to an exogenous tax cut (panel A) and an exogenous tax rise (panel B) estimated using the sample from 1955Q1 to 2011Q4. The bottom panel reports the statistical difference in the estimated IRFs between the states. The dependent variable and the tax shock are normalized by the potential GDP estimated by the Congressional Budget Office. Heteroskedasticity and autocorrelation consistent (HAC) standard errors of Newey and West (1987) are used. For the case of the tax decrease in Panel A, we switch the sign of the response to be consistent with the baseline analysis.

In Figure 10, we summarize the results of this exercise. In the case of the tax cut in Panel A, we switch the response sign to be consistent with the baseline analysis and leave the response sign for the tax increase in Panel B (i.e., negative numbers indicate an output decrease after a tax increase). Interestingly, a tax cut (rise) significantly increases (decreases) consumption only when households are heavily indebted, consistent with the implication of binding borrowing constraints of households.[30]

[30] If household borrowing constraints are not binding (i.e., during the low-debt period), changes in the constraint do not necessarily lead to a change in consumption response because households are at their unconstrained optimum.

However, the state-dependent effect of tax shocks on output is mainly driven by a tax cut. This observation complements the finding of Klein (2017), who asserts that fiscal austerity, especially tax-based consolidation, is particularly painful in periods of private-debt overhang using the large consolidation episodes from the 12 OECD countries. However, given that Klein (2017) only focused on consolidation episodes, our finding implies that such debt-dependent effects could be even stronger if stimulus episodes are further taken into consideration. In other words, gains from tax-based expansion could be particularly helpful in stimulating consumption and output during periods of high household debt.

## D. Exploring channels via additional exercises

This section explores the response of other macroeconomic variables to the identified tax shock to better understand the mechanism through which tax policies interact with household indebtedness. Building on the existing literature on the transmission channel of fiscal policy, we consider three following channels (labor market, housing market, and confidence) to enhance our understanding of household-debt dependent effects of tax policy.

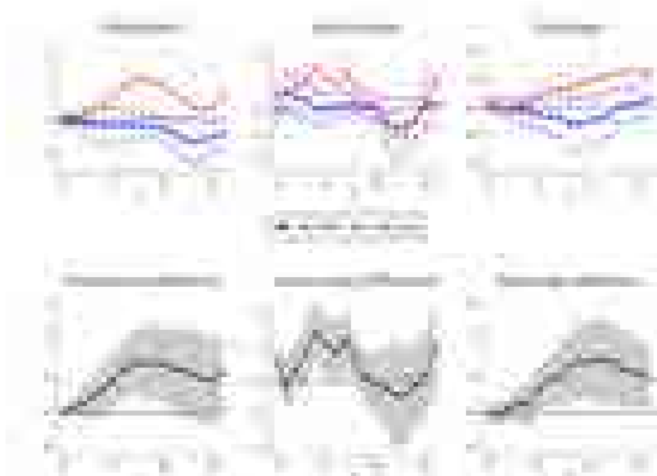
*Effects on the labor market.* First of all, we examine the state-dependent effects of tax shocks on labor market variables. Since one of the main channels through which fiscal policy affects the output in a neoclassical model is household labor supply decisions, investigating the response of labor market variables helps interpret our main findings. Sequentially, as summarized in Figure 11, we explore the responses of employment, average hours worked, and real wages to the identified tax shock.[31]

The strong state-dependency in the employment and average hours worked response resembles that of output and consumption, implying the relevance of the labor supply channel of a standard neoclassical model in addition to the Keynesian aggregate demand channel considered above. The insignificant effect of a tax reduction on output in the low-debt state can be attributed to the lack of an increase in labor supply as the positive income effect from a tax cut partially offsets the substitution effect. Such an income effect is absent when households are heavily indebted, which is consistent with the ample micro-level evidence about

[31] The linear response of these variables is summarized in Figure B.7 in Appendix B. The precise description of each variable is as follows: the total number of nonfarm employees, average weekly hours of production and nonsupervisory employees, and average hourly earnings of production and nonsupervisory employees deflated by the CPI, respectively. All data are downloaded from the Bureau of Labor Statistics.

the consequence of borrowing constraints on labor supply decisions (e.g., Del Boca and Lusardi, 2003; Rossi and Trucchi, 2016).

**Figure 11.** Effect of an exogenous tax cut on labor market variables



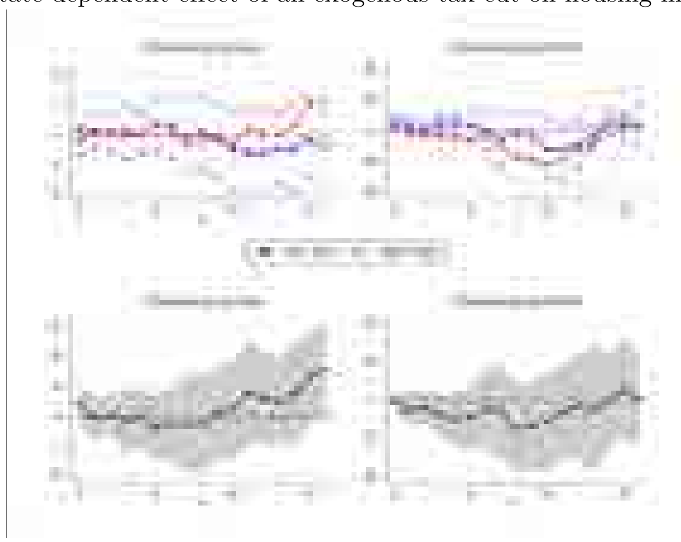
Note: This graph shows the state-dependent response of employment (left), hours worked (middle), and real wages (right) with a 90% confidence interval to an exogenous tax cut estimated using the sample from 1955Q1 to 2011Q4. The bottom panel reports the statistical difference in the estimated IRFs between the states. The tax shock is normalized by the potential GDP estimated by the Congressional Budget Office. Heteroskedasticity and autocorrelation consistent (HAC) standard errors of Newey and West (1987) are used.

Interestingly, the response of real wages shows a pattern similar to that of labor supply, implying that labor demand response is also state-dependent (i.e., increases during the high-debt and decreases during the low-debt state), more than dampening the labor supply effect on real wages. The increased labor demand squares with the increased business investment during the high-debt state presented earlier (Figure 6). Combining the absence of the income effect and a higher MPC can account for the strong expansionary effects of tax cuts when households are heavily indebted.

*Effects on the housing market.* We examine the state-dependent response of housing market variables to the exogenous tax shock to shed light on the role of housing cycles in transmitting tax policy. We use the median sales price of houses from the U.S. Census Bureau to measure housing prices at the national level, which is deflated by the CPI. We take the number of new private housing units authorized by the U.S. Census Bureau to measure the supply side of housing markets.

As shown in Figure 12, the response of housing prices does not depend significantly on the underlying state of household debt, which is in sharp contrast to the consumption and labor responses.[32] Importantly, it is not statistically significant in the linear model either, as shown in Figure B.8 in Appendix B, suggesting a no first-order effect of a tax cut on housing prices. The lack of a housing price response to a tax shock is distinct from the case of a government spending increase, which typically finds an appreciation in housing prices in the data (Khan and Reza, 2017). The response of housing permits to an exogenous tax cut is neither statistically significant in the linear model nor in the state-dependent model. Combined with the earlier finding on the residential investment response, which does not depend on the state of household indebtedness (Figure 6), changes in housing prices are unlikely to be the main channel for the household debt-dependent effects of tax policy.

**Figure 12.** State-dependent effect of an exogenous tax cut on housing market variables



Note: This graph shows the state-dependent response of housing prices (left) and housing permits (right) with a 90% confidence interval to an exogenous tax cut estimated using the sample from 1963Q1 to 2011Q4 (housing prices) and from 1960Q1 to 2011Q4 (housing permits). The bottom panel reports the statistical difference in the estimated IRFs between the states. The tax shock is normalized by the potential GDP estimated by the Congressional Budget Office. Heteroskedasticity and autocorrelation consistent (HAC) standard errors of Newey and West (1987) are used.

The recent literature following the seminal contribution by Iacoviello (2005) has emphasized the role of housing as collateral and explained the state-dependent effects of government spending policy via the housing collateral channels (e.g., Andrés et al., 2015; Alpanda et al., 2021; McManus et al., 2021; Klein et al., 2022). In this class of models, household collateral constraints are tied to the value of housing and the

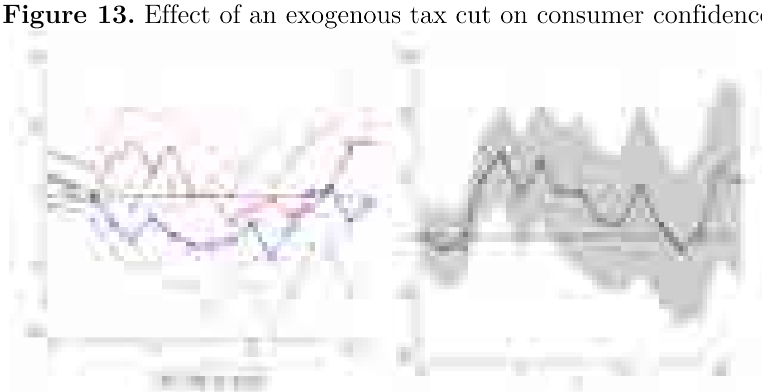
[32] We obtain similar results using the S&P/Case-Shiller U.S. National Home Price Index—available for the full sample period—, which are available on request.

appreciation of housing prices is key to amplifying the effect of government spending increases on consumption. However, given the first-order effect of tax changes on current disposable income—distinct from the indirect effect of government spending changes—, the appreciation of housing prices is not necessary to generate the household debt-dependent effect of tax policy. The Ricardian equivalence no longer holds when households are borrowing-constrained so an increase in current income due to an income tax cut can have a direct and immediate effect on consumption.

*Effects on consumer confidence.* The literature on the effectiveness of fiscal policy has also recognized the role of confidence in shaping the size of government spending multipliers (e.g., Bachmann and Sims, 2012; De Grauwe and Foresti, 2020). Through the lens of the expectation-driven business cycle models, tax cuts can have strong expansionary effects if they make consumers more optimistic about the future path of the economy. In other words, if the identified tax shock affects consumers' beliefs about the state of the economy, it increases consumption and output independently of the household debt channel.

To test whether the consumer confidence channel can explain our findings, we investigate the effects of the tax shock on consumer confidence. We measure consumer confidence using the Index of Consumer Sentiment (ICS) hosted by the University of Michigan. This index has been widely used to measure consumer confidence because of its extensive time-series coverage since the 1960s. The survey contains questions on the respondents' confidence about the current business conditions and their expectations about future business conditions. The index used in the following exercise is the average of the current and expected index, and higher numbers represent more confidence about the current and future state of the U.S. economy.

**Figure 13.** Effect of an exogenous tax cut on consumer confidence



Note: This graph shows the state-dependent response of consumer confidence (left) with a 90% confidence interval to an exogenous tax cut estimated using the sample from 1960Q1 to 2011Q4. The right panel reports the statistical difference in the estimated IRFs between the states. The tax shock is normalized by the potential GDP estimated by the Congressional Budget Office. Heteroskedasticity and autocorrelation consistent (HAC) standard errors of Newey and West (1987) are used.

The left panel in Figure 13 shows that consumer confidence is not very responsive to the exogenous tax shock in both states—despite some statistically significant differences in the response across the household debt states—, limiting its role in understanding the macroeconomic effects of tax changes.[33] Thus, the household debt-dependent effects of the tax shock are unlikely to be explained by the consumer confidence channel.

## V. Conclusion

In this study, we find that tax policy can be more effective when households are heavily indebted. The primary mechanism through which the household debt-dependent tax multiplier manifests is the response of private consumption, which is consistent with the identifying assumption that household indebtedness proxies their borrowing constraints even when households have a positive net worth (Kaplan and Violante, 2014; Klein et al., 2022). The findings remain robust after controlling for other confounding factors, such as the stance of monetary policy, the nature of fiscal policy actions, and fiscal foresight. When the household debt gap is augmented with other states of the economy, such as the phase of business cycles, slack of labor markets, and financial market conditions, the household debt-dependent effects of tax policy remain robust.

The sharp difference in the response of employment and average hours worked between the states suggests an additional source of asymmetry in tax multipliers. While a tax cut does not increase labor supply due to the offsetting income effect in the low-debt state, the income effect becomes largely absent when households are heavily indebted. This leads to a further increase in labor supply and, therefore, output. This finding is consistent with ample evidence from micro-level studies on household borrowing constraints and labor supply. Given the first-order effect of tax cuts on household current disposable income, we show that the mechanism at play is distinct from the housing collateral channel or confidence channel, which has been claimed as the main transmission channel of government spending policy.

With inference from the recent study by Alpanda and Zubairy (2019) that monetary policy becomes less effective when households are heavily indebted, our findings provide interesting policy implications. We shed new light on the existing literature by presenting evidence that tax cuts could also be a viable option for

[33] See Figure B.9 in Appendix B for linear IRFs. We obtain similar findings when using each subcomponent of the index only (i.e., either current conditions or future conditions), which is available upon request.

effective fiscal stimulus when households are heavily indebted. Despite the stronger consumer demand effect in the high-debt state, the inflationary pressure is weaker than in the low-debt state due to the supply-side response of the economy driven by a strong labor supply response. This feature of data is particularly welcoming amid the greater concern about rising inflation worldwide these days. Moreover, the authorities do not need to worry about the subsequent housing price booms and busts that could undermine financial stability, which is often the case for expansionary government spending (Khan and Reza, 2017).

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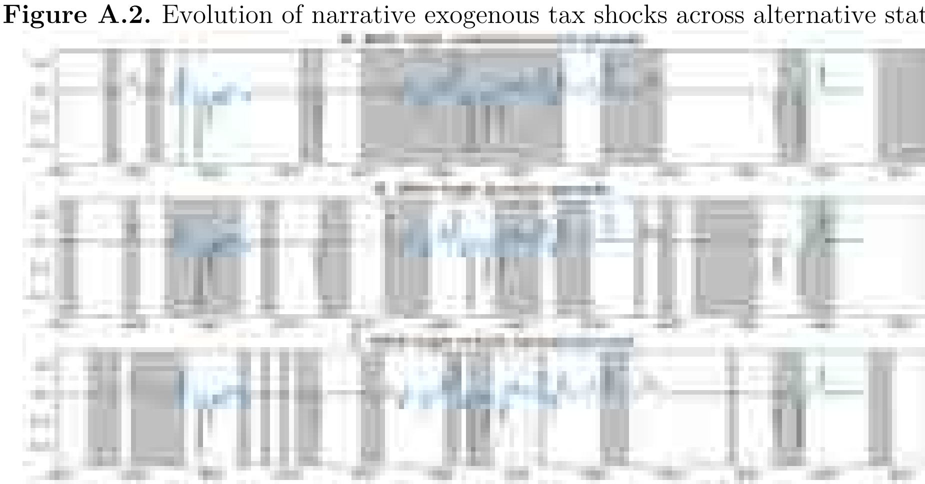
# Appendix

## A. Additional figures and tables

**Figure A.1.** Household debt gap measure: baseline and probability measures

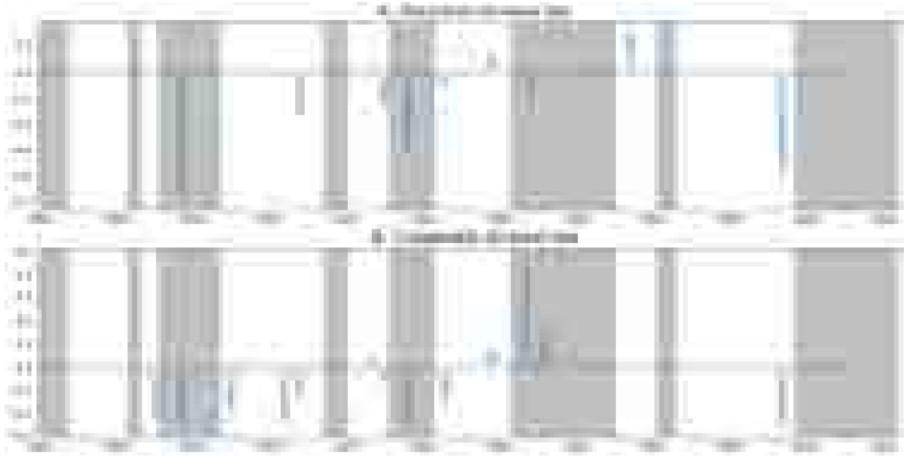
Note: This graph shows the baseline debt gap measure using the HP-detrended household debt to GDP ratio (left) and the probability of a high-debt state generated through a smooth transition function (right) from 1951Q4 to 2015Q4. The shaded area denotes the recession period defined by the National Bureau of Economic Research.

**Figure A.2.** Evolution of narrative exogenous tax shocks across alternative states



Note: This graph plots measures of exogenous tax changes, which is narrative tax shock series from Romer and Romer (2010) as a share of the potential GDP (%). The shaded areas correspond to alternative states, including those based on unemployment, real GDP growth, and credit spread, respectively.

**Figure A.3.** Evolution of surprise personal income and corporate income tax shocks across states



Note: This graph plots the unanticipated personal income tax shock (Panel A) and the unanticipated corporate income tax shock (Panel B) taken from Mertens and Ravn (2013) as a share of potential GDP (%). The shaded area is a high household debt state.

**Table A.1.** Correlation matrix of state variables

| | Debt (binary) | Debt (smooth) | Unemployment | Real GDP | Credit spread |
|---|---|---|---|---|---|
| Debt (binary) | 1 | | | | |
| Debt (smooth) | 0.708 | 1 | | | |
| Unemployment | -0.048 | -0.015 | 1 | | |
| Real GDP | 0.035 | -0.116 | 0.018 | 1 | |
| Credit spread | -0.139 | -0.102 | 0.310 | -0.129 | 1 |

Note: This table shows the correlation between state variables. Debt (binary) is a dummy variable for the high-debt state, which is our baseline measure. Debt (smooth) is the probability of a high-debt state generated through a smooth transition function. Unemployment is a dummy variable for a high unemployment rate (labor market slack). Real GDP is a dummy variable capturing economic expansions.

**Table A.2.** Data description

| Data | Source | Definition |
|---|---|---|
| Real GDP | Bureau of Economic Analysis | The value of the goods and services produced in the United States. |
| Consumption | | Personal consumption expenditures. Goods and services purchased by households and nonprofit institutions serving households. |
| Durable consumption | | Personal consumption expenditure on durable goods (goods with at least three years of useful life on average). |
| Non-durable consumption | | Personal consumption expenditure on non-durable goods (goods with less than three years of useful life on average). |
| Service consumption | | Personal consumption expenditure on services (commodities that cannot be stored or inventoried and that are usually consumed at the place and time of purchase). |
| Fixed investment | | Spending by private businesses, nonprofit institutions, and households on fixed assets in the U.S. economy. |
| Residential investment | | Spending on residential structures and equipment. |
| Non-residential investment | | Spending on non-residential structures, equipment, and intellectual property products. |
| Government spending | | Government consumption and expenditures and gross investment. Spending by the government to produce and provide services to the public. |
| Tax revenues | | Federal current receipt. Federal government's revenue, including current tax receipts and contributions for government social insurance. (FGRECPT) |
| Potential GDP | Congressional Budget Office | CBO's estimate of the output the economy would produce with a high rate of use of its capital and labor resources. |
| Consumer Price Index | Bureau of Labor Statistics | CPI for all urban consumers. (CIPAUCSL) |
| Employment | | The total number of nonfarm employees. |
| Hours worked | | Average weekly hours of production and nonsupervisory employees. |

| | | |
|---|---|---|
| Wages | | Average hours earnings of production and nonsupervisory employees. |
| Household debt | FRED | Household and nonprofit organizations; Debt securities and loans (CMDEBT). |
| Federal funds rate | | The effective federal funds rate. |
| Credit spread | Moody's | The difference between the Baa corporate bond yield and Aaa corporate bond yield. |
| Housing prices | U.S. Census Bureau | The median sales price of houses. |
| Housing permits | | New private housing units authorized. |
| Shiller Real Housing Price Index | Robert Shiller's Homepage | Housing price index developed by Karl Case and Robert Shiller.<br>Available at http://www.econ.yale.edu/~shiller/data.htm |
| Index of Consumer Sentiment | Surveys of Consumers website | Survey on consumers' sentiment conducted by the University of Michigan.<br>Available at http://www.sca.isr.umich.edu/ |
| Tax shock | Romer and Romer (2010) | Series of exogenous tax shock based on analysis of narrative sources such as presidential speeches, reports of Congressional committees, etc. |
| Personal/corporate tax shock | Mertens and Ravn (2013) | Unanticipated tax shock based on the series of Romer and Romer (2010). Tax changes whose lag between legislation and implementation is longer than a quarter are excluded as they are "anticipated" by economic agents. |
| Military spending news shock | Ramey (2011) | Series of exogenous changes in government expenditure based on news reports about military spending. |

Note: This table provides the source and description of the data used in the analysis.

**Table A.3.** Difference between the two states and statistical significance: robustness checks

| | GDP | | Consumption | | Investment | |
|---|---|---|---|---|---|---|
| | Coef diff | p-value | Coef diff | p-value | Coef diff | p-value |
| | | | Controlling for tax revenues | | | |
| On impact | 0.21 | 0.58 | 0.44 | 0.00 | 0.21 | 0.25 |
| Q4 | 1.69 | 0.08 | 1.25 | 0.00 | 0.32 | 0.35 |
| Q8 | 2.83 | 0.01 | 1.17 | 0.01 | 0.02 | 0.98 |
| Q12 | 1.76 | 0.17 | 0.75 | 0.27 | -0.82 | 0.25 |
| | | | Controlling for monetary policy | | | |
| On impact | 0.14 | 0.76 | 0.51 | 0.02 | 0.10 | 0.60 |
| Q4 | 0.99 | 0.07 | 0.88 | 0.06 | 0.13 | 0.80 |
| Q8 | 1.89 | 0.02 | 0.66 | 0.19 | -0.35 | 0.55 |
| Q12 | 0.82 | 0.61 | 0.62 | 0.43 | -1.15 | 0.24 |
| | | | Using a smooth transition function | | | |
| On impact | 0.91 | 0.38 | 1.61 | 0.00 | 0.68 | 0.13 |
| Q4 | 6.21 | 0.00 | 3.26 | 0.00 | 1.13 | 0.13 |
| Q8 | 9.32 | 0.00 | 2.87 | 0.03 | 1.87 | 0.12 |
| Q12 | 6.56 | 0.02 | 2.32 | 0.10 | 0.71 | 0.73 |
| | | | Using a band-pass filter | | | |
| On impact | 0.58 | 0.21 | 0.59 | 0.00 | 0.25 | 0.21 |
| Q4 | 2.20 | 0.07 | 1.01 | 0.02 | 0.21 | 0.56 |
| Q8 | 3.20 | 0.00 | 0.96 | 0.05 | -0.38 | 0.57 |
| Q12 | 3.64 | 0.00 | 1.06 | 0.15 | -0.91 | 0.32 |
| | | | Allowing for immediate switch between states | | | |
| On impact | 1.75 | 0.24 | 1.02 | 0.04 | 0.39 | 0.34 |
| Q4 | 2.92 | 0.00 | 1.05 | 0.00 | 0.45 | 0.44 |
| Q8 | 2.52 | 0.03 | 0.85 | 0.16 | -0.05 | 0.96 |
| Q12 | 1.75 | 0.24 | 1.02 | 0.04 | 0.39 | 0.34 |
| | | | Controlling for future tax shocks | | | |
| On impact | 0.27 | 0.58 | 0.50 | 0.00 | 0.18 | 0.34 |
| Q4 | 2.08 | 0.12 | 1.30 | 0.00 | 0.53 | 0.24 |
| Q8 | 3.21 | 0.00 | 1.33 | 0.01 | 0.64 | 0.38 |
| Q12 | 3.54 | 0.02 | 1.59 | 0.02 | 0.27 | 0.74 |
| | | | Dropping the Great Recession | | | |
| On impact | 0.27 | 0.58 | 0.50 | 0.00 | 0.18 | 0.34 |
| Q4 | 1.96 | 0.14 | 1.24 | 0.00 | 0.25 | 0.59 |
| Q8 | 3.10 | 0.01 | 1.23 | 0.01 | 0.26 | 0.58 |
| Q12 | 2.18 | 0.13 | 1.04 | 0.16 | -0.35 | 0.58 |

Note: This table summarizes the difference in the coefficients between the two states in Equation (2) and the corresponding p-values for the null hypothesis of the two coefficients being equal.

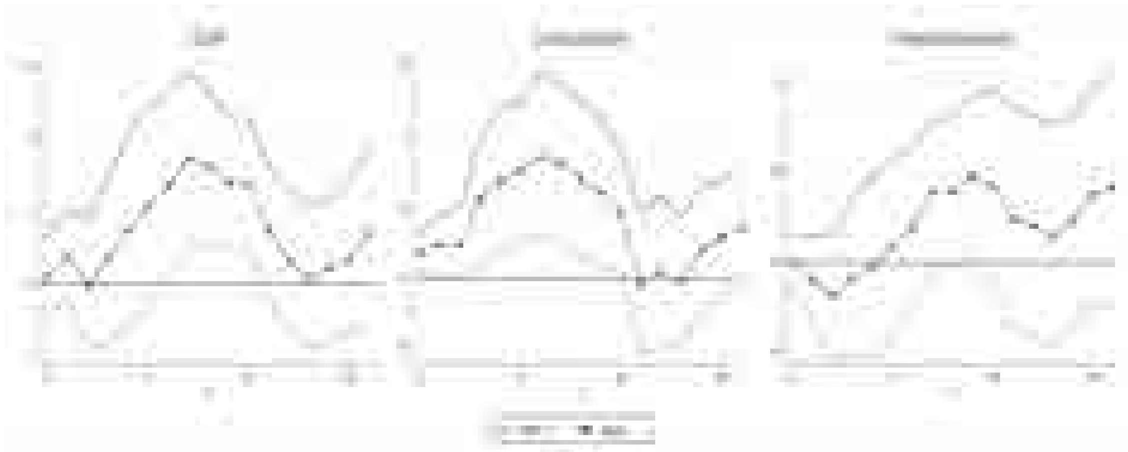
**Table A.4.** Robustness checks: controlling for additional states

| GDP | On impact | Q4 | Q8 | Q12 | Consumption | On impact | Q4 | Q8 | Q12 | Fixed Investment | On impact | Q4 | Q8 | Q12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Controlling for business cycles** | | | | | | | | | | | | | | |
| Baseline | 0.672 | 0.870 | 0.718 | -0.726 | Baseline | 0.149 | 0.189 | 0.229 | -0.346 | Baseline | 0.303 | 0.274 | 0.545 | 0.296 |
| | (0.006) | (0.376) | (0.210) | (0.568) | | (0.406) | (0.631) | (0.493) | (0.596) | | (0.047) | (0.254) | (0.169) | (0.594) |
| High debt | 0.555 | 2.571 | 3.801 | 1.728 | High debt | 0.695 | 1.524 | 1.441 | 0.583 | High debt | 0.438 | 0.475 | 0.054 | -0.995 |
| | (0.164) | (0.003) | (0.002) | (0.140) | | (0.000) | (0.000) | (0.005) | (0.389) | | (0.034) | (0.150) | (0.928) | (0.107) |
| Expansion | 1.077 | 2.337 | 2.157 | 0.551 | Expansion | 0.506 | 0.721 | 0.902 | -0.075 | Expansion | 0.743 | 0.818 | 0.636 | 0.127 |
| | (0.006) | (0.014) | (0.086) | (0.695) | | (0.050) | (0.058) | (0.042) | (0.910) | | (0.002) | (0.003) | (0.100) | (0.855) |
| **Controlling for labor market slack** | | | | | | | | | | | | | | |
| GDP | On impact | Q4 | Q8 | Q12 | Consumption | On impact | Q4 | Q8 | Q12 | Fixed Investment | On impact | Q4 | Q8 | Q12 |
| Baseline | -0.110 | 0.897 | -1.000 | -0.699 | Baseline | shock | -0.206 | -0.118 | -0.064 | Baseline | -0.451 | 0.555 | 0.548 | 0.925 |
| | (0.873) | (0.487) | (0.376) | (0.464) | | | (0.325) | (0.825) | (0.872) | | (0.119) | (0.235) | (0.292) | (0.173) |
| High debt | 0.381 | 1.102 | 2.630 | 0.364 | High debt | 0.657 | 1.287 | 0.576 | 0.152 | High debt | 0.499 | -0.185 | -0.143 | -1.195 |
| | (0.531) | (0.295) | (0.011) | (0.782) | | (0.001) | (0.000) | (0.144) | (0.842) | | (0.118) | (0.666) | (0.795) | (0.099) |
| High slack | 0.139 | -1.319 | 0.700 | -0.854 | High slack | 0.192 | 0.140 | -0.079 | 0.020 | High slack | 0.492 | -0.660 | -0.343 | -0.957 |
| | (0.827) | (0.409) | (0.601) | (0.400) | | (0.480) | (0.804) | (0.862) | (0.972) | | (0.046) | (0.317) | (0.553) | (0.185) |
| **Controlling for financial market conditions** | | | | | | | | | | | | | | |
| GDP | On impact | Q4 | Q8 | Q12 | Consumption | On impact | Q4 | Q8 | Q12 | Fixed Investment | On impact | Q4 | Q8 | Q12 |
| Baseline | 1.305 | 0.114 | 1.126 | -0.199 | Baseline | 0.070 | -0.029 | 0.446 | -0.503 | Baseline | -0.125 | -0.017 | 1.053 | 0.923 |
| | (0.005) | (0.911) | (0.333) | (0.892) | | (0.744) | (0.960) | (0.552) | (0.566) | | (0.521) | (0.980) | (0.331) | (0.343) |
| High debt | -0.310 | 1.379 | 1.644 | 0.935 | High debt | 0.456 | 1.029 | 0.255 | 0.516 | High debt | 0.243 | 0.232 | -0.686 | -1.504 |
| | (0.161) | (0.126) | (0.128) | (0.535) | | (0.071) | (0.068) | (0.718) | (0.561) | | (0.274) | (0.698) | (0.453) | (0.122) |
| High spread | -1.306 | -0.308 | -1.094 | -0.966 | High spread | 0.016 | 0.223 | -0.365 | 0.126 | High spread | 0.038 | -0.328 | -0.911 | -0.775 |
| | (0.064) | (0.756) | (0.378) | (0.539) | | (0.950) | (0.567) | (0.619) | (0.885) | | (0.823) | (0.584) | (0.343) | (0.371) |

Note: This table summarizes the coefficients of each additional state in Equation (3) and the corresponding p-values for the null hypothesis of the additional coefficients being zero.

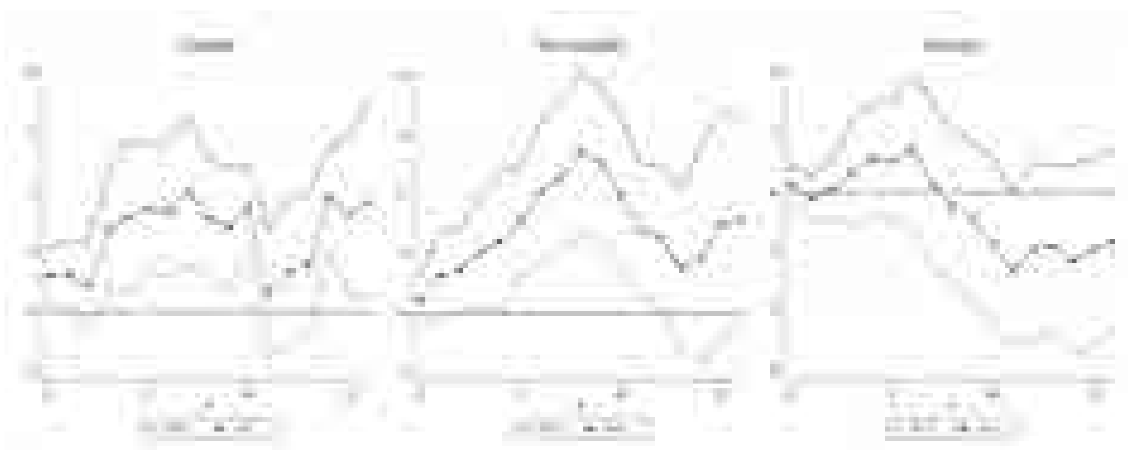
## B. Linear impulse response functions

**Figure B.1.** Effect of an exogenous tax cut on output, consumption, and investment



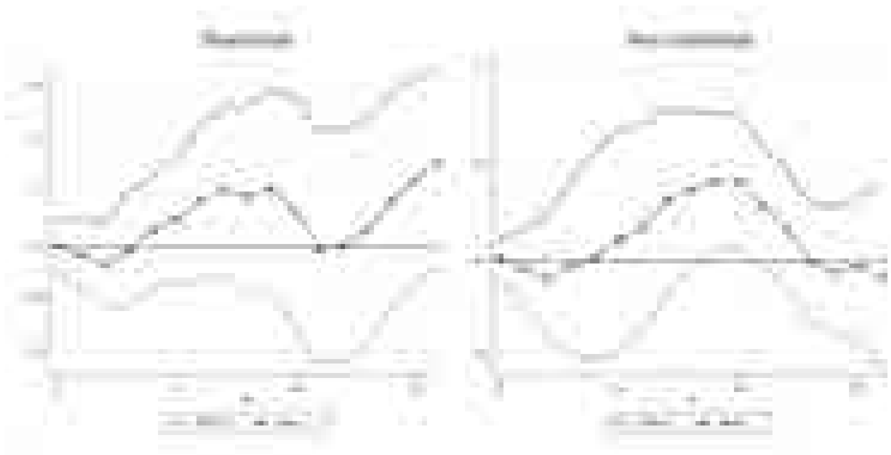
Note: This graph shows the response of GDP, private consumption, and private fixed investment with a 90% confidence interval to an exogenous tax cut estimated using the sample from 1955Q1 to 2011Q4. The dependent variable and the tax shock are normalized by the potential GDP estimated by the Congressional Budget Office. Heteroskedasticity and autocorrelation consistent (HAC) standard errors of Newey and West (1987) are used.

**Figure B.2.** Effect of an exogenous tax cut on components of consumption



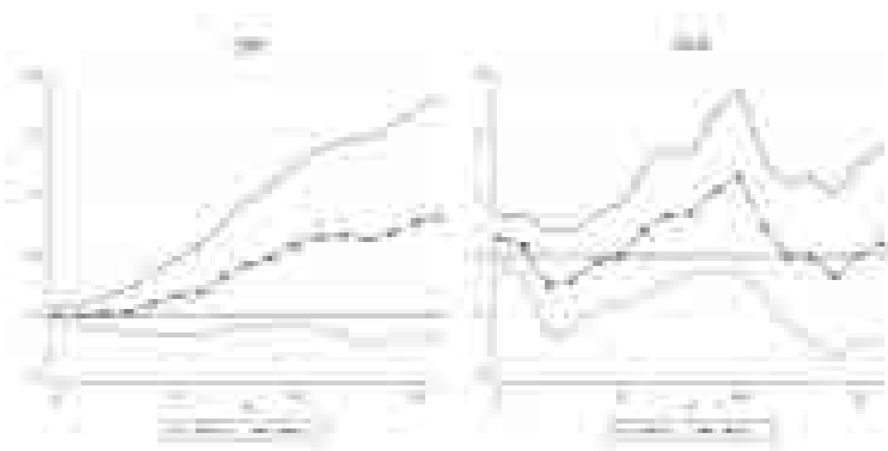
Note: This graph shows the response of each component of private consumption with a 90% confidence interval to an exogenous tax cut estimated using the sample from 1955Q1 to 2011Q4. The dependent variable and the tax shock are normalized by the potential GDP estimated by the Congressional Budget Office. Heteroskedasticity and autocorrelation consistent (HAC) standard errors of Newey and West (1987) are used.

**Figure B.3.** Effect of an exogenous tax cut on components of investment



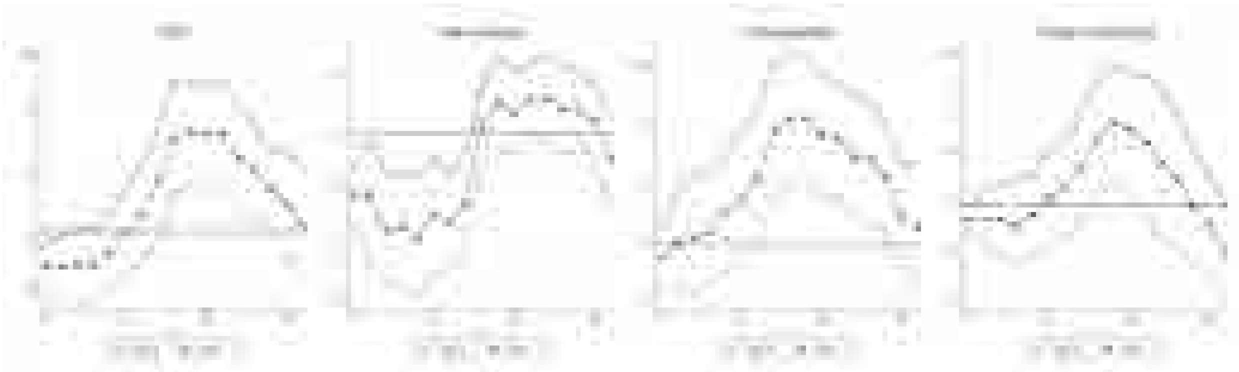
Note: This graph shows the response of each component of private fixed investment with a 90% confidence interval to an exogenous tax cut estimated using the sample from 1955Q1 to 2011Q4. The dependent variable and the tax shock are normalized by the potential GDP estimated by the Congressional Budget Office. Heteroskedasticity and autocorrelation consistent (HAC) standard errors of Newey and West (1987) are used.

**Figure B.4.** Effect of an exogenous tax cut on the CPI and the federal funds rate



Note: This graph shows the response of the log CPI and federal funds rate with a 90% confidence interval to an exogenous tax cut estimated using the sample from 1955Q1 to 2011Q4. The tax shock is normalized by the potential GDP estimated by the Congressional Budget Office. Heteroskedasticity and autocorrelation consistent (HAC) standard errors of Newey and West (1987) are used.

**Figure B.5.** Effect of changes in the average marginal income tax rate on output, consumption, and investment

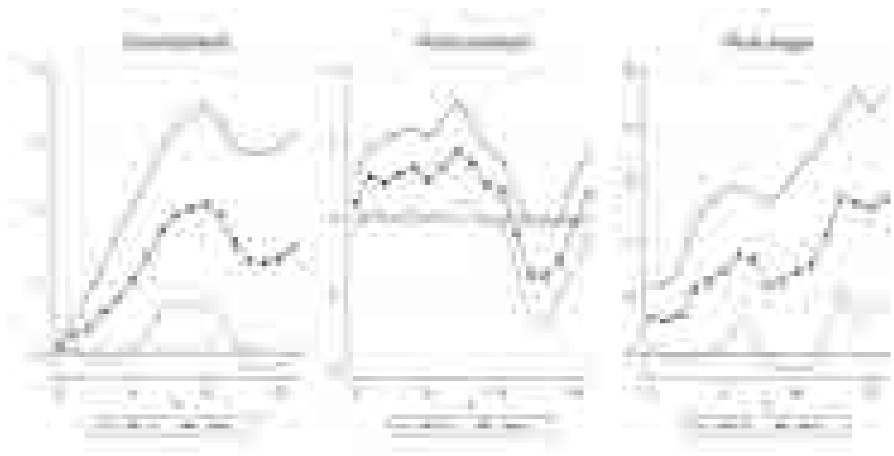


Note: This graph shows the response of GDP, consumption, and fixed investment with a 90% confidence interval to an exogenous tax cut estimated using the sample from 1955Q1 to 2011Q4. The dependent variable and the tax shock are normalized by the potential GDP estimated by the Congressional Budget Office. Heteroskedasticity and autocorrelation consistent (HAC) standard errors of Newey and West (1987) are used.

**Figure B.6.** Effect of changes in an unanticipated personal tax cut

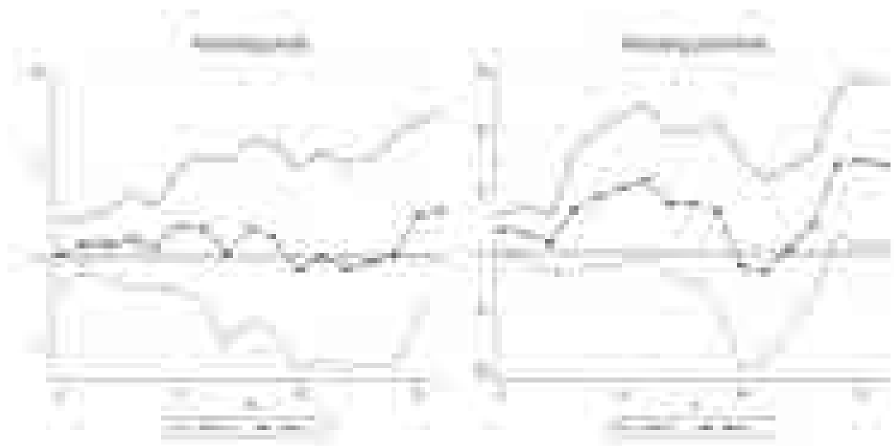
Note: This graph shows the response of GDP, consumption, and fixed investment with a 90% confidence interval to an unanticipated personal income tax cut after controlling for a corporate income tax cut estimated using the sample from 1955Q1 to 2011Q4. The dependent variable and the tax shock are normalized by the potential GDP estimated by the Congressional Budget Office. Heteroskedasticity and autocorrelation consistent (HAC) standard errors of Newey and West (1987) are used.

**Figure B.7.** Effect of an exogenous tax cut on labor market variables



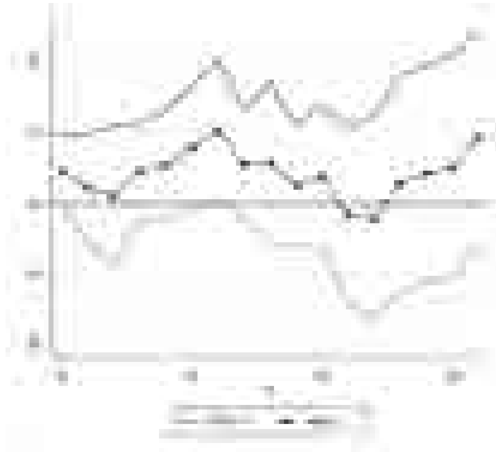
Note: This graph shows the response of labor market variables with a 90% confidence interval to an exogenous tax cut estimated using the sample from 1955Q1 to 2011Q4. The tax shock is normalized by the potential GDP estimated by the Congressional Budget Office. Heteroskedasticity and autocorrelation consistent (HAC) standard errors of Newey and West (1987) are used.

**Figure B.8.** Effect of an exogenous tax cut on housing market variables



Note: This graph shows the response of housing market variables with a 90% confidence interval to an exogenous tax cut estimated using the sample from 1963Q1 to 2011Q4 (housing prices) and from 1960Q1 to 2011Q4 (housing permits). The tax shock is normalized by the potential GDP estimated by the Congressional Budget Office. Heteroskedasticity and autocorrelation consistent (HAC) standard errors of Newey and West (1987) are used.

**Figure B.9.** Effect of an exogenous tax cut on consumer confidence



Note: This graph shows the response of consumer confidence with a 90% confidence interval to an exogenous tax cut estimated using the sample from 1960Q1 to 2011Q4. The tax shock is normalized by the potential GDP estimated by the Congressional Budget Office. Heteroskedasticity and autocorrelation consistent (HAC) standard errors of Newey and West (1987) are used.