The Role of Corporate Tax Policy on Monetary Effectiveness: A Quasi-Experimental Approach*

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Abstract

This paper documents the first empirical evidence on how corporate tax policy affects monetary policy outcomes. Using exogenous marginal tax reforms in the US, I show that the average impact of monetary policy differs based on the tax treatments firms receive. Specifically, I find that monetary policy is more effective on employment and investment when firms face tax increases relative to the times when firms face stable taxes. Moreover, I show that monetary policy is least effective when firms face marginal tax cuts. The empirical findings are rationalized using a New Keynesian model featuring capital and corporate income taxes.

JEL Classification: E52, E62, E63

Keywords: monetary policy, corporate taxes, tax narrative approach

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1. Introduction

Corporate tax policy and monetary policy have been at the center of policy debates in recent decades. However, despite the intertwined nature of these two policies, most of the current empirical literature studies them in isolation. This paper aims to explore the intersection of monetary policy and tax policy by posing the following questions: Do dynamics of the tax system matter for the effectiveness of monetary policy? Can changes in US corporate taxes weaken the effectiveness of monetary policy? The answers to these questions are crucial for public policy and understanding how tax policy affects monetary policy outcomes.

This paper presents the first empirical evidence on how corporate tax policy influences the effectiveness of monetary policy using micro-data. My framework employs macro identification of tax changes using narrative methods1 and builds a novel quasi-experimental design that tests the impact of tax policy on monetary effectiveness. The main findings show that tax cuts (increases) cause consequent monetary policy to be less (more) effective. In other words, changes in tax policy generate considerable variation in monetary effectiveness.

The interaction of monetary policy and tax policy can be observed in traditional theories of investment within a user cost channel (Hayashi, 1982; Hall and Jorgenson, 1967) where the cost of financing a firm’s investment and its tax treatment jointly affects firms’ investment decisions. A simple textbook user cost equation would predict that an increase in statutory taxes raises firms’ user cost, leading to a lower level of capital and a higher required level of marginal product of capital (MPK) for the investment projects to be profitable. When a monetary contraction hits during this period, firms contract the capital stock more as the current productivity level they seek is much higher than before. My paper provides first empirical evidence that pins down this interaction in micro-data and shows that tax policy dynamics can change the efficacy of consequent monetary policy. I also build a conventional New Keynesian model featuring capital and corporate taxes that rationalizes the empirical findings.

There are a set of empirical challenges in identifying the impact of monetary policy conditional on tax policy. First, aggregate policy measures are usually actions taken in response to prevailing economic conditions, and hence it is challenging to isolate the causes and effects of these policy changes. Second, identifying

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1Narrative accounts use historical records such as archives of congressional reports and presidential speeches to isolate exogenous discretionary policy interventions.
monetary policy and tax policy jointly in pure time-series settings may not yield sufficient variation to study the interaction of these two policies. I tackle these issues with a novel empirical design using distinct institutional features of monetary policy and tax policy.

First, monetary policy and tax policy have distinct cross-sectional features that can be pinned down in micro-data. Specifically, monetary policy is levied uniformly across the distribution of firms, whereas tax policy has considerable cross-sectional variation with the multi-bracket nature of the tax code. From 1968 to 2006, the US corporate tax code incorporated 12 historically stable income brackets, with sizable cross-sectional variation across these brackets. The fiscal component of my framework uses the changes in statutory rates on different income brackets to pin down firm-level tax treatments as in Cloyne et al. (2022). This method combines micro level corporate statutory rate changes with tax narrative accounts and allows me to exploit time-series and cross-sectional variation in statutory tax changes across income brackets over time.

Second, monetary and tax policies differ significantly in terms of their effectiveness window. Tax reforms occur at much lower frequencies and have longer spans that lead to persistent treatments. In contrast, monetary policy changes occur at a much higher frequency than tax reforms. This feature allows me to pin down the role of tax reforms on monetary effectiveness over time. Specifically, I allocate firms into persistent tax treatment groups, interact these groups with monetary policy shocks and analyze firms’ response to monetary policy conditional on the underlying tax treatments. In sum, my framework uses distinct cross-sectional and time-series features of monetary policy and tax policy to build a novel quasi-experimental research design.

I employ the annual Compustat dataset for the period 1969–2006, which contains rich income statements and balance sheet information on 18,987 publicly traded US firms. I combine these data with monetary policy shocks, constructed by Romer and Romer (2004) and updated by Wieland and Yang (2020), and generate narratively identified corporate statutory rate changes as in Cloyne et al. (2022). Then, I construct a firm-level taxable income measure and sort firms into respective income brackets over time; the final data pin down the underlying changes in the tax treatment of firms over time. Next, I use institutional features of monetary policy and tax policy and build a novel empirical framework that tests the implications of these identified tax treatments on monetary effectiveness. In this framework, I test whether firms that receive alternative tax treatments
respond differently to monetary policy. Last, I use flexible research design of local projections-instrumental variables (LP-IV) (Jordà, 2005) that allows me to test the effectiveness of monetary policy conditional on firms’ tax treatment using a variety of specifications.

The key results can be summarized as follows. First, changes in tax policy play an important role in monetary effectiveness. Specifically, firms facing a 1 percentage point (pp) tax increase cut employment by 0.3 pp more than firms with stable taxes in response to a 25 bps contractionary monetary policy shock. The same group of firms also show a 0.6 pp larger response in investment to monetary policy, which correspond to about 40 percent larger response in both variables. These results suggest that tax increases can amplify the monetary policy effectiveness. Second, I find that monetary contractions are least effective for firms receiving persistent tax cuts. As compared to firms with stable statutory tax rates, the firms facing tax cuts have a considerably muted response to monetary policy in employment and investment. These findings suggest that the direction of tax shifts may significantly amplify or reduce the effectiveness of monetary policy.

Taken together, this paper contributes to the literature by presenting the first empirical evidence, to the best of my knowledge, quantifying the interaction of monetary policy and corporate tax policy in the micro-data. This is a previously unexplored dimension that is different than the earlier approaches used in the monetary transmission literature. The main finding of my paper is that the effectiveness of monetary policy interacts significantly with the dynamics of the tax system. In other words, depending on the nature of the preceding tax changes, monetary policy can be more or less effective than it otherwise would be. More interestingly, given the historical downward trend in corporate taxes, my findings would predict a lower effectiveness of monetary policy in recent decades.

Related literature. This paper connects to literature on the transmission of monetary policy, tax narrative accounts, and the interaction of monetary and fiscal policy. First, there is a growing literature studying the heterogeneity of monetary policy on firm-level data. These papers provide evidence on how financial and non-financial factors like balance sheet conditions (Gertler and Gilchrist, 1994; Ottonello and Winberry, 2020), firm age-dividend (Cloyne et al., 2019), liquidity

2 See the ECB speech by J. M. González-Páramo in 2005 that highlights this aspect with regard to coordination of fiscal and monetary policy in European Union countries.

3 See Boivin et al. (2010) and Barakchian and Crowe (2013) that document weaker effects of monetary policy in recent decades.
conditions (Jeenas, 2019b; Fazzari et al., 1988; Kashyap et al., 1994; Gilchrist and Himmelberg, 1995), and collateral assets (Bahaj et al., 2020) play a role in the transmission of monetary policy. I contribute to this literature by providing the first empirical evidence documenting the role of corporate tax policy in changing firms’ responsiveness to monetary policy. This is a new dimension that has not been previously addressed in the literature, and my results provide evidence for tax-policy-induced variation in monetary policy outcomes.

Second, this paper connects to narrative macroeconometric studies. Employing tax reforms for identification, recent studies estimate the short- and medium-run effects of tax policy on real economic activity (Romer and Romer, 2010; Mertens and Ravn, 2013, 2012; Mertens and Olea, 2018; Zidar, 2019; Cloyne, 2013; Hayo and Uhl, 2014; Cloyne et al., 2022; Barro and Redlick, 2011; Howes, 2019; Hussain and Liu, 2018; Nguyen et al., 2021). I contribute to this literature by providing the first analysis using corporate tax narratives jointly with monetary policy in the micro-data.4

Among the tax narrative literature, Mertens and Olea (2018), Zidar (2019), and Cloyne et al. (2022) share similarities to my analysis in their use of counterfactual statutory rate analysis. Zidar (2019) and Mertens and Olea (2018) study the effects of personal income tax changes at an aggregate level, either across income distribution or regions.5 In contrast, my paper uses narratively identified corporate tax changes in a more disaggregate format following Cloyne et al. (2022).6 My paper differs from Cloyne et al. (2022) with its focus and empirical framework. In Cloyne et al. (2022), we explore the effects of corporate tax changes on firm capital formation and growth, whereas this paper focuses on the intersection of tax and monetary policy by questioning the role of tax policy changes on monetary effectiveness.

Third, this paper also connects to the literature studying regime-dependent effects of monetary policy. Tenreyro and Thwaites (2016), Berger and Vavra (2014), Angrist et al. (2018), Matthes and Barnichon (2015) and Owyang et al. (2013) ex-

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4Note that recent work by Cloyne et al. (2020) also studies tax and spending narratives jointly with monetary policy and highlights the role of monetary policy on the effectiveness of fiscal policy using international data.

5Mertens and Olea (2018) analyze the changes in the average marginal tax rate across years and study the elasticity of reported income along the income distribution. Zidar (2019) constructs regional tax liability changes in personal income tax changes and estimates employment effects using income distribution differences across states.

6The use of disaggregate tax treatment gives clean treatment effects and also deals with the concerns for general equilibrium effects that may arise in studies using aggregate data.
explore whether policy interventions have differential effectiveness based on whether the economy is in a recession or expansion or based on uncertainty. This paper shares some characteristics with these studies yet also has a fundamentally different approach. Most of these studies estimate impulse response functions in regime-switching environments where regimes are computed at the aggregate level with transition probabilities across regimes. In this paper, I define binary tax regimes following discrete and persistent events of statutory rate changes. Moreover, since I use disaggregated changes in statutory rates, my approach can be categorized as a micro-regime application where every firm gets exposed to its own fiscal shock. Taken together, my paper addresses the state-dependent effects of monetary policy in the aftermath of tax shifts. However, as compared to the aggregate literature, I define regimes at the micro level and do not employ regime-switching models.

Last, this paper relates to an influential strand of literature theoretically modeling the interaction of fiscal and monetary policy rules (Canzoneri et al., 2010; Chen et al., 2020; Davig and Leeper, 2011; Sargent and Wallace, 1984; Aiyagari and Gertler, 1985; Leeper, 1991). These papers study policy outcomes under an alternative coordination of monetary and fiscal policy. Specifically, they characterize a non-cooperative game between the government and central bank to consider implications of active and passive monetary and fiscal policy interactions in altering the effectiveness of alternative stimulus policies as well as determining price stability. This paper diverges from these studies in that it does not explicitly model the endogenous interaction of fiscal and monetary policy and instead studies the effectiveness of monetary transmission conditional on underlying tax structures. To motivate my empirical predictions, I also present a medium-scale New Keynesian model featuring capital and corporate income taxes. The theoretical predictions reconcile the findings of the quasi-experimental exercise that preceding persistent tax policy interventions can influence the effectiveness of monetary policy.

The rest of the paper is organized as follows. Section 2 discusses firm-level data, tax policy variables, and monetary policy shocks. Section 3 presents the empirical strategy, discusses main empirical and theoretical results, and presents robustness checks. Section 4 concludes.

As a matter of fact, a useful, though dated, reference is Black and Blitz (1976) which uses a simple IS-LM framework to study the role of changes in tax rates on the interest sensitivity of investment and also concludes that high tax rates lead to greater effects of interest rates on business investment.
2. Dataset

2.1 Firm-level variables

This paper uses the annual Compustat database on publicly traded C-corporations in North America. Compustat provides high-quality information on balance sheet and income statement components of active and inactive companies. The sample spans from 1969 to 2006 and consists of 198,060 firm-year observations of 18,987 firms. The main explanatory variables I analyze are the number of employees ($emp$, Compustat item 29) and investment (defined as capital expenditures, $capx$, Compustat item 128) of firm $j$ in period $t$. Other variables of interest are book value of total assets ($at$, Compustat item 6), liquidity ratio,\(^8\) leverage,\(^9\) and net sales ($sale$, Compustat item 12). Details of data construction are discussed in Appendix A.

Using Compustat data in this paper is advantageous for two reasons. First, Compustat is a long enough panel to study within-firm variation. I analyze 37 years of annual firm-level data where the average firm is observed for about 11 years. Second, Compustat has a rich cross-sectional dimension. The detailed balance sheet information in Compustat allows me to construct a taxable income measure, test alternative hypotheses, and conduct heterogeneity analysis.

There are a few limitations of using Compustat data. First, Compustat only consists of publicly held companies, and hence the estimates represent only the effects of the corporate tax code on the behavior of publicly traded C-corporations. Second, despite the good coverage across different sized firms, Compustat data may disproportionately feature large companies and therefore may underrepresent small firms. Last, Compustat is mainly a report of financial statements; hence the gross income and tax variables are not reported for the purposes of tax books. Although a growing public finance literature (Kleven et al., 2016) increasingly suggests the use of third-party information on business records in developed countries to be accurate with little discrepancy between the tax reports and the third-party information,\(^{10}\) extracting the corporate tax variable out of Compustat (despite being second-party information) may still be subject to measurement error. Since both marginal tax rates and taxable income are unobserved data in the generic

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\(^8\)Liquidity ratio is calculated as the share of cash and short-term investments ($cheq$, Compustat item 1) to total assets.

\(^9\)Leverage is defined as total debt divided by the book value of total assets. Total debt is calculated as the sum of debt in current liabilities ($dcl$, Compustat item 34), long-term debt ($dllt$, Compustat item 9).

\(^{10}\)Kleven et al. (2016) further suggest that this transparency is especially true for the large firms where tax enforcement through auditing is strong.
financial statements in Compustat, I follow Blouin et al. (2010) and construct taxable income using the following definition:

\[
TI = \text{Net income} - \text{Interest expense} + \text{Special items} - \frac{\text{Deferred tax expense}}{mtr} + \frac{\text{Income from extraordinary items}}{1 - mtr}
\]

(1)

According to the definition, taxable income is calculated using firms’ profits net of allowable cost deductions. The definition closely follows existing definitions in the literature and is discussed in detail in Appendix A.

2.2 Corporate taxes

This section constructs firm-level measures of exogenous statutory corporate tax changes over time. This is a two-stage procedure. In the first stage, I select tax reforms from the tax narrative accounts of Romer and Romer (2009) focusing on corporate income tax reforms that have persistent statutory rate changes and are classified as exogenous by Romer and Romer (2009) and Mertens and Ravn (2013).\textsuperscript{11} According to Romer and Romer (2009) categorization, a tax reform is exogenous if its motivation is to address inherited budget deficits or to achieve some long-run goal such as increasing fairness or changes in philosophy of the government.\textsuperscript{12} Hence, discarding the changes in tax liabilities that are related to the current state of the economy fulfills the required assumption on the orthogonality of tax reforms and therefore form the exogenous series.

Next, many corporate reforms are implemented with either a delay or have gradual multiyear phase-ins such as the Economic Recovery Tax Act of 1981 and the Tax Reform Act of 1986. I focus on tax changes implemented within one quarter of their legislation to avoid anticipation effects (Mertens and Ravn, 2012). After the tax changes based on exogenous and unanticipated ones are eliminated, the selection procedure yields five tax reforms between 1969 and 2006 with significant, immediate, and persistent impacts on corporate statutory tax rates. Appendix Table B.1 lists these reforms together with their impact on the corporate statutory rate schedule.

\textsuperscript{11}The narrative accounts use historical records of congressional reports and presidential speeches to construct exogenous discretionary tax shocks with descriptive information on size, timing, and motivation. Mertens and Ravn (2013) disaggregated tax narratives originate from Romer and Romer (2009) aggregate series and provide exogenous tax policy shocks on the US corporate and personal income tax separately.

\textsuperscript{12}Similarly, a tax reform is considered endogenous if it is motivated by current economic conditions.
In the second step, I follow the approach in Cloyne et al. (2022) and decompose the selected tax reforms into a panel of statutory rate changes across taxable income brackets. Tracking the statutory rate changes across 12 distinct income brackets over years allows the five benchmark tax reforms to generate a large amount of variation in statutory tax rates. The details of this step are explained below in detail.

**Corporate income tax code.** The US corporate income tax code is a piece-wise linear system where the taxable income is divided into brackets where marginal tax rates are fixed within but vary across these brackets. Appendix Table B.2 provides IRS historical statutory marginal tax rates across different taxable income brackets that reveal several unique features of the corporate tax code. First, the corporate tax code has adhered to 12 historically stable taxable income brackets ranging from under $25,000 to over $18.333 million.\footnote{These brackets are $0–$25,000, $25,000–$50,000, $50,000–$75,000, $75,000–$100,000, $100,000–$335,000, $335,000–$1,000,000, $1,000,000–$1,405,000, $1,405,000–$10,000,000, $10,000,000–$15,000,000, $15,000,000–$18,333,000, and above $18,333,000.}

Second, the gradual rate structure has consistently been an important characteristic of corporate tax code—the Revenue Act of 1978, the 1986 Tax Reform Act, and the Omnibus 1993 provide examples of substantial size-dependent tax rates. Third, there is considerable variation in the tax cuts and tax increases. Of the five exogenous tax reforms, two (1984 and 1993) are tax increases and three (1979, 1982, 1987) are tax cuts. Finally, we observe a considerable heterogeneity in the dose of tax changes across different income brackets. For example, some acts changed tax rates for very high income levels, while others were more uniform.\footnote{See, for example, the 1975 legislation that suggests an 18 pp decline in the top statutory tax rate for firms with taxable income from $50,000 to $75,000 and a 2 pp decline in the top statutory tax rate for firms with taxable income above $100,000. However, not surprisingly, since the 18 pp is only levied on the $25,000 income from $50,000 to $75,000, the dollar impact of the 18 pp cut is actually quite small. Note that this feature of varying progressiveness is an obstacle in terms of making direct comparisons of marginal tax rate changes across firms of different income brackets. To deal with this, I use a liability-based measure across firms through time.}

All these features highlight important time-series and cross-sectional variation in corporate statutory taxes and form the basis of my quasi-experimental research design.

Figure 1 sketches the basic research design. Consider an economy with alternative marginal tax rates, $\tau_1$, $\tau_2$, $\tau_3$, and $\tau_4$ on alternative taxable income brackets.\footnote{The marginal tax rate is defined as the statutory rate that incurs on the additional dollar of income. Throughout the paper, I use marginal and statutory tax rates interchangeably.} At time $t$, a new legislation is executed that changes the marginal tax rate for
some brackets and leaves it unchanged for others. I take this feature and form a quasi-experimental research design using variation in the direction and level of tax treatment across income brackets through time. My identification strategy has two layers. First, I exploit the direction of statutory rate changes where the treatment group consists of firms that are in the income brackets that receive a statutory rate change and the control group consists of firms in the brackets that do not receive a statutory rate change. This allows me to pin down whether a firm received a statutory tax change and the sign of tax treatment (e.g. contractionary or expansionary) across different years. Second, I explore the persistent effects of tax treatment dose and test whether alternative tax treatments change the effectiveness of consequent monetary policy innovations. The next section details the construction of the two measures and underlying assumptions.

**Constructing the tax treatment measure.** This section constructs a measure of statutory rate changes that deals with the endogenous nature of marginal tax rates. I follow the earlier methods of Mertens and Olea (2018), Zidar (2019), and Cloyne et al. (2022), where the estimated statutory change in year $t$ is calculated as
the difference between a counterfactual statutory rate calculated using year \((t-1)\) taxable income and year \(t\) rates and the actual year \((t-1)\) statutory tax rate. Using the previous year’s taxable income strips away the behavioral responses of firms in adjusting their income.\(^{16}\) Equation 2 formulates the \(\Delta mtr_t\) measure, which is interpreted as the change in the statutory rate on an additional \$1\) income earned today. This is a proxy for the change in statutory rate, with no income response.

\[
\Delta mtr_t = \tau_t(TI_{t-1}) - \tau_{t-1}(TI_{t-1}).
\]  

(2)

I repeat this exercise for 12 distinct taxable income brackets from 1968 to 2006 and generate a new measure capturing variation in statutory rate changes across income brackets. Figure 2 plots the output of this exercise where the \(y\)-axis has the pp change in the statutory tax rate \(\Delta mtr_t\) of different income brackets from 1968 to 2006. Positive numbers show statutory rate increases, and negative numbers show statutory rate cuts. This measure allows me to determine whether a firm is subject to a higher or lower statutory rate in the aftermath of a legislation, where a higher rate is labeled as high only if it exceeds firm’s previous period’s tax treatment.\(^{17}\) To visualize the labels clearly, the figure is split across large and small firms such that Figure 2a (2b) covers firms with taxable income less (higher) than \$1\) million.

Figure 2 shows three interesting features of statutory corporate income tax changes. First, the figure allows us to visualize the time-series variation in tax treatment by income brackets. For example, Figure 2a shows that firms with taxable income between \$25,000\) and \$1,000,000\) face a statutory tax increase of 4.8 pp in 1968 and two tax cuts of 3.6 and 1.2 pp in 1970 and 1971, respectively. Second, Figure 2 illustrates that each legislation results in different tax treatments across different income brackets. For instance, the Revenue Act of 1978 lowered statutory tax rates at four different rates for firms of different sizes. Third, Figure 2 suggests there is sizable variation in the sign of treatment across different brackets. Particularly for large firms, three years of tax increases and five years of tax cuts impact various brackets. After generating different tax treatments across income brackets, I follow Cloyne et al. (2022) and match the Compustat-constructed taxable

\(^{16}\)On the corporate income side, the tax brackets are matched to brackets on a nominal basis every year; hence I do not deflate the taxable income measure through time. Similarly, in the liability changes, I use a share of liability change measure that also does not require deflating.

\(^{17}\)This measure also automatically incorporates forward-looking nature of firms such that a higher tax rate is defined as higher in comparison to the tax rate the firm was previously paying.
Figure 2: Corporate tax rate changes by alternative taxable income brackets

(a) Taxable Income \(\leq \$1,000,000\)

(b) Taxable Income \(> \$1,000,000\)

Note: The *exogenous* statutory rate changes in Romer and Romer (2009) and Mertens and Ravn (2013) are marked with stars (1979, 1982, 1984, 1987, and 1993) and will be used in the baseline results. These also correspond to reforms summarized in Appendix Table B.1. All the tax changes are categorized as persistent in Mertens and Ravn (2012). Source: IRS historical statutory corporate tax rates.

income variable to the right taxable income brackets, which allows me to obtain a firm-level measure of tax treatment over time.

Next, I lay out the framework that allows me to study monetary policy in the aftermath of tax reforms. First, I use the term *tax regime* to refer to periods following discrete and persistent tax policy changes. Using the sign of tax changes,
I assign firms to three possible tax regimes: expansionary, contractionary, and neutral. For example, if a firm has received a tax cut (increase) in year $t$, it enters an expansionary (contractionary) tax regime, while firms that have not received any change in their statutory rate are assigned to the neutral regime. This exercise labels the tax treatment of firms in the aftermath of persistent tax shifts. Once a firm is allocated to a new regime, unless an opposite tax change occurs in the subsequent years, the firm continues to stay in the relevant regime for up to five years. The choice of five years is guided by the persistent nature of specific tax legislations and the maximum length of years in between exogenous reforms.

Figure 3: IRS corporate rate changes and fiscal regimes by taxable income groups

Note: Taxable income (TI) is in $1,000. Shaded areas denote the respective regimes.

Figure 3 visualizes example tax regimes for large firms. The left panel shows the marginal tax treatment of large firms (same as Figure 2b), and the right panel sketches the tax regimes across income brackets using the shaded colors. The left panel shows that firms with taxable income greater than $1,405,000 received a tax increase of 4.8 pp in 1968, a tax cut of 2.6 pp in 1970, and another tax cut of 1.2 pp in 1971. In the right panel, I shade the respective tax regimes for firms in this bracket, which marks 1968 to 1970 as contractionary tax regime years and 1970 to 1974 as expansionary tax regime years. Since this particular income bracket does not receive any more treatment in the following years, the firms in this income bracket switch to a neutral regime in 1974, five years after the reform. Hence, repeating this exercise across income brackets allows me to construct micro tax regimes of income brackets through time. Using exogenous tax reforms, 4% of the sample is identified as receiving a persistent tax increase and 16% of the sample is identified as receiving a persistent tax cut.
One of the underlying assumptions of this framework is that it allocates firms to a regime using last year’s taxable income, which may overlook potential income responses. To not rely on the assumption of static taxable incomes through time, I restrict my sample to firms that continue to stay in the treated brackets when the policy changes. In other words, once a firm is allocated to a regime, I continue to track its income for the next year to confirm that it continued to stay in that particular reform’s treated brackets. Although this certainly decreases the number of firms allocated to a regime, it minimizes potential measurement error due to income dynamics. I also drop the regime observations of firms that jump more than one neighboring income bracket after a tax reform. This also automatically deals with firms that switch to zero or negative taxable income after the tax reform.

The US tax code has a non-linear, kinked structure, and hence it restricts statutory treatment comparisons across brackets. To overcome this, I construct a firm-level dose measure using the difference between tax liabilities under the previous and the new legislation. Specifically, I calculate the changes in the share of tax burden for each firm that has received a statutory rate change. To facilitate comparison across firms and time, I also scale liability changes with lagged taxable income:

\[
Dose = \frac{\Delta mtr \times (TI_{t-1} - \overline{TI}_{t-1})}{TI_{t-1}}
\]

where \( \overline{TI} \) is the starting threshold of taxable income in that particular bracket. Repeating this exercise for every firm at every tax legislation generates a firm-level dose variable that measures the share of tax burden changes after every tax reform.\(^\text{18}\) The new measure allows me to explore both the direction and the intensity of the tax change, helping me make comparisons across firms with different fiscal treatments. Furthermore, using a liability-based measure allows me to test the implications of balance sheet channels across firms.

\(^\text{18}\) Appendix Figure B.1 presents a detailed example of the dose calculation, and Appendix Figure B.2 plots a histogram of the tax treatment dose in the sample. The measure closely follow marginal tax rate changes most of the time, yet it also takes into account the kinked nature of corporate taxes and the specific portion of a firm’s taxable income receiving the tax change.
2.3 Summary statistics

Appendix Table A.2 presents summary statistics of the key variables of interest in the firm-level data covering the sample period 1969–2006. The sample contains 198,060 observations of 18,987 firms. Since the sample consists of public firms, the average size (total real assets) is $1.3 million and the average taxable income is $44 million. The right-skewed size distribution of firms motivates the use of log variables in regressions. The average number of employees in the sample is 5.9 thousand. The average marginal tax rate is 27% and the average tax treatment dose is 1.4 pp tax cut. The taxable income and marginal tax rate are variables constructed in the paper, and income tax \((txt)\) is a tax variable reported in Compustat. The numbers at different percentiles of the “income tax” variable and the generated “taxable income” variable suggest the constructed variables are consistent with the reported data.

The summary statistics are also provided across different tax regimes. Neutral regime firms account for 80% of the total sample and consist of 18,971 unique firms with 158,617 observations. Expansionary tax regime firms account for 16% of the total sample and consist of 5,787 firms with 32,291 observations. Contractionary tax regime firms account for 4% of the total sample and consist of 1,733 firms with 7,098 observations. Comparing employment, asset, and income taxes across tax groups suggests that contractionary tax regime firms are larger in size than expansionary or neutral regime firms. Regarding the marginal tax rate, all groups seem to have sizable variation, confirming the sizable heterogeneity in the treatment groups.

Finally, Appendix Figure C.2 presents descriptive charts that lay out characteristics of each tax regime. According to the figure, contractionary regime firms heavily consist of large firms (high assets and high sales) with high debt-to-asset ratios and low investment rates. In contrast, expansionary and neutral regime firms are more homogeneous across alternative firm characteristics. In the robustness section, I provide alternative specifications that address confounding effects of firm characteristics in the main results.

2.4 Monetary policy shocks

I use the Romer and Romer (2004) monetary policy shock series (Romer shocks) that have recently been updated by Wieland and Yang (2020). These are resid-
uals from a regression of the federal funds rate on lagged values and the Federal Reserve’s information set using Greenbook forecasts. The series are summed to an annual frequency and span from 1969 to 2006. Following Gertler and Karadi (2015), I instrument changes in the one-year Treasury rate with the Romer shocks. Since this paper is a micro-data application using aggregate shocks, I use a panel data feasible local projections-IV (LP-IV) method as in Jordà et al. (2015).

There are many alternative approaches to identifying monetary policy shocks in the monetary policy literature. One of the many prominent approaches is using a SVAR framework complemented with a Cholesky decomposition, evidence-or theory-based sign restrictions, or calibrated elasticities. Although SVAR approaches provide a valid characterization of the transmission mechanism, they are not feasible for micro-data applications. Another approach is to use high frequency shocks to the federal funds futures rate, used in Gurkaynak et al. (2005), Jeenas (2019b), and Gertler and Karadi (2015). These studies employ a hybrid approach to identify exogenous shocks via high frequency surprises on interest rate futures around policy shocks. However, many of these measures are only available starting in the late 1980s and 1990s due to the record of federal funds meeting dates. Since I need a larger window to capture enough variation in both tax and monetary policy, I do not use this approach for this paper.

3. Empirical framework

This section provides the empirical framework that explores the role of tax changes on the effectiveness of monetary policy. Given the lack of existing work on the interaction of monetary policy and tax policy, pinning down the precise estimation is not straightforward. My empirical framework is geared toward understanding the heterogeneous effects of monetary policy conditional on the preceding tax treatment of firms.

3.1 LP-IV approach using tax treatment

I use a local projections-IV (LP-IV) approach combining local projections with IVs as in Jordà et al. (2015). This approach allows me to estimate a flexible specification without imposing VAR dynamics on the main variables. Equation (3) presents the baseline LP-IV estimating dynamic causal effects of exogenous monetary policy changes subject to alternative tax treatment of firms:
\[
\Delta_h \log(y_{j,t+h}) = \alpha_j^h + \beta^h \Delta R_t + \Gamma^h \Delta R_t \text{Dose}_{j,t} + \theta^h \text{Dose}_{j,t} + \Omega'(L) Z_{j,t-1} + \epsilon_{j,t+h},
\]

where horizon is \( h = 0, 1, \ldots, 4 \) years and \( j \) and \( t \) denote firm and time, respectively. The left-hand side of equation (3) is the cumulative change in the outcome variable \( y \), \( \Delta_h \log(y_{j,t+h}) \equiv \log(y_{j,t+h}) - \log(y_{j,t-1}) \), where \( y \) is log employees and log real investment. The specification regresses the dynamic cumulative change in variable \( y \) on monetary policy changes subject to firms’ tax treatment. \( \alpha_j^h \) denotes a firm fixed effect that soaks up permanent differences across firms and allows me to explore within-firm variation. \( \Delta R_t \) is the changes in the one-year Treasury rate instrumented with extended Romer and Romer (2004) monetary policy shocks. The one-year Treasury rate is scaled by a quarter, so the instrument reflects a 25 basis point increase in the one-year Treasury rate. The main coefficient of interest, \( \beta^h \), gives the impulse response of the dependent variable at time \( t + h \) to a monetary policy change at time \( t \). \( \Gamma^h \) captures the marginal effect of tax treatment on firms’ responsiveness to monetary policy, where the \( \text{Dose} \) variable is calculated as the change in the liability share of firms using the previous and the next year’s rate.\(^{19}\) The interaction term is instrumented with the interaction of Romer shocks and the \( \text{Dose} \) variable.

\( Z_{j,t-1} \) includes the following control variables: log real investment, log real assets, log real taxable income, real asset growth, growth in the number of employees, debt to gdp ratio, and top statutory tax rate. Firm-level controls in logs help soak up differences in cross-sectional characteristics in financial and non-financial variables. The variables in log difference or growth form capture the time-series trend. To ensure exogeneity with respect to the shock, all the control variables in \( Z_{j,t-1} \) are measured at the end of the last year before the monetary shocks and tax changes.\(^{20}\) The estimation is calculated up to a horizon of \( H = 4 \) years, and the lag structure on control variable is 2 years. The standard errors are two-way clustered at the firm-year level where serial correlation adjustment is set to two years using the Driscoll and Kraay (1998) methodology. This is a standard method to account for serial correlation at the firm level and through time.\(^{21}\) Following Mertens and Olea (2018), I use year dummies on 1981 and 2001 as a dependent variable. These

\(^{19}\)Note that \( \text{Dose} \) is positive when statutory tax rate increases, implying firms have higher tax liabilities and vice versa.

\(^{20}\)See Appendix A for the sample selection procedure.

\(^{21}\)See Cloyne et al. (2019) and Bahaj et al. (2020).
corresponds to a period of relative macroeconomic turbulence and unusual policy variation associated with the Volker era and the dot-com recession. Finally, note that the baseline specification imposes linearity in the effect of the tax treatment on explaining firms’ responsiveness to monetary policy changes.

The identifying assumptions for this model are as follows. First, monetary policy shocks should satisfy instrument validity and exogeneity conditions, where the former suggests the shocks are correlated with movements in the one-year Treasury rate and the latter suggests the shocks are uncorrelated with all other shocks. I address these two conditions by using the plausibly exogenous monetary shocks of Romer and Romer (2004) that isolates changes in the federal funds rate that are orthogonal to the information set reported in the Greenbook forecasts. Regarding the instrument validity, the first-stage F-statistic is above the threshold value of 10 proposed by Stock and Yogo (2005), suggesting Romer-Romer shocks provide a relevant instrument for changes in one-year Treasury rates.

Second, the dynamic structure of LPs requires monetary policy innovations to be exogenous with respect to other current and lagged endogenous variables (Stock and Watson, 2018; Nakamura and Steinsson, 2018). In my particular setting, since I test the implications of an aggregate shock on micro-data, the analysis does not suffer from reverse causality, which would imply that firm-level variables affect aggregate shocks. However, since my research design incorporates two aggregate policy measures, I test the current and lagged exogeneity within the tax and monetary policy measures. Appendix Table D.1 provides two-way Granger causality estimates that suggest orthogonality between monetary shocks and statutory tax changes. The Granger causality results are discussed in detail in the robustness section.

Finally, specific to my research design, I use narratively identified exogenous and unanticipated tax reforms that deal with anticipation effects and endogenous selection into tax treatment (Romer and Romer, 2009; Mertens and Ravn, 2013). In addition, I use lagged taxable income to compute tax regimes of firms, which ensures that monetary policy does not affect firms’ tax treatment through income changes.

Note that since the policy shocks only contain variables realized at date $t$ or earlier, the lead exogeneity requirement is less concerning (Stock and Watson, 2018, p.10).
3.2 Results

This section presents the impulse responses of specification 3 on the number of employment and investment. Figure 4 plots the estimated coefficients as well as their 95% confidence intervals on the number of employees. For neutral regime firms, shown in Figure 4a, I find that the number of employees have an average semi-elasticity of –0.34% to monetary policy, where the peak effect is –0.70% occurring two years after the monetary policy shock. In contrast, Figure 4b shows sizable heterogeneity in monetary policy outcomes conditional on the alternative tax treatment of firms. Specifically, firms with tax cuts respond monotonically less to contractionary monetary policy. In contrast, firms facing a statutory tax increase experience a larger fall in the number of employees relative to the neutral regime firms. Figure 4c suggests that, firms facing 1 pp tax hikes (cuts) respond to monetary policy about 0.26 pp more (less) than firms with stable taxes. Since firms with tax cuts have a sizable share (16%) of the total sample of firms, these findings highlight an important result that contractionary monetary policy is significantly ineffective on firms facing statutory tax cuts.

Figure 4: Impulse responses of the number of employees using specification 3

Next, Figure 5 shows the impulse responses of investment, where the dependent variable is the cumulative change in log real capital expenditures. For neutral regime firms, shown in Figure 5a, I find a –0.4% average semi-elasticity of investment.
ment to the monetary policy shock. The peak effect is reached three years after the monetary shock at a value around –1.5%. In comparison, Figure 5b suggests that the estimates are noticeably more negative (positive) across the horizon for firms with increasing (decreasing) taxes. A comparison of the average effects suggests that firms facing a 1 pp tax increase (decrease) show a –0.6 pp larger (smaller) semi-elasticity to monetary shocks.24

There are two main results that emerge from Figures 4 and 5. First, firms facing tax increases exhibit larger responses to monetary policy shocks than firms in expansionary or neutral tax regimes. Second, firms facing statutory rate cuts have much lower responses to monetary contractions. These findings suggest underlying tax treatment of companies can amplify or reduce their responsiveness to monetary policy, hence considerably alter the effectiveness of monetary policy.

Next, I confirm the baseline results using a less parametric estimation that handles expansionary and contractionary tax changes separately. This specification uses bins of tax regimes and estimates the marginal effects of a 1 pp contractionary or expansionary tax change on the effectiveness of monetary policy. Equation 4

24 These elasticities compare well with the earlier estimated elasticities in the literature. For instance, Ottonello and Winberry (2020) reports an average semi-elasticity of investment around 2 using Compustat data from January 1990 to December 2007. Similarly, Jeenas (2019a) reports a 10 pp high leverage ratio to lead to about 0.4 pp slower growth in capital using Compustat data from 1990Q1 to 2007Q4. Using aggregate data spanning 1969:1–2007:IV, Tenreyro and Thwaites (2016) also documents that output can be twice more responsive to monetary policy in expansions than recessions.
provides the details of the specification as follows:

\[
\Delta_h \log(y_{j,t+h}) = \alpha^{h,r}_{j} + \beta^{h} \ast \Delta R_t + \beta^{h,r} \ast \Delta R_t \ast \mathbb{1}\{ \Delta \tau^{r}_{j,t} \} \ast |Dose_{j,t}| \\
+ \delta^{h,r} \ast |Dose'_{j,t}| + \theta^{h,r} + \Omega'(L)^{h,r} \ast Z^{r}_{j,t-1} + \epsilon_{j,t+h}, \tag{4}
\]

where the regime indicator function \((\mathbb{1}\{ \Delta \tau^{r}_{j,t} \})\) and the \(Dose\) variable capture the direction and the intensity of tax rate changes firms receive. Figure 6 plots the impulse responses where \(\beta^{+}(\beta^{-})\), which shows the marginal effect of receiving a 1 pp increase (decrease) in firms’ tax burden.

Figure 6: Impulse responses using specification 4

Note: This plot shows impulse responses of the number of employees (first row) and investment (second row) using IV local projection regressions in specification 4 where Romer and Romer (extended) monetary policy shocks instrument the one-year government bond rate. The horizon is 4 years, and the lag is set to 2. The time span is 1969–2006. The control variables are log real investment, log real assets, log real taxable income, real asset growth, growth in the number of employees, debt to gdp ratio, and top statutory tax rate. Standard errors are clustered by firm and year.

The results from specification (4) align with the results of the baseline specification. Specifically, in both charts we can observe that receiving tax cuts lower the effectiveness of monetary policy and receiving tax increases amplify the effectiveness of monetary policy. Overall, both the continuous interaction and the group-based estimation results underscore the interaction between firms’ tax treatments and the responsiveness to monetary policy.
Last, I conduct one final specification by binning firms across different regime-dose categories. For this exercise, I calculate the mean of tax burden changes in each regime and allocate firms into groups that received a high- or low-dose tax treatment by regime. For instance, if a firm has received a low-dose tax cut (e.g., the change in tax burden is lower than the average tax burden change), it is assigned to the expansionary low regime. Alternatively, if a firm has received a high-dose tax cut, it is assigned to the expansionary high regime.

Figure 7: Impulse responses of the number of employees using equation 5

Note: The plots show impulse responses of the number of employees using IV local projection regressions with Romer and Romer (extended) monetary policy shocks instrumenting the one-year government bond rate. The horizon is 4 years, and the lag is set to 2. The time span is 1969–2006. The control variables are log real investment, log real assets, log real taxable income, real asset growth, growth in the number of employees, debt to gdp ratio, and top statutory tax rate. Standard errors are clustered by firm and year.

Appendix Figure B.3 plots the histogram of tax burden changes across the sample where firms are allocated to the following five regime-dose categories: contractionary high, contractionary low, expansionary high, expansionary low, and neutral.
In this specification, the impact of liability changes is estimated using

\[
\Delta_h \log(y_{j,t+h}) = \alpha_{j}^{h,r} + \beta^{h,r} \Delta R_t \mathbb{I}\{\Delta \tau_{j,t}^{r}\} + \Omega'(L)^{h,r} Z_{j,t-1}^{r} + \epsilon_{j,t+h},
\]

where \( \beta^{h,r} \) captures the average treatment effect across firms in different tax regime-dose groups \( r \). Figure 7 plots impulse response of number of employees following the specification 5. The first row plots the effects of monetary policy when a firm is in a neutral regime. The second (third) row plots the effects of monetary policy when the firm is facing an increase (cut) in the marginal tax rate. Columns 1 and 2 reflect the dose of treatment being low and high, respectively.

Figure 8: Impulse responses of investment using equation 5

Note: The plots show impulse responses of investment using IV local projection regressions with Romer and Romer (extended) monetary policy shocks instrumenting the one-year government bond rate. The horizon is 4 years, and the lag is set to 2. The time span is 1969–2006. The control variables are log real investment, log real assets, log real taxable income, real asset growth, growth in the number of employees, debt to gdp ratio, and top statutory tax rate. Standard errors are clustered by firm and year.

The tax-group-based results confirm the linear interaction findings. Specifically, Figures 7–8 plot the monotonic effects of firms’ tax treatments and the
responsiveness to monetary policy. In both employment and investment results, the largest response to monetary contraction occurs with firms that face high statutory tax increases. In contrast, for firms that face a high persistent tax cut, the response to a contractionary monetary policy shock is not contractionary.

3.3 Mechanism and model results

We can pin down the interaction between monetary policy and tax policy via a number of channels. One channel can be traced in user cost of capital models where the nominal interest rate and taxes jointly affect firms’ investment behavior (see Hayashi 1982; Hall and Jorgenson 1967). According to the arbitrage condition (6), firms invest until the MPK is equal to the user cost of capital, which is a function of the cost of financial funds, the depreciation rate, potential capital gains, and the corporate tax rate:

\[
\text{MPK} = \frac{r + \bar{d} - \frac{\Delta p_k}{p_k}}{1 - \tau} = \frac{r + \bar{d}}{1 - \tau} - \frac{\Delta p_k}{p_k} (6)
\]

This optimality condition suggests that an increase in statutory taxes increases firms’ user cost, leading to a lower level of capital and a higher required level of MPK for the investment to be profitable. This implies that firms are now divesting projects that were previously marginally profitable. In particular, when a monetary contraction hits during this period, the firms contract the capital stock more since the current required level of productivity is much higher than before. Moreover, due to decreasing returns to capital, the elasticity to monetary policy may be higher(lower) in transition with a lower(higher) level of capital.\textsuperscript{26}

It is worth highlighting that user cost models provide us with partial equilibrium conditions, yet since firms are forward-looking agents and tax changes are persistent, it is actually crucial to see alternative channels within a general equilibrium model. In the next exercise, I present the results from a medium-scale New Keynesian model that simulates how corporate tax shifts can alter the efficacy of consequent monetary policy. In Appendix E, I layout a full New Keynesian model. The aim is to show whether an economy with persistent preceding tax interventions shows a differentiated response to monetary policy. Figure 9 plots the

\textsuperscript{26}We can also simply check the partial derivative of user cost term with respect to interest rate, which is an increasing function of the tax rate.
results of a simulation exercise that compares the effectiveness of monetary policy in three economies with differing preceding tax interventions. Output, investment, and hours worked are variables of interest, and units are interpreted as percent deviations from the steady state.

Figure 9: Theoretical impulse responses to monetary innovations

Notes: This figure plots impulse responses of to 25 basis point monetary policy innovation in three economies with differing prior tax interventions. The figure only plots the effects of monetary innovations. The impulse response functions with tax shocks are provided in Figures E.2.1 and E.2.2.

Figure 9 presents the responses to a 25 basis point monetary policy innovation in the three economies. The red economy receives a 50 basis point increase in the corporate tax rate, and the yellow economy receives a 50 basis point decrease in the corporate tax rate at time $t = 1$. The blue economy is the benchmark economy that does not receive any preceding tax shock. At time $t = 10$, all economies receive a 25 basis point contractionary monetary policy shock. Comparing the responses shows that the economy that received a preceding tax increase shows

---

27The choice of 10 quarters is guided by the half-life of a 5-year regime length. I use second-order approximation to capture the level effect of an initial tax shock on the subsequent monetary policy shock. In first-order approximation, the initial condition, the sequence of shocks, their sign and size do not matter.
the largest response to a monetary policy innovation. Similarly, the economy that receives a persistent preceding tax cut shows the least contraction to a monetary tightening. Overall, the theoretical results support the empirical findings such that a preceding contractionary tax policy amplifies the impact of monetary shocks and a preceding expansionary tax policy reduces the impact of monetary shocks. Full layout and robustness checks of the theoretical model is provided in Appendix E.

3.4 Robustness

This section conducts a large number of checks that confirm the baseline results are robust to alternative estimation strategies, control set, and underlying assumptions. I also test the confounding effects of firm characteristics, address several potential threats to identification, and discuss measurement issues.

Orthogonality of tax and monetary shocks. One of the biggest concerns related to the identification strategy is that federal tax reforms may influence monetary policy innovations. This paper uses exogenous changes in federal funds rate and exogenous and unanticipated changes in tax reforms where original sources (Romer and Romer, 2009, 2004) address general endogeneity concerns. However, it is still necessary to address the orthogonality of monetary policy with respect to tax policy and vice versa.

To verify monetary policy shocks are not endogenous to the Romer and Romer (2009) tax reforms, I perform a Granger causality test using aggregate data. Appendix Table D.1 provides the test results suggesting Romer monetary policy shocks are orthogonal to the tax reforms. Similarly, Appendix Table D.2 ensures that the exogenous set of tax reforms are not Granger caused by monetary policy shocks as well. The specifications include alternative versions with different aggregate controls, and none of them provides evidence on the endogeneity of the two policy measures. Furthermore, Appendix Figure C.1 plots the distribution of monetary policy shocks across tax regimes and shows that monetary innovations have sufficient randomness and mean-zero distribution in the neutral tax regime. The contractionary and expansionary regimes also have comparable left-skewed distributions of monetary shocks.\footnote{The negative shock in the expansionary regime in Figure C.1 belongs to the year 1981, which is controlled in the regressions due to an unusual policy variation of the Volker era.}

Next, one may also be worried that the income groups that received tax changes might be predicted from the political party in power. Regarding the tax scheme
specific anticipation effects, I match the tax reforms in Table B.1 to respective political parties. Out of three tax cuts, two were legislated under the Republican party and one was legislated under the Democratic party.\(^{29}\) Out of two tax increases, the Deficit Reduction Act of 1984 was legislated under the Republican party under Reagan, and Omnibus 1993 was passed under the Democratic party. There are also no conventions on the income range that receives a statutory rate change. For example, the Deficit Reduction Act of 1984—despite being legislated under the Republican party—has increased the statutory taxes by 5 pp for large firms with income in between $1 and $1.4 million. Thus, there is sufficient randomness in the specifics of exogenous tax shifts and preferences of political parties.

**Baseline robustness checks.** One of the underlying assumptions of my empirical strategy is that it allocates firms to a certain tax treatment using last year’s taxable income, which may overlook potential income responses. In order to account for this, the baseline specification restricts the sample to firms that continue to stay in the treated income bracket for two years around the policy change. As a further robustness check, Appendix Figure D.3.1 re-estimates the baseline specification when firms stay in the treated income brackets for three years around the policy change. The results confirm the baseline findings. Note that the movement of taxable income per se is not crucial as long as the firm stays in the same bracket.

Second, the baseline analysis sets an upper bar of five years for firms in each regime, which is guided by the largest gap year within the exogenous reforms. It also captures the persistence feature of tax reforms and ensures that the average firm life across regimes is comparable. In Appendix Figure D.4.1, I change the maximum regime life of a firm to eight years. The results are robust to alternative regime lengths as well.

Next, I re-estimate the baseline analysis on the full set of tax reforms: exogenous and endogenous. Appendix Figure D.6.1 plots the results that do not significantly deviate from the baseline findings using exogenous tax reforms. In addition, it’s important to note that although narratively identified tax changes is necessary to achieve a sharper identification, the main implications of this paper can be tested using endogenous changes in tax levels as well. Although this approach would be subject to endogeneity concerns, Figures D.8.7 and D.8.8 confirm that firms with high marginal taxes show a larger response in employment and

---

\(^{29}\)The Revenue Act of 1978 was legislated under the Democratic party, while the Economic Recovery Tax Act of 1981 and the Tax Reform Act of 1986 was passed under the Republican party.
investment than firms with low marginal taxes, even without the use of identified exogenous tax interventions.

I also explore the possibility that the baseline estimates could be prone to omitted variable bias and test alternative financial variables that might explain the differences in responses. Appendix Figure D.5.1 re-estimates the baseline with additional controls on leverage and the liquidity ratio of firms. The results are quite robust to additional controls. Following Ottonello and Winberry (2020), I also test whether heterogeneity in other observable firm characteristics can drive the main results. Appendix Figures D.7.1–D.7.3 re-estimate the main results using specification 2 where monetary shocks are interacted with various other firm characteristics such as leverage, asset growth and sales growth. In each case, the coefficient on the monetary and tax regime interaction remains robust, suggesting the main results are not driven by these characteristics. In other words, these alternative channels of monetary policy do not offset the corporate tax channel I test.

To explore the role of specific firm characteristics within the baseline findings, I also group firms based on their cross-sectional characteristics using size (number of employees), leverage, and liquidity and explore whether certain groups are more sensitive to indirect effects of taxes on monetary outcomes. Appendix Figures D.8.1 and D.8.2 provide estimates of employment and investment by firm size groups. The results suggest that the average response observed in Figure 4 is generally similar across firms of different sizes. I also analyze responses based on liquidity and leverage ratio of firms. Appendix Figures D.8.3, D.8.4, D.8.5 and D.8.6 show that the indirect effects of taxes on monetary effectiveness is observed more clearly on low liquidity and high leverage firms which seem consistent with a financial frictions type mechanism as well. In a financial frictions type mechanism, borrowers’ balance sheet conditions can play a significant role in access to credit when there are capital market imperfections (Gertler and Gilchrist, 1994; Bernanke and Gertler, 1989; Kiyotaki and Moore, 1997; Calomiris and Hubbard, 1990). As tax reforms change firms’ tax liability rate, this may also alter the tightness of financial constraints and contribute to the financial propagation mechanism.

In addition, Figure D.8.9 checks the response of firms’ debt issuance and shows that high taxes lead firms to further lower debt issuance rates in response to contractionary monetary policy. In other words, high taxes and high interest rates jointly lower firms’ debt issuance where the role of the former is much less prominent than the latter’s. In fact, heterogeneity results using firms with high
vs low interest expense (Figure D.8.10) show that high interest expense firms do not respond significantly different than low interest expense firms on debt issuance rate. This suggests that interest deductibility is not one of the prominent channels through which taxes alter the effectiveness of the monetary policy.

**Measurement error.** There may be two measurement-related concerns in this study that are related to the definition of taxable income and tax avoidance of firms. One of the key features of my framework is to use the taxable income to sort the firms into tax brackets and pin down the tax treatment across different income brackets. Hence, the exact amount of taxable income is less of a concern as long as the firm is approximately matched to the right tax bracket.

Second, it is well documented that firms may engage in a variety of behavioral responses to minimize the tax burden (Rego, 2003). This type of measurement error would be highest for taxpayers with higher income as they may have greater access to avoidance opportunities. This is less of a concern for my analysis since the treatment effects are based on the large taxable income brackets the firms are in. Hence, even though the firm might not have a taxable income of $2 million, but say $5 million, it will be allocated to the same tax regime as long as the numbers are within the same taxable income brackets.\(^{30}\)

### 4. Conclusion

This paper provides the first empirical evidence on how tax policy dynamics influence the transmission of monetary policy. Using a unique feature of the US corporate tax code, tax narrative accounts, and detailed firm-level data, I show that changes in tax policy alter the average impact of monetary policy innovations and lead to heterogeneous effects. Specifically, I estimate employment and investment responses to monetary policy changes, allowing the effects to vary based on changes in firms’ tax treatment. Overall, my findings show that the dynamics of the tax system may explain sizable variation in monetary effectiveness.

The results of this paper are particularly important for three reasons. First, this study is the first to evaluate the impact of monetary policy conditional on underlying tax structures. This is quite different than previous approaches adopted in the monetary transmission literature that mainly use firm characteristics to explain the heterogeneous effects of monetary policy. Second, this paper is the first

\(^{30}\)In addition, since the taxable income brackets for high income firms are vast, this significantly lowers the chance of having mismeasured treatment effects for large firms.
attempt to evaluate the intersection of two main policy tools in an applied setting with micro-data and rich institutional features. In this regard, these findings contribute to our understanding of the scope of monetary policy while accounting for the dynamics of the tax system.

Last, the findings of this paper are particularly relevant as they provide an insight on how the historical downward trend in corporate taxes may have weakened effectiveness of monetary policy (Boivin et al., 2010; Barakchian and Crowe, 2013). Overall, the results of this paper encourage future work questioning the role of downward trends in corporate taxes on the gradual decline of interest rates in the United States.
References


Boivin, J., M. T. Kiley, and F. S. Mishkin (2010). *How has the monetary transmission mechanism evolved over time?, Volume 3.* Elsevier Ltd.


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Online Appendix

The Role of Corporate Tax Policy on Monetary Effectiveness: A Quasi-Experimental Approach

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June 8, 2022

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E.8 Impulse responses of q and marginal product of capital
A. Data appendix

Firm-level variables. I use the annual version of Compustat from 1969 to 2006 in all regressions. Compustat provides high-quality information on balance sheet and income statement components of publicly traded C-corporations in North America. Detailed variable definitions of Compustat can be accessed through Wharton Research Data Services for the United States.

Table A.1 provides variable names and respective codes in Compustat. Leverage is the ratio of short- and long-term debt to total assets. Liquidity ratio is the ratio of cash and short-term investments \( (che) \) to total assets. Tobin’s Q is defined as total assets at market value over total assets at book value following Cloyne et al. (2019).\(^{31}\) \( csho \) is common shares outstanding,\(^{32}\) \( ceq \) is common/ordinary equity, and \( txditc \) is deferred taxes and investment tax credit. The dividend variable is used as an indicator of whether the firm has paid cash dividends in the previous year. \( aqc \) (acquisitions) represent the cash outflow or funds used to acquire a company. All variables in level are deflated using the aggregate gross value added (GVA) deflator. I explain in detail the variables used in the taxable income definition on the next page.

<table>
<thead>
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<th>Variable</th>
<th>Compustat variable</th>
</tr>
</thead>
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<td>Leverage</td>
<td>( (dlc + dltt) \times 100/\text{at} )</td>
</tr>
<tr>
<td>Liquidity ratio</td>
<td>( che \times 100/\text{at} )</td>
</tr>
<tr>
<td>Tobin’s Q</td>
<td>( (\text{at} + \text{prcc} \times csho - \text{ceq} + txditc)/\text{at} )</td>
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<tr>
<td>Employees</td>
<td>emp</td>
</tr>
<tr>
<td>Investment</td>
<td>capx</td>
</tr>
<tr>
<td>Total assets (Book value)</td>
<td>at</td>
</tr>
<tr>
<td>Sales</td>
<td>sale</td>
</tr>
<tr>
<td>Dividend</td>
<td>dv</td>
</tr>
<tr>
<td>Acquisitions</td>
<td>( aqc/\text{at} )</td>
</tr>
</tbody>
</table>

I drop firms in the finance, insurance, real estate, and public administration sectors. Following Ottonello and Winberry (2020), I also drop firms with acquisitions accounting for more than 5% of total assets. I drop firms that are in the panel for less than five years as well as the first and last year observations of firms as these years lead to natural build-up or depletion of company assets and may lead to bias.

\(^{31}\)Note that \( \text{prcc} \) refers to the closing price of the fiscal year.

\(^{32}\)This item includes common stock, capital surplus, and retained earnings.
**Sample restrictions.** The baseline trimming excludes firms with i) top 1% of leverage ratio, ii) top and bottom 1% of real sales growth, iii) Tobin’s Q ratio greater than 4, and iv) acquisitions that are more than 5% of total assets. Trimming is done by year. To address volatility of taxable income, I drop firms that jump up more than one neighboring income bracket after a tax reform. I also drop firms that switch to a non-treated income bracket after a tax reform.

**Macro time-series data.** The one-year risk-free rate is the one-year Treasury constant maturity rate from the FRED series GS1. Debt to GDP is FRED series GFDEGDQ188S. The GVA deflator series is the price index (business: nonfarm) from FRED (data series is B358RG3Q086SBEA). The top statutory rate is from IRS historical Table 13.


**Definition of taxable income.** $TI$ is the main definition employed in this paper and it closely follows Blouin et al. (2010)[p.38] definition.\(^{33}\) Net income is the sum of operating ($ebit$) and nonoperating ($nopi$) income. Compustat $ebit$ is the sum of sales (net) minus cost of goods sold ($cogs$) minus selling, general, and administrative expense ($xsga$) minus depreciation/amortization ($dp$).\(^{34}\) Following Blouin et al. (2010), income from extraordinary items ($xido$) is grossed up by one minus the top statutory rate to express it on a pretax basis.\(^{35}\) Following Blouin et al. (2010) and Shevlin (1990), deferred taxes ($txdc$) are grossed up using the top statutory tax rate.\(^{36}\) Special items is $spi$ and interest expense is $xint$.\(^{37}\)

\[
TI = \text{Net income} - \text{Interest expense} + \text{Special items} - \frac{\text{Deferred tax expense} \cdot (1 - mtr)}{mtr}
\]

\(^{33}\)The definitions are also consistent with the historical IRS instructions on corporate tax filings. See the 1984 IRS corporate income tax return form 1120-A.

\(^{34}\)It is also referred to as operating income after depreciation ($oiadpq$).

\(^{35}\)Income from extraordinary items also include firms’ tax carryforward and carrybacks and accounts for firms’ forward-looking behaviour and incentives to allocate income across time. See Compustat 2003 User Guide, p.114.

\(^{36}\)As noted in Blouin et al. (2010)[p.37], most US firms record deferred taxes at top statutory rates as firms can reach the top statutory rates at relatively low income levels. Following Graham (1996)[p.193 footnote 3], if deferred tax expense from the statement of cash flows is missing, I substitute the change in deferred taxes from the balance sheet. Finally, no adjustment is made for the minority interest since EBIT already includes the minority interest (Blouin et al., 2010, p.36 footnote 21).

\(^{37}\)Since interest on lease is not reported on Compustat, I use interest expense ($xint$) which is also part of the pretax income definition in Compustat 2003 User Guide, p.9.
Table A.2: Descriptive Statistics

<table>
<thead>
<tr>
<th>Table A.2: Descriptive Statistics</th>
<th>Employees</th>
<th>Taxable income</th>
<th>Marginal tax rate</th>
<th>Income taxes</th>
<th>Investment</th>
<th>Assets</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Total sample</td>
<td>182,128</td>
<td>198,060</td>
<td>198,039</td>
<td>197,278</td>
<td>195,812</td>
<td>198,060</td>
<td>198,060</td>
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<tr>
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<td>182,128</td>
<td>198,060</td>
<td>198,039</td>
<td>197,278</td>
<td>195,812</td>
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<td>B. Neutral regime</td>
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<td>158,670</td>
<td>159,936</td>
<td>159,551</td>
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<td>14,424</td>
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<td>C. Contractionary Regime</td>
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<td>7998</td>
<td>7998</td>
<td>7998</td>
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<td>7.368</td>
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<td>17</td>
<td>168</td>
<td>691.4</td>
<td>7613</td>
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</table>

Notes: The table presents summary statistics of key variables of interest in the data covering the period 1969–2006. The sample contains 198,060 observations on 18,987 firms. The summary statistics are also provided across different tax regimes. Neutral regime firms account for 80 percent of the total sample and consists of 18,971 unique firms with 158,617 observations. Contractionary tax regime firms account for 4 percent of the total sample and consists of 1,733 firms with 7,098 observations in total. Expansionary tax regime firms account for 16 percent of the total sample and consists of 5,787 firms with 32,291 observations.
B. List of tax reforms and calculation of tax treatment

Table B.1: List of tax reforms matching statutory rate changes

<table>
<thead>
<tr>
<th>Exogenous statutory tax rate changes</th>
<th>Signed</th>
<th>Effective Year</th>
<th>Type</th>
<th>Persistence</th>
<th>Statutory rate changes</th>
<th>Exogenous</th>
<th>Years</th>
</tr>
</thead>
</table>

Notes: The list covers exogenous corporate tax reforms with statutory rate changes from 1969 to 2006. Following Mertens and Ravn (2012), anticipated tax liability changes with more than a 90-day difference between the signing of the legislation and their implementation are classified as anticipated tax reforms. The baseline specification only includes tax changes categorized as exogenous and unanticipated. The larger number of tax cuts is also due to the lack of indexation in the tax code. Note that the 1986 Tax Reform Act was implemented in two stages, occurring in 1987 and 1988. Source: Romer and Romer (2009), Mertens and Ravn (2012, 2013), Joint Committee of Taxation, and IRS SOI files.
Table B.2: IRS Corporate Income Tax Brackets (1968–2016)

<table>
<thead>
<tr>
<th>Years</th>
<th>Taxable income</th>
<th>Rate</th>
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</thead>
<tbody>
<tr>
<td>1968-1969</td>
<td>First $25,000</td>
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</tr>
<tr>
<td></td>
<td>Over - $25,000</td>
<td>52.80</td>
</tr>
<tr>
<td>1970</td>
<td>First $25,000</td>
<td>22.55</td>
</tr>
<tr>
<td></td>
<td>Over - $25,000</td>
<td>49.20</td>
</tr>
<tr>
<td>1971-1974</td>
<td>First $25,000</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Over - $25,000</td>
<td>48</td>
</tr>
<tr>
<td>1975-1978</td>
<td>First $25,000</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$25,000-$50,000</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Over - $50,000</td>
<td>48</td>
</tr>
<tr>
<td>1979-1981</td>
<td>First $25,000</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>$25,000-$50,000</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>$50,000-$75,000</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>$75,000-$100,000</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Over - $100,000</td>
<td>46</td>
</tr>
<tr>
<td>1982</td>
<td>First $25,000</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>$25,000-$50,000</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>$50,000-$75,000</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>$75,000-$100,000</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Over - $100,000</td>
<td>46</td>
</tr>
<tr>
<td>1983</td>
<td>First $25,000</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>$25,000-$50,000</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>$50,000-$75,000</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>$75,000-$100,000</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Over - $100,000</td>
<td>46</td>
</tr>
<tr>
<td>1984-1986</td>
<td>First $25,000</td>
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</tr>
<tr>
<td></td>
<td>$50,000-$75,000</td>
<td>30</td>
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<tr>
<td></td>
<td>$75,000-$100,000</td>
<td>40</td>
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<tr>
<td></td>
<td>$100,000-$1,000,000</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>$1,000,000-$1,405,000</td>
<td>51</td>
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<tr>
<td></td>
<td>Over $1,405,000</td>
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<td>1987</td>
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</tr>
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<td>1988-1992</td>
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<td>Over $335,000</td>
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<tr>
<td>1993-2016</td>
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</tr>
<tr>
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<td>25</td>
</tr>
<tr>
<td></td>
<td>$75,000-$100,000</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>$100,000-$335,000</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>$335,000 - $10,000,000</td>
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<td>38</td>
</tr>
<tr>
<td></td>
<td>Over $18,333,000</td>
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</table>

Note: See the full historical data on U.S. Corporation Income Tax Brackets and Rates at IRS historical Table 13.
Calculation of tax treatment

Figure B.1 presents an example calculation of average tax burden. Suppose at year $t$ a new tax legislation has decreased the statutory tax rates by 3 pp for the ($5,000, \$10,000$) taxable income bracket and by 2 pp for the ($10,000, \$30,000$) taxable income bracket. Firm A has $8,000 taxable income, and firm B has $30,000 taxable income. Using the closest taxable income thresholds at $5,000$ and $10,000$ of taxable income, respectively, the changes in liability for firm A and B can be calculated as $90$ and $400$, respectively.\(^{38}\) Next, to facilitate comparison across firms and time, I scale the liability changes with the lagged taxable income, which leads to a $1.12\%$ and $1.33\%$ change in average tax burden of firm A and B, respectively.

Figure B.1: Sketch of change in tax burden calculation

<table>
<thead>
<tr>
<th>Taxable Income</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
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<tr>
<td>$5,000$</td>
<td>$8,000$</td>
<td>$10,000$</td>
</tr>
</tbody>
</table>

Statutory rate change: $\Delta \text{mtr} = 3\%$  
$\Delta \text{mtr} = 2\%$

$\Delta$ Liability:  
$3000 \times \frac{3}{100} = 90$  
$20000 \times \frac{2}{100} = 400$

$\Delta$ Tax burden:  
$\frac{90}{8000} = 1.12\%$  
$\frac{400}{30000} = 1.33\%$

Note: $5,000$ and $10,000$ correspond to taxable income thresholds; $8,000$ is the actual taxable income of firm A, and $30,000$ is the actual taxable income of firm B. The statutory rate change reflects the changes in the statutory tax rate in the relevant taxable income bracket. $\Delta$ Liability shows the change in tax liability in the treated taxable income bracket. $\Delta$ Tax burden calculates the changes in share of tax burden within the treated taxable income bracket.

\(^{38}\)The liability change of firm A is $(8000 - 5000) \times 3/100 = 90$, and the liability change of firm B is $(30000 - 10000) \times 2/100 = 400$
Figure B.2: Histogram of changes in tax burden (dose)

Note: This figure plots the histogram of tax burden changes across the sample. The dose is calculated as the change in tax liability over taxable income. Negative doses are from expansionary tax changes, and positive doses are from contractionary tax changes. The gray thresholds show the mean dose of each regime on points –0.028 and 0.0062. The highest expansionary tax shock changes a firm’s share of tax liabilities by 6%.

Figure B.3: Histogram of changes in tax burden (dose) by regime bins

Note: This figure plots the histogram of tax burden changes across the sample where the firms are allocated to the following five regime-dose groups: contractionary high (dark purple), contractionary low (light purple), expansionary high (dark orange), expansionary low (light orange), and neutral. The dose is calculated as the change in tax liability over lagged taxable income. Negative doses are from expansionary tax changes, and positive doses are from contractionary tax changes. The dark shades reflect higher dose treatments. The gray thresholds show the mean dose of each regime on points –0.028 and 0.0062. For instance, if a firm receives a tax dose lower than –0.028, it is labeled as receiving a high expansionary tax treatment.
C. Monetary shocks and firm characteristics by tax regimes

Figure C.1: Histogram of monetary policy shocks across regimes (1969–2006)

Note: The figure plots the distribution of Wieland and Yang (2020) monetary policy shocks across different tax regimes from 1969 to 2006. The neutral regime confirms the randomly distributed monetary policy shocks. The shocks in contractionary and expansionary regimes are also comparable in terms of having a right-skewed distribution. The −0.5 in the expansionary tax regime corresponds to year 1981 and is controlled in the regressions with a year dummy.
Figure C.2: Firm characteristic decomposition by each tax regime.

Note: The figure plots the quartiles of real asset, real sales, leverage, and investment in each regime. The quartiles is generated by year, and the histogram spans observations from 1969 to 2006.
D. Robustness

D.1 Baseline specification with standard errors by dose

Figure D.1.1: Impulse responses of the number of employees to monetary shocks (by dose)

Note: The plots show impulse responses of employees using LP-IV. The horizon is 4 years, and the lag is set to 2. The time span is 1969–2006. Standard errors are clustered by firm and year. Dose = 0% is equal to the neutral regime plot. Shaded areas show 95% confidence intervals.
Figure D.1.2: Impulse responses of investment to monetary shocks (by dose)

Note: The plots show impulse responses of investment using LP-IV. The horizon is 4 years, and the lag is set to 2. The time span is 1969–2006. Standard errors are clustered by firm and year. Dose = 0% is equal to the neutral regime plot. Shaded areas show 95% confidence intervals.
D.2 Baseline specification in details

Figure D.2.1: Impulse responses of the number of employees to monetary shocks

(a) Neutral regime ($\hat{\beta}_h$)

(b) $\hat{\beta}_h + \hat{\Gamma}_h$

(c) $\hat{\Gamma}_h$

(d) $\hat{\theta}_h$

Note: The plots show impulse responses of employees using IV local projection regressions with Romer and Romer (extended) monetary policy shocks instrumenting the one-year government bond rate. The horizon is 4 years, and the lag is set to 2. The time span is 1969–2006. Standard errors are clustered by firm and year. $Dose = 0\%$ is equal to the neutral regime plot. Shaded areas show 95% confidence intervals.
Figure D.2.2: Impulse responses of log investment to monetary shocks

(a) Neutral regime ($\hat{\beta}_h$)  
(b) $\beta^h + \hat{\Gamma}^h$

(c) $\hat{\Gamma}^h$  
(d) $\hat{\theta}^h$

Note: The plots show impulse responses of investment using IV local projection regressions with Romer and Romer (extended) monetary policy shocks instrumenting the one-year government bond rate. The horizon is 4 years, and the lag is set to 2. The time span is 1969–2006. Standard errors are clustered by firm and year. $Dose = 0\%$ is equal to the neutral regime plot. Shaded areas show 95% confidence intervals.
D.3 Additional taxable income restrictions

Figure D.3.1: Impulse responses using additional income restrictions

(a) Neutral regime ($\hat{\beta}_h$)

(b) Total effects by dose ($\hat{\beta}_h + \hat{\Gamma}_h$)

(c) Neutral regime ($\hat{\beta}_h$)

(d) Total effects by dose ($\hat{\beta}_h + \hat{\Gamma}_h$)

Note: The plots show impulse responses using LP-IV regressions with Romer and Romer (extended) monetary policy shocks instrumenting the one-year government bond rate. The control variables are log real investment, log real assets, log real taxable income, real asset growth, growth in the number of employees, debt to gdp ratio, and top statutory tax rate. Standard errors are clustered by firm and year. Dose = 0% is equal to the neutral regime plot. Shaded areas show 95% confidence intervals.
D.4 Extended regime length

Figure D.4.1: Impulse responses using extended regime length

(a) Neutral regime ($\hat{\beta^h}$)

(b) Total effects by dose ($\hat{\beta^h} + \hat{\Gamma^h}$)

(c) Neutral regime ($\hat{\beta^h}$)

(d) Total effects by dose ($\hat{\beta^h} + \hat{\Gamma^h}$)

Note: The plots show impulse responses using LP-IV regressions with Romer and Romer (extended) monetary policy shocks instrumenting the one-year government bond rate. The horizon is 4 years, and the lag is set to 2. The time span is 1969–2006. The control variables are log real investment, log real assets, log real taxable income, real asset growth, growth in the number of employees, debt to gdp ratio, and top statutory tax rate. Standard errors are clustered by firm and year. Dose = 0% is equal to the neutral regime plot. Shaded areas show 95% confidence intervals.
D.5 Additional controls

Figure D.5.1: Impulse responses using additional controls

(a) Neutral regime ($\hat{\beta}^h$)  
(b) Total effects by dose ($\hat{\beta}^h + \hat{\Gamma}^h$)

(c) Neutral regime ($\hat{\beta}^h$)  
(d) Total effects by dose ($\hat{\beta}^h + \hat{\Gamma}^h$)

Note: The plots show impulse responses of investment using LP-IV regressions with Romer and Romer (extended) monetary policy shocks instrumenting the one-year government bond rate. The horizon is 4 years, and lag is set to 2. The time span is 1969–2006. The control variables are log real investment, log real assets, log real taxable income, real asset growth, growth in the number of employees, debt to gdp ratio, top statutory tax rate, leverage ratio, and liquidity ratio. Standard errors are clustered by firm and year. Dose = 0% is equal to the neutral regime plot. Shaded areas show 95% confidence intervals.
D.6 Baseline with endogenous and exogenous tax reforms

Figure D.6.1: Impulse responses with full set of tax reforms

![Impulse response plots](image)

(a) Neutral regime ($\hat{\beta}^h$)  
(b) Total effects by dose ($\hat{\beta}^h + \hat{\Gamma}^h$)  
(c) Neutral regime ($\hat{\beta}^h$)  
(d) Total effects by dose ($\hat{\beta}^h + \hat{\Gamma}^h$)

Note: The plots show impulse responses using IV local projection regressions with Romer and Romer (extended) monetary policy shocks instrumenting the one-year government bond rate. The horizon is 4 years, lag is set to 2. The time span is 1969–2006. Full set of tax reform (both endogenous and exogenous) are used in this specification. The control variables are log real investment, log real assets, log real taxable income, real asset growth, growth in the number of employees, debt to gdp ratio, and top statutory tax rate. Standard errors are clustered by firm and year. Dose = 0% is equal to the neutral regime plot. Shaded areas show 95% confidence intervals.
D.7 Heterogeneity in observable firm characteristics

This section shows that the heterogeneous effects of monetary policy are not driven by firm characteristics such as sales growth, asset growth, or leverage. I expand the baseline specification as

$$\Delta_h \log(y_{j,t+h}) = \alpha_h^j + \beta_h^j \Delta R_t + \Gamma_h^j \Delta R_t \text{Dose}_{j,t} + \beta_y^h \Delta R_t \text{S}_{j,t}$$

$$+ \theta^h \text{Dose}_{j,t} + \Omega'(L) Z_{j,t-1} + \epsilon_{j,t+h},$$

where $s_{jt}$ is lagged real sales growth, lagged leverage, and lagged real asset growth. In each case, the coefficient on the monetary and tax regime interaction remains robust. Hence, firm-level characteristics that may be correlated with tax regimes or monetary effectiveness do not drive the heterogeneous responses in tax regimes.

Figure D.7.1: Impulse responses of employees using equation 2 with lagged asset growth

(a) Neutral regime ($\hat{\beta}^h$)  (b) Total effects by dose ($\hat{\beta}^h + \Gamma^h$)

(c) $\hat{\Gamma}^h$  (d) $\hat{\beta}_y^h$

Note: The plots show impulse responses using IV local projection regressions with using equation 2 where $s_t$ is lagged real asset growth. Firms are allowed to stay in a regime for a maximum of 5 years. The horizon is 4 years, and the lag is set to 2. The time span is 1969–2006. The control variables are log real investment, log real assets, log real taxable income, real asset growth, growth in the number of employees, debt to gdp ratio, and top statutory tax rate. Standard errors are clustered by firm and year.
Figure D.7.2: Impulse responses of employees using equation 2 with lagged sales growth

(a) Neutral regime ($\hat{\beta}^h$)

(b) Total effects by dose ($\hat{\beta}^h + \hat{\Gamma}^h$)

(c) $\hat{\Gamma}^h$

(d) $\hat{\beta}^h_y$

Note: The plots show impulse responses of equation 2 where $s_t$ is lagged sales growth. The horizon is 4 years, and the lag is set to 2. The time span is 1969–2006. The control variables are log real investment, log real assets, log real taxable income, real asset growth, growth in the number of employees, debt to gdp ratio, and top statutory tax rate. Standard errors are clustered by firm and year.
Figure D.7.3: Impulse responses of employees using equation 2 with lagged leverage ratio

Note: The plots show impulse responses using IV local projection regressions with using equation 2 where $s_t$ is lagged leverage ratio. Firms are allowed to stay in a regime for a maximum of 5 years. The horizon is 4 years, and the lag is set to 2. The time span is 1969–2006. The control variables are log real investment, log real assets, log real taxable income, real asset growth, growth in the number of employees, debt to gdp ratio, and top statutory tax rate. Standard errors are clustered by firm and year.
D.8 Heterogeneity in the baseline results

D.8.1 Marginal tax rate estimates based on firm size

Figure D.8.1: Impulse responses of employees using LP-IV specification 3

Note: The plots show impulse responses of employees using IV local projections. The horizon is 5 years, and
the lag is set to 2. The time span is 1969–2006. Standard errors are clustered by firm and year. The left panel
shows the impulse responses to monetary shock absent any tax intervention. Large (small) firms refer to firms
with greater (less) than 400 employees.
Figure D.8.2: Impulse responses of investment using LP-IV specification 3

Note: The plots show impulse responses of investment using IV local projection regressions with Romer and Romer (extended) monetary policy shocks instrumenting the one-year government bond rate. The time span is 1969–2006. Standard errors are clustered by firm and year. Large (small) firms refer to firms with greater (less) than 400 employees.
D.8.2 Marginal tax rate estimates based on liquidity

Figure D.8.3: Impulse responses of employees using LP-IV specification 3

Note: The plots show impulse responses of employees using IV local projections. The horizon is 5 years, and lag is set to 2. The time span is 1969–2006. Standard errors are clustered by firm and year. High (low) liquidity firms refer to firms with liquidity ratio greater (less) than median liquidity rate by year.
Figure D.8.4: Impulse responses of investment using LP-IV specification 3

Note: The plots show impulse responses of investment using IV local projection regressions with Romer and Romer (extended) monetary policy shocks instrumenting the one-year government bond rate. The time span is 1969–2006. Standard errors are clustered by firm and year. High (low) liquidity firms refer to firms with liquidity ratio greater (less) than median liquidity rate by year.
D.8.3 Marginal tax rate estimates based on leverage

Figure D.8.5: Impulse responses of employees using LP-IV specification 3

Note: The plots show impulse responses of employees using IV local projections. The horizon is 5 years, and the lag is set to 2. The time span is 1969–2006. Standard errors are clustered by firm and year. High (low) leverage firms refer to firms with leverage ratio greater (less) than median leverage rate by year.
Figure D.8.6: Impulse responses of investment using LP-IV specification 3

Note: The plots show impulse responses of investment using IV local projection regressions with Romer and Romer (extended) monetary policy shocks instrumenting the one-year government bond rate. The time span is 1969–2006. Standard errors are clustered by firm and year. High (low) leverage firms refer to firms with leverage ratio greater (less) than median leverage rate by year.
D.8.4 Marginal tax rate estimates based on marginal tax rates

Figure D.8.7: Impulse responses of employees using LP-IV specification 3

Note: The plots show impulse responses of employees using IV local projections. The horizon is 5 years, and the lag is set to 2. The time span is 1969–2006. Standard errors are clustered by firm and year. High (low) marginal tax rate firms refer to firms with marginal tax rate greater (less) than 0.35.
Figure D.8.8: Impulse responses of investment using LP-IV specification 3

Note: The plots show impulse responses of investment using IV local projection regressions with Romer and Romer (extended) monetary policy shocks instrumenting the one-year government bond rate. The time span is 1969–2006. Standard errors are clustered by firm and year. High (low) marginal tax rate firms refer to firms with marginal tax rate greater (less) than 0.35.
D.8.5 Additional Results on Debt Issuance and Interest Deductibility

Figure D.8.9: Impulse responses of debt issuance rate using LP-IV specification 3

Figure D.8.10: Impulse responses of debt issuance rate using LP-IV specification 3

Note: The plots show impulse responses of employees using IV local projections. The horizon is 5 years, and the lag is set to 2. The time span is 1969–2006. Standard errors are clustered by firm and year. High (low) interest expense refer to firms with higher (lower) interest expense than median interest expense by year.
D.9 Granger causality tests

This section provides Granger causality tests confirming that the Romer monetary shock series are uncorrelated to the exogenous tax reforms. Specifically, I regress annual monetary innovations on a set of lagged tax reforms and aggregate variables, including changes in real government spending, changes in total employees, and changes in total public real debt. The lag length is three years. The null hypothesis is that Romer shocks are not predictable from the exogenous tax reforms. According to Table D.1, all p-values are above 10% and mostly above 40%; hence we cannot statistically reject the hypothesis of exogeneity of the monetary shocks to tax reforms. This suggests that studying tax changes around monetary policy innovations is suitable.

Table D.1: Granger tests on monetary policy shocks

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.m_rate</td>
<td>0.0239 (0.830)</td>
<td>-0.117 (0.334)</td>
</tr>
<tr>
<td>L2.m_rate</td>
<td>0.0498 (0.654)</td>
<td>-0.0996 (0.423)</td>
</tr>
<tr>
<td>L3.m_rate</td>
<td>0.0122 (0.913)</td>
<td>-0.0422 (0.695)</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.0128 (0.935)</td>
<td>-1.345 (0.177)</td>
</tr>
<tr>
<td>F</td>
<td>0.0863</td>
<td>0.967</td>
</tr>
</tbody>
</table>

Note: All regressions span from 1969 to 2006, and p-values are provided in parentheses. The table estimates: 
\[ \text{Romer shocks} = c + \sum_{i=1}^{L} \beta_i x_{t-i} + v_i. \] 
Specification (1) regresses monetary innovations on the exogenous tax liability changes (Mertens and Ravn, 2013) on the dates with marginal tax rate changes. Specification (2) adds the following left-hand side variables: changes in real GDP, changes in real government spending, changes in total employees, and changes in total public real debt.

In addition, Table D.2 provides Granger causality tests confirming that the exogenous tax reforms are uncorrelated to the monetary policy shocks. Specifically, I regress the Mertens and Ravn (2013) corporate exogenous tax liability changes on lagged annual monetary innovations and a set of aggregate variables.39

Table D.2: Granger tests on tax reforms

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.resid_full</td>
<td>-0.0781 (0.824)</td>
<td>-0.232 (0.666)</td>
</tr>
<tr>
<td>L2.resid_full</td>
<td>0.184 (0.595)</td>
<td>0.381 (0.491)</td>
</tr>
<tr>
<td>L3.resid_full</td>
<td>-0.0814 (0.791)</td>
<td>-0.375 (0.467)</td>
</tr>
<tr>
<td>_cons</td>
<td>0.168 (0.515)</td>
<td>-1.404 (0.406)</td>
</tr>
<tr>
<td>F</td>
<td>0.0993</td>
<td>0.418</td>
</tr>
</tbody>
</table>

Note: All regressions span from 1969 to 2006, and p-values are provided in parentheses. The table estimates: 
\[ \text{Aggregate Tax Shocks} = c + \sum_{i=1}^{L} \beta_i x_{t-i} + v_i. \] 
Specification (1) regresses exogenous tax liability changes (Mertens and Ravn, 2013) on lags of monetary innovations. Specification (2) adds the following left-hand side variables: changes in real GDP, changes in real government spending, changes in total employees, and changes in total public real debt.

39Specifically, I focus on Mertens and Ravn (2013) corporate tax reforms with a statutory rate change, however the results are robust to full set of reforms as well.
D.10 Average treatment effects across regimes

The average causal effects of monetary policy shocks are estimated using

\[ y_{j,t+h} - y_{j,t-1} = \alpha_j^h + \beta^h \Delta R_t + \Omega(L) Z_{j,t-1} + \epsilon_{j,t+h} \text{ where } h = 0, 1, \ldots, H, \]  

Figure D.10.1: Impulse responses to monetary policy shocks (1969–2006)

Note: The plots show impulse responses of employees using Romer and Romer monetary policy shocks as instruments for the one-year Treasury rate. The horizon is 4 years, and the lag is set to 2. The specification includes a year dummy for 1981 and 2001. Standard errors are clustered by firm and year. Controls follow the baseline specification.

Figure D.10.2: Impulse responses to monetary policy shocks by regime

E. Model

E.1 Model outline

This section builds a medium-sized New Keynesian model featuring capital, corporate taxes, and Rotemberg (1982) type price rigidities. The purpose of the model is to lay out how corporate tax shifts can affect the transmission channels of monetary policy. The model is populated by identical infinitely lived households, a continuum of monopolistic and competitive intermediate goods firms, a final goods firm, and government. The time is discrete, and the planning horizon is infinite.

Households. Households purchase consumption goods, provide labor services to the productive sector, and save with bonds. A representative infinitely lived household is seeking to solve the following dynamic optimization problem:

\[
\max_{C_t, N_t, B_{t+1}} E_t \sum_{t=0}^{\infty} \beta^t \left\{ \ln C_t - \frac{N_t^{1+\chi}}{1+\chi} \right\} \quad \text{s.t.}
\]

\[
P_t C_t + Q_t B_t \leq B_{t-1} + W_t N_t + \Pi_t + T_t,
\]

where \(C_t\) is the final goods consumption. \(N_t\) denotes hours of employment,\(^{40}\) \(W_t\) is the nominal wage, and \(P_t\) is the price of the final good. \(\chi\) is the inverse of Frisch elasticity, and \(B_t\) is the stock of one-period nominally riskless savings household purchases. Each bond pays one unit at maturity, and its price is \(Q_t\).\(^{41}\) \(T_t\) is government transfers, and \(\Pi_t\) is the dividend distribution from the ownership of firms.\(^{42}\) The consumption index, \(C_t\), is given by

\[
C_t \equiv \left( \int_0^1 C_t(i)^{1-\frac{1}{\epsilon}} \, di \right)^{\frac{\epsilon}{1-\epsilon}},
\]

where \(C_t(i)\) is the quantity of good \(i\) consumed by the household in period \(t\).

The representative household must solve two problems: allocation of spending across goods and allocation of spending across time. The solution to the problems is standard and provided in Appendix E.3. The first-order conditions bring the

\(^{40}\) Note that \(N_t\) can be interpreted as the number of household members employed as in Galí (2009).
\(^{41}\) \(Q_t\) is equal to the inverse of the gross nominal interest rate.
\(^{42}\) The dividends received by households are just the sum of profits from the intermediate goods producers. Since the final goods firms are competitive, they earn no profit.

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optimality conditions on consumption savings and labor supply decisions:

\[ \theta N_t^c C_t = \frac{W_t}{P_t} = w_t \]  \hspace{1cm} (4)

\[ Q_t = \beta E_t C_t \frac{1}{C_{t+1} 1 + \pi_{t+1}} \quad \text{for } t = 0, 1, 2, ..., \]  \hspace{1cm} (5)

where \( \pi_{t+1} = \frac{P_{t+1}}{P_t} - 1 \) is the net inflation rate and \( w_t = \frac{W_t}{P_t} \) is real wages.

**Production.** Production is split into two sectors: final goods and intermediate goods. There is a representative competitive final goods firm that aggregates intermediate inputs according to a CES technology. This generates a downward-sloping demand for each intermediate good and grants the pricing power to intermediate producers. The intermediate firms produce output using capital and labor and are subject to price rigidities.

**Final goods producers.** The final goods producers are perfectly competitive and aggregate intermediate goods into final goods for consumption using a CES technology:

\[ Y_t = \left( \int_0^1 Y_t(i)^{1-\frac{\epsilon}{\epsilon-1}} di \right)^{\frac{\epsilon}{\epsilon-1}}, \]

where \( \epsilon > 1 \) is the constant elasticity of substitution between different intermediate goods, \( i \).

**Intermediate goods producers.** The intermediate goods producers are a continuum of firms indexed by \( i \in [0, 1] \). Each firm produces a differentiated good for which it sets the price. All firms use an identical technology, represented by a standard Cobb-Douglas production function:

\[ Y_t(i) = A_t K_t(i)^\alpha N_t(i)^{1-\alpha}, \]  \hspace{1cm} (6)

where \( A_t \) represents the level of technology, assumed to be common to all firms.

\[ \text{As standard, the cost minimization problem of the final goods producers implies that the demand for intermediate goods } i \text{ is given by} \]

\[ Y_t(i) = \left( \frac{P_t(i)}{P_t} \right)^{-\epsilon} Y_t \text{ for all } i \in [0, 1], \]

where \( P_t(i) \) is the price of intermediate good \( i \). This suggests that the relative demand for good \( i \) is a function of its relative price, price elasticity of demand, \( \epsilon \), and aggregate output, \( Y_t \). We can also reach the aggregate price index from the zero-profit condition: \( P_t \equiv \left( \int_0^1 P_t(i)^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}} \)
All firms face an identical isoelastic demand schedule and take the aggregate price level, $P_t$, aggregate consumption index, $C_t$, and wage level, $W_t$, as given. Following Rotemberg (1982), each monopolistic firm faces a quadratic cost of adjusting nominal prices, measured in terms of the final good:

$$
\text{Adj } P_t(i) = \frac{\psi}{2} \left( \frac{P_t(i)}{P_{t-1}(i)} - 1 \right)^2 Y_t,
$$

where $\psi$ is the degree of nominal price rigidities. Firms own the capital stock and generate more capital through investment. The capital accumulation process is subject to convex capital adjustment costs. Capital accumulates according to

$$K_{t+1}(i) = I_t(i) - \frac{\phi}{2} \left( \frac{I_t(i)}{I_{t-1}(i)} - 1 \right)^2 + (1 - \delta) K_t(i).
\tag{7}
$$

Investment is financed out of dividends, and for simplicity, we assume that the firm issues no intertemporal debt. The dividend payout is then

$$\Pi_t = (Y_t - w_t N_t)(1 - \tau_t) - I_t.$$

Note that the corporate taxes are levied on the accounting profits of the firm as explored in the empirical section. Firm $i$ will aim to maximize the value of future profits discounted by the stochastic discount factor of the household, $E_t \beta^{\lambda_{t+1}} = Q_t$. Each period, the firm maximizes profits subject to two constraints. $q_t$ is the multiplier on the accumulation equation (since the units of the firm’s problem are in real terms, $q_t$ is interpreted as reflecting how many goods the firm would give up for an additional unit of installed capital). $MC^n_t(i)$ measures how much nominal costs change if the firm produces an additional unit of its good. First-order conditions are

$$N_t(i) : \quad W_t(1 - \tau_t) = MC^n_t(i)[(1 - \alpha) A_t K_t(i)^\alpha N_t(i)^{-\alpha}],$$

where $MC^n_t = MC_t * P_t$ and $MC_t$ is the real marginal cost and $w$ is the real wage. Hence, the labor demand equation becomes

$$w_t(1 - \tau_t) = MC_t(i)[(1 - \alpha) A_t K_t(i)^\alpha N_t(i)^{-\alpha}],$$

mapping real wage into the quantity of labor demanded given the level of technol-
ogy and capital.

\[ I_t(i) : 1 = q_t[1 - \phi(I_t(i) - 1)I_t + \beta \frac{\lambda_{t+1}}{\lambda_t} q_{t+1} \left( \phi I_{t+1} - 1 \right)] \]  

\[ K_{t+1}(i) : q_t = \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \left( q_{t+1}(1-\delta) + MC_{t+1}(i)(A_{t+1} \alpha K_{t+1}(i))^{\alpha-1} N_{t+1}(i)^{1-\alpha} \right) \]

\[ P_t(i) : \frac{1}{P_t} \left[ (1-\epsilon)(\frac{P_t}{P_{t-1}})^\epsilon Y_t(1-\tau_t) - \psi(\pi_t) - \frac{1}{P_{t-1}} P_t Y_t \right] \]

\[-MC^n(i) \left( -\epsilon \frac{P_t}{P_{t-1}}^{\epsilon-1} Y_t \right) + \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \left[ \psi(\pi_{t+1}) (\pi_{t+1} + 1) \right] P_t Y_t = 0, \]

where \( \pi_t = \frac{P_t}{P_{t-1}} - 1 \). By imposing symmetry and simplifying, we can reach the steady state mark-ups:

\[ (1-\epsilon)Y_t(1-\tau_t) - \psi \pi_t(\pi_t + 1) Y_t + \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \psi(\pi_{t+1}) (\pi_{t+1} + 1) Y_{t+1} = -\epsilon MC_t Y_t, \]

where equation 9 is the counterpart of a New Keynesian Phillips curve relating nominal variables to the real economy. Under steady state,

\[ P = MC^n \frac{\epsilon}{(\epsilon - 1)(1-\tau)}, \]

where \( \frac{\epsilon}{(\epsilon - 1)} \) is the conventional flexible price mark-up, \( \mathcal{M} \). The equation suggests that the optimal price would be a fixed mark-up over nominal marginal cost, and the existence of taxes shows up like an increase in the steady state mark-up.

The market-clearing conditions are standard. Since the firm issues no intertemporal debt, the household cannot have any stock of savings. Note that from the investment first-order condition (equation 8), it is clear that \( q = 1 \) in steady state, where there is no adjustment costs. Labor market clearing requires that the sum of labor used by firms equals the total labor supplied by households; e.g., \( \int_0^1 N_t(i) di = N_t \). There is no market for capital since firms own the capital stock.
The goods market-clearing condition is

\[ Y_t = C_t + I_t + \frac{\psi}{2}(\pi_t)^2 Y_t. \] (11)

**Government.** The government sets tax policy, and an independent monetary authority, the central bank, conducts monetary policy. It is assumed the government holds a balanced budget and distributes the corporate tax returns to households as lump-sum transfers. Tax policy follows the following rule:

\[ \tau_t = (1 - \rho)\tau_{ss} + (\rho)\tau_{t-1} + s_t \epsilon_t. \] (12)

Monetary policy sets the nominal interest rate according to the following Taylor (1993) rule:

\[ i_t = \rho i_{t-1} + (1 - \rho)\phi_\pi \pi_t + s_i \epsilon_i, \] (13)

where \( \phi_\pi > 1 \) and \( \epsilon_{i,t} \) is an exogenous stochastic disturbance in the nominal interest rate, which follows a white noise process with zero mean and finite variance. A positive realization of \( \epsilon_{i,t} \) is interpreted as a contractionary monetary policy shock, leading to a rise in the nominal interest rate.\(^{44}\) Combining the above conditions and imposing symmetry leads to the set of equilibrium conditions provided in Appendix E.3.

### E.2 Model results

This section discusses a simulation exercise that compares the effects of monetary policy in two economies with differing preceding tax interventions. Output, investment, capital, and hours worked are variables of interest, and units are interpreted as percent deviations from the steady state. The parameters are provided in Appendix Table E.1. I use a second-order approximation to capture the level effect of an initial tax shock on the subsequent monetary policy shock.\(^{45}\) The aim is to test whether an economy with persistent preceding tax interventions shows a differentiated response to monetary policy.\(^{46}\)

Figure E.2.1a plots the impulse responses of the blue and red economy in

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\(^{44}\)Note that this rule implies a countercyclical monetary policy where the central bank increases the nominal interest rates when inflation is positive.

\(^{45}\)In first-order approximation, the initial condition, the sequence of shocks, and their sign and size do not matter.

\(^{46}\)Matlab implementation follows Johannes Pfeifer’s Github reference on RBC news shock model.
which the red economy receives a 50 basis point increase in the corporate tax rate at time $t = 1$; the blue economy does not receive a tax shock. The responses to tax shocks start at time $t = 1$ and are presented with boxed lines. At time $t = 10$, both economies receive a 25 basis point contractionary monetary policy shock. The object of interest is the shaded area that is the difference between the boxed ($\tau$) and the solid ($MP + \tau$) lines, capturing the effects of monetary policy in each economy. Comparing shaded areas of the two economy shows that the economy that received a preceding tax increase has a larger response to a monetary policy shock than the economy with stable taxes. To visualize the effect more clearly, Figure E.2.1b plots the gap between the solid line ($MP + \tau$) and the boxed ($\tau$) line, which is the total effect of monetary policy in each economy. Figure E.2.1b shows that the effects of monetary policy are larger in an economy that faces a preceding contractionary tax shock.

Figure E.2.1: Impulse responses to monetary policy shock following contractionary tax shifts

(a) Total effect ($\tau + MP$)  
(b) Effect of monetary policy

Note: The monetary policy shocks are a 25 basis point (0.25 pp) increase to the steady state nominal interest rate and a 50 basis point (0.5 pp) increase to the steady state corporate tax rate ($\tau_{ss} = 0.20$).

The choice of 10 quarters is guided by the half-life of the five-year regime length used in the empirical section.
Figure E.2.2: Impulse responses to monetary policy shock following expansionary tax shifts

(a) Total effect \((\tau + MP)\)
(b) Effect of monetary policy

Note: The monetary policy shocks are a 25 basis point (0.25 pp) increase to the steady state nominal interest rate and a 50 basis point (0.5 pp) increase to the steady state corporate tax rate \((\tau_{ss} = 0.20)\).

Next, I compare the effects of monetary policy when an economy faces a preceding expansionary tax shock. The bottom panel of Figure E.2.2b shows the impulse responses to monetary policy shocks when the dashed (red) economy receives an expansionary tax shock at time \(t = 1\) and a contractionary monetary shock at time \(t = 10\). Similarly, the blue economy only receives a contractionary monetary shock at time \(t = 10\). Comparing the two impulse responses suggests that the effectiveness of monetary policy is reduced if monetary innovations are preceded by a persistent tax cut.

Overall, these results support the empirical findings such that a preceding contractionary tax policy amplifies the impact of monetary shocks and a preceding expansionary tax policy reduces the impact of monetary shocks.\(^{48}\) The main mechanism follows as a persistent contractionary tax policy lowers the net present value of projects and leads firms to downsize capital subject to adjustment costs. When monetary policy hits during this transition, firms re-optimize their investment path

\(^{48}\text{Although the theoretical model does not lay out cross-sectional features of taxes, the simulation results rationalize the empirical findings of this paper.}\)
as a response to the transitory change in funding cost. However, due to increasing MPK and decreasing returns to capital, the elasticity to monetary policy may be higher in transition with a lower level of capital.

The interaction between the interest rate and tax policy can be seen within the Euler-q equation, where interest rate interacts with variables such as share of capital and marginal product of capital and triggers a further movement in the q (Appendix Figure E.8.4). In this transition, the adjustment costs may also have a role in propagating the effect on investment such that with higher adjustment costs, the total effect of monetary policy is lower (Appendix Figures E.5.1a and E.5.1b). In addition, Figure E.6.2 shows that the investment results are amplified if the economy has higher capital share.

\[ q_t \downarrow = \frac{E_t(1 + \pi_{t+1})}{(1 + i_t)} \left\{ q_{t+1}(1 - \delta) + (1 - \tau_{t+1}) w_{t+1} \left( \frac{\alpha}{1 - \alpha} \right) \frac{N_{t+1}}{K_{t+1}} \right\} (14) \]

As for robustness, Figure E.7.3 suggest that the amplification effect varies with the timing of the monetary policy shock. The sooner the monetary policy shock hits, the larger is the amplification on investment.

**Alternative mechanisms.** An alternative mechanism accounting for these results might be that changes in liability rates alter the tightness of financial constraints of firms. In an environment with capital market imperfections, borrowers’ balance sheet conditions (Gertler and Gilchrist, 1994; Bernanke and Gertler, 1989; Kiyotaki and Moore, 1997; Calomiris and Hubbard, 1990) play a significant role in access to credit. As tax shifts change the balance sheet conditions of firms, we may see tax policy contribute to the financial propagation mechanism. The impact of the tax policy can be seen both directly and indirectly. First, an increase in the tax rate would weaken the balance sheet by lowering cash flows. Second, it may also lower the value of collateral assets through the decline in net worth. Hence, in a model with financial frictions, tax policy can potentially amplify these two channels.
E.3 Model solution

Households’ problem is as follows:

\[
\mathcal{L} = E_t \sum_{t=0}^{\infty} \beta^t \left\{ \ln C_t - \theta N_t^{1+\chi} \frac{1}{1+\chi} + \lambda_t \left( \frac{W_t N_t}{P_t} + \frac{\Pi_t}{P_t} + \frac{T_t}{P_t} + \frac{B_{t-1} - P_tC_t}{P_t} - \frac{Q_t B_t}{P_t} \right) \right\},
\]

where \( P_t \equiv \left( \int_0^1 P_t(i)^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}} \) is the aggregate price index and \( C_t \) is the final goods consumption:

\[
C_t(i) = \left( \frac{P_t(i)}{P_t} \right)^{-\epsilon} C_t \text{ for all } i \in [0,1].
\]

Hence, consumption expenditures can be expressed as the product of the price index times the quantity index as follows:

\[
P_tC_t = \int_0^1 P_t(i)C_t(i)di.
\]

Note that in addition to the flow budget constraint, the household is also subject to a solvency constraint that prevents it from engaging in Ponzi-type schemes:

\[
\lim_{T \to \infty} E_t \left\{ \Lambda_{t,T} - \frac{B_T}{P_T} \right\} \geq 0 \text{ for all } t, \text{ where } \Lambda_{t,T} \equiv \beta^{T-t}U_{c,T}/U_{c,t}.
\]

The first-order conditions

\[
C_t : \quad \frac{1}{C_t} = \lambda_t \quad (15)
\]

\[
N_t : \quad \theta N_t^\chi = \lambda_t \frac{W_t}{P_t} \quad (16)
\]

\[
B_t : \quad \frac{\lambda t Q_t}{P_t} = \beta E_t \left( \frac{\lambda_{t+1}}{P_{t+1}} \right) \quad (17)
\]

bring the optimality conditions on consumption savings and labor supply decisions:

\[
\theta N_t^\chi C_t = \frac{W_t}{P_t} = w_t \quad (18)
\]
\[ Q_t = \beta E_t \frac{C_t}{C_{t+1}} \frac{1}{1 + \pi_{t+1}} \quad \text{for } t = 0, 1, 2, \ldots, \] (19)

where \( \pi_{t+1} = \frac{P_{t+1}}{P_t} - 1 \) is the net inflation rate and \( w_t = \frac{W_t}{P_t} \) is real wages. Equation 18 can be interpreted as the competitive labor supply condition determining the quantity of labor supplied as a function of the real wage given the marginal utility of consumption (which is a function of consumption only). Workers do not have any market power, and hence they take the wage as given.49

Firms’ problem is:

\[
\mathcal{L} = E_t \sum_{j=0}^{\infty} \beta^j \frac{\lambda_{t+j}}{\lambda_t} \left\{ \frac{1}{P_{t+j}} \left( P_{t+j}(i)Y_{t+j}(i) - W_{t+j}N_{t+j}(i) \right) (1 - \tau_t) - \psi \frac{P_{t+j}(i)}{P_{t+j-1}(i)} - 1 \right\} - \phi \frac{I_t(i)}{I_{t-1}(i)} - 1)^2 + (1 - \delta)K_{t+j}(i) - K_{t+j+1}(i) \right\} \}
\]

subject to the demand function that follows the Dixit-Stiglitz model of imperfect competition,

\[ Y_t = \left( \frac{P_t(i)}{\tilde{P}_t} \right)^{-\epsilon} Y_t = \left( \frac{P_t}{\tilde{P}_t(i)} \right)^{\epsilon} Y_t = \tilde{P}_{t}(i)^{\epsilon} Y_t, \]

where \( Y_t = A_t K_t(i)^\alpha N_t(i)^{1-\alpha} \) and \( \frac{P_t}{\tilde{P}_t(i)} = \tilde{P}_{t}(i) \).

49 Last, equation 19 can also be used to determine the implied real interest rate in linear form as

\[ r_t \equiv i_t - E_t \{ \pi_{t+1} \}. \]

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Equilibrium conditions:

\[ \theta N_t^s C_t = w_t \]  \hspace{1cm} (20)

\[ \frac{1}{C_t} Q_t E_t (1 + \pi_{t+1}) = \beta E_{t+1} \frac{1}{C_{t+1}} \]  \hspace{1cm} (21)

\[ MC_t (1 - \alpha) A_t K_t^\alpha N_t^{-\alpha} = w_t (1 - \tau_t) \]  \hspace{1cm} (22)

\[ 1 = q_t [1 - \phi \left( \frac{I_t(i)}{I_{t-1}(i)} - 1 \right) \frac{1}{I_{t-1}} + \beta \frac{\lambda_{t+1}}{\lambda_t} q_{t+1} \left[ \phi \frac{I_{t+1}}{I_t} \left( \frac{I_{t+1}}{I_t} - 1 \right) \right] \]  \hspace{1cm} (23)

\[ q_t = \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \left\{ q_{t+1}(1 - \delta) + MC_{t+1} A_{t+1} \alpha K_{t+1}^{\alpha - 1} N_{t+1}^{1 - \alpha} \right\} \]  \hspace{1cm} (24)

\[ (1 - \epsilon) (1 - \tau_t) - \psi \pi_t (\pi_t + 1) + \beta E_t \frac{C_t}{C_{t+1}} [\psi \pi_{t+1} (\pi_{t+1} + 1) \frac{Y_{t+1}}{Y_t}] = -\epsilon MC_t(i) \]  \hspace{1cm} (25)

\[ i_t = 0.7 i_{t-1} + 0.3 * \phi \pi_{t+1} + s_t \epsilon_{t+1} \]  \hspace{1cm} (26)

\[ Y_t = A_t K_t^\alpha N_t^{1 - \alpha} \]  \hspace{1cm} (27)

\[ Y_t = C_t + I_t + \frac{\psi}{2} (\pi_t)^2 Y_t \]  \hspace{1cm} (28)

\[ K_{t+1}(i) = I_t(i) - \frac{\phi}{2} \left( \frac{I_t(i)}{I_{t-1}(i)} - 1 \right)^2 + (1 - \delta) K_t(i) \]  \hspace{1cm} (29)

\[ \tau_t = (1 - \rho_t) \tau_{ss} + (\rho_t) \tau_{t-1} + s_t \epsilon_{t+1} \]  \hspace{1cm} (30)

\[ Q_t = \frac{1}{1 + i_t} \]  \hspace{1cm} (31)
### E.4 Calibration details

Table E.1: Quarterly parametrization values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>Discount factor</td>
<td>0.97</td>
<td></td>
</tr>
<tr>
<td>$\delta$</td>
<td>Capital depreciation rate</td>
<td>0.025</td>
<td>Christiano et al. (2005)</td>
</tr>
<tr>
<td>$\epsilon$</td>
<td>Elasticity of substitution between goods</td>
<td>9</td>
<td>Gali (2009)</td>
</tr>
<tr>
<td>$\theta$</td>
<td>Labor disutility parameter</td>
<td>1.34</td>
<td></td>
</tr>
<tr>
<td>$\alpha$</td>
<td>Capital income share</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>$\phi$</td>
<td>Capital adjustment parameter</td>
<td>6</td>
<td>Torres (2015)</td>
</tr>
<tr>
<td>$\chi$</td>
<td>Inverse labor elasticity</td>
<td>0.5</td>
<td>Sims and Wolff (2017)</td>
</tr>
<tr>
<td>$\rho$</td>
<td>Persistence of interest rate</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>$\rho_T$</td>
<td>Persistence of tax shock</td>
<td>0.995</td>
<td></td>
</tr>
<tr>
<td>$\phi_\pi$</td>
<td>Coefficient of inflation target in Taylor rule</td>
<td>1.5</td>
<td>Gali (2009)</td>
</tr>
<tr>
<td>$\psi$</td>
<td>Rotemberg price adjustment cost parameter</td>
<td>88.07</td>
<td></td>
</tr>
</tbody>
</table>

Note: I assume that a time period in the model corresponds to one quarter. I set $\beta = 0.97$ and $\delta = 0.025$, which implies an annual rate of depreciation on capital equal to 10 percent. $\epsilon = 9$ implies $M = 1.125$, suggesting a steady state markup of 12.5 percent following Gali (2009). The steady-state share of capital income is 30 percent. These are typical estimates for U.S. data. Rotemberg price adjustment cost parameter is calculated using $\psi = \frac{\Theta(\epsilon-1)}{(1-\Theta)(1-\Theta\beta)}$ where $\Theta = 0.75$ is calvo price parameter. Since one period equals one quarter and $\Theta = 0.75$ (Miao and Ngo, 2019), then the average lifetime of a nominal price chosen today is equal to: $\frac{1}{1-0.75} = 4$ quarters, suggesting on average prices remain unchanged for one year. Inverse labor elasticity is 0.5, which implies a Frisch elasticity of 2. The labor disutility parameter is analytically computed using the labor supply first order condition. Assuming the share of hours available that is spent on work is 1/3, I compute the labor disutility parameter as $\theta = 1.34$. 

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E.5 Comparison of capital adjustment costs ($\phi$)

Figure E.5.1: Impulse response to monetary policy with different capital adjustment costs

(a) $\phi = 6$ (Baseline)  
(b) $\phi = 10$

Note: This figure plots the impulse responses to 25 basis points innovation in monetary policy. The left economy plots the responses when the economy has capital adjustment cost of 6 (baseline), the right economy plots the responses when the economy has higher capital adjustment costs.
E.6 Testing share of capital

Figure E.6.2: Impulse responses to monetary policy following contractionary tax shifts

(a) $\alpha = 0.30$

(b) $\alpha = 0.35$

Note: This figure plots the impulse responses to 25 basis points innovation in monetary policy. The left economy plots the responses when the economy has a capital share of 0.30, the right economy plots the responses when the economy has a capital share of 0.35.
E.7 Testing lags between the monetary policy and the tax reforms

Figure E.7.3: Impulse responses to monetary policy following contractionary tax shifts

(a) 10 quarter gap

(b) 6 quarter gap

Note: This figure plots the impulse responses to 25 basis points innovation in monetary policy. The left economy plots the responses when the economy receives a tax shock 10 quarters before the monetary policy shock. The right economy plots the responses when the economy receives a tax shock 6 quarters before the monetary policy shock.
E.8 Impulse responses of q and marginal product of capital

Figure E.8.4: Impulse responses to monetary policy following contractionary tax shifts

Note: This figure plots the impulse responses to 25 basis points innovation in monetary policy.

Figure E.8.5: Impulse responses to monetary policy following expansionary tax shifts

Note: This figure plots the impulse responses to 25 basis points innovation in monetary policy.