Firm Investment and the User Cost of Capital: New U.S. Corporate Tax Reform Evidence

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Abstract

The Tax Cuts and Jobs Act of 2017 (TCJA) marked the first time in three decades that material changes were made to the corporate tax code of the United States. We use corporate tax law changes including TCJA as quasi natural experiments to estimate the impact of changes in user cost on investment. Following the method of Auerbach and Hassett (1991), using cross-sectional data we find that the user cost of capital is associated with higher rates of investment consistent with previous studies. BEA asset types with greater reductions in user cost of capital and marginal effective tax rate (METR) after the 2017 TCJA had greater statistically significant increases in their investment rates several years after the tax reform. Specifically, we find the magnitude of a 1 percentage point decrease in user cost is associated with a 1.43 to 2.39 percentage point increase in the rate of investment, larger than prior estimates of the responsiveness of investment with respect to user cost of capital.

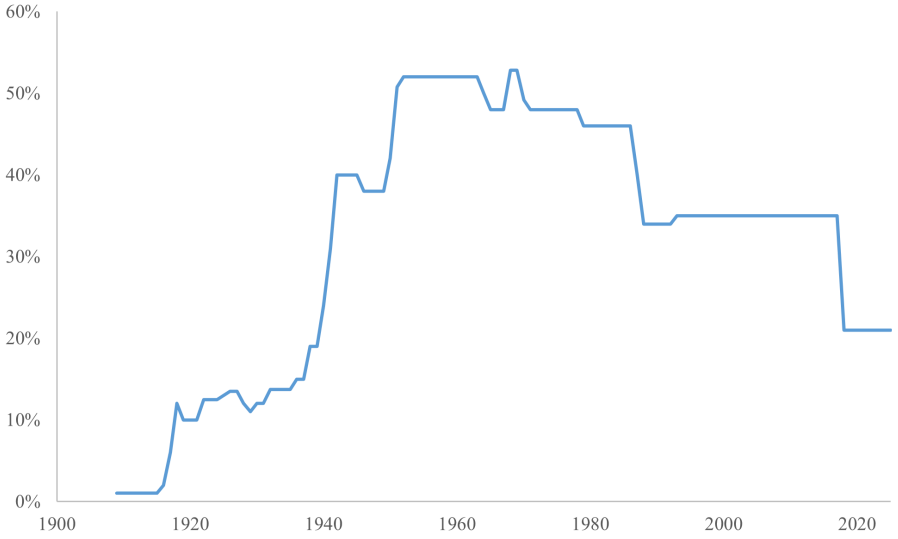
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1 Introduction

Figure 1: Top U.S. Statutory Marginal Corporate Income Tax Rate Over Time (1909-2024)



The Tax Cuts and Jobs Act of 2017 (TCJA), which was signed into law on December 22, 2017, marked the first time in three decades (since the Tax Reform Act of 1986) that material changes were made to the corporate tax code of the United States. Most prominently, the top marginal corporate tax was changed from 35 percent to 21 percent effective in 2018 (Figure 1). In addition to the change in the marginal corporate tax rate schedule, TCJA also included major reforms to the corporate tax base. Certain capital expenditures received automatic expensing through 2023 with staged phaseout through 2027. Together these changes reduced the user cost of capital for investments in the US.[1]

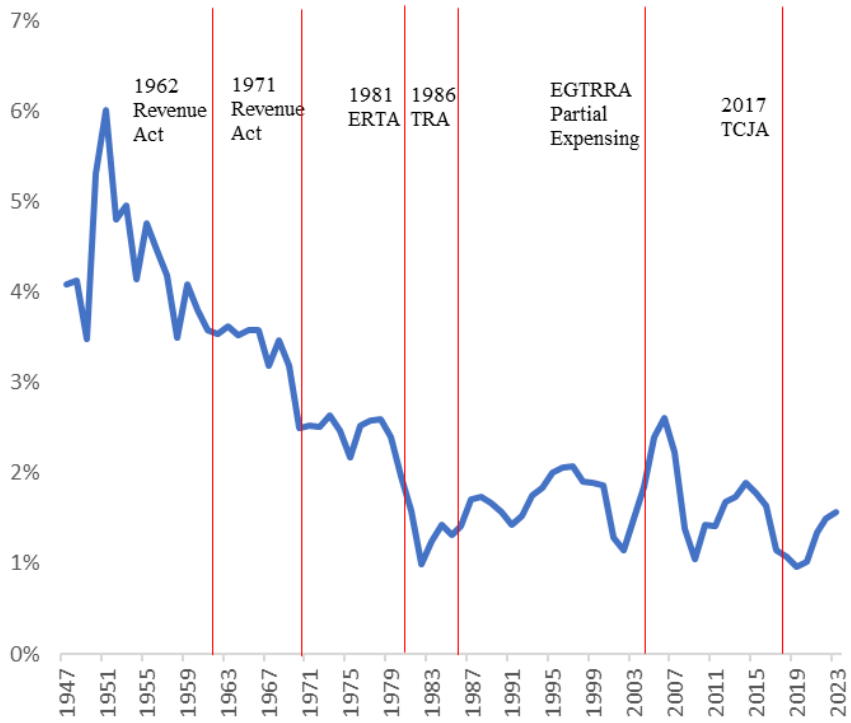
At the time of passage of the TCJA, the Congressional Budget Office (CBO) estimated overall that TCJA would reduce revenues by $2.314 trillion on a static basis, and by $1.854 trillion on a dynamic basis from 2018 to 2027.[2] Some of this expected decline in tax revenues was due to reductions in projected corporate tax revenues. However, corporate tax revenues have surged in recent years from closer to 1% of GDP in the 2018-2020 period to closer to 1.5% of GDP since 2021 (Figure 2). The costs of TCJA therefore could ultimately prove to have been much smaller if there has been a bigger investment response than the scoring agencies expected.[3]

[1] A host of international provisions also aimed to incentivize the repatriation of accumulated foreign cash holdings and of ongoing earnings, while moving the US more towards a territorial system of taxation, although these have not yet driven major changes in the international investment patterns and geographic allocation of capital of multinationals (Garcia-Bernardo et al., 2022)

[2] See "How the 2017 Tax Act Affects CBO's Projections", Congressional Budget Office, November 29, 2024 (https://www.cbo.gov/publication/53787) and Congressional Budget Office "The Budget and Economic Outlook: 2018 to 2028" Appendix B"The Effects of the 2017 Tax Act on CBO's Economic and Budget Projections" (https://www.cbo.gov/sites/default/files/115th-congress-2017-2018/reports/53651-outlook-appendixb.pdf. The original score from the CBO for the Tax Cuts and Jobs Act of 2017, was released on December 21, 2017, estimated that the legislation would reduce revenues by about $1,649 billion and decrease outlays by about $194 billion over the period from 2018 to 2027: "Distributional Effects of Changes in Taxes and Spending Under the Conference Agreement for H.R. 1" https://www.cbo.gov/publication/53429)

[3] Logically, budgetary costs are also more justifiable if they generate greater prosperity in the form of much more economic output.

Figure 2: U.S. Federal Corporate Tax Revenue As A Fraction of GDP (1948-2023)



Notes: Data for corporate tax revenues are obtained from the BEA. Nominal GDP data is obtained from FRED.

This may in principle be a result of dynamic economic growth effects, reflecting corporations' response to investment incentives.[4] Indeed, increasing business investment was one of the main goals of TCJA. The driving idea is that if the TCJA can successfully lower the cost of capital for businesses, then the lower cost of capital would induce higher fixed investment and economic growth. In this paper, we investigate the elasticity of firm fixed investment with respect to changes in the user cost of capital using recent tax reforms as sources of identifying variation.

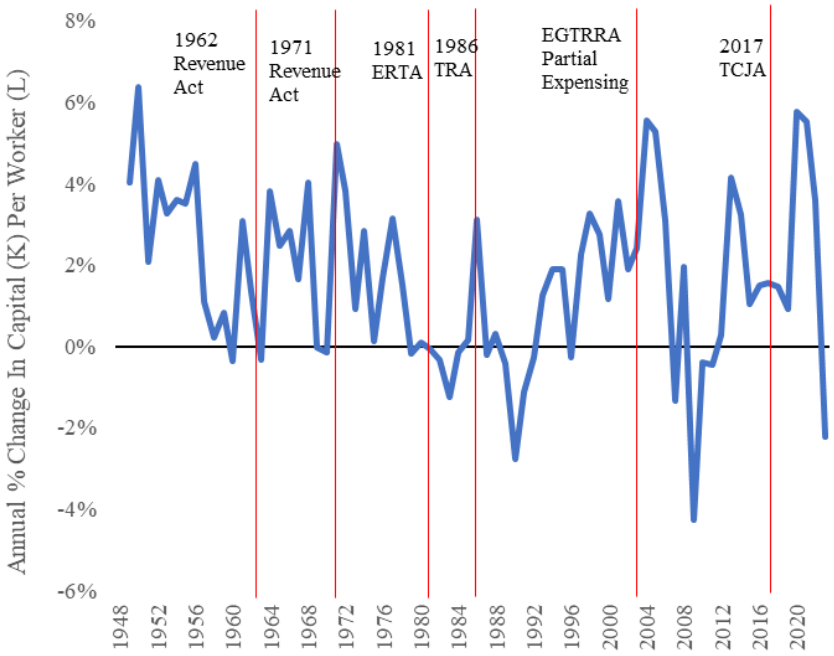
The macro evidence following TCJA is generally consistent with positive effects of a lower user cost of capital on capital formation, although disentangling these effects from other contemporaneous events requires an asset-level approach. Productivity fell substantially in the United States over the decades from the 1950s through early 2000s (Gordon (2017)), which has contributed to economic growth falling below its postwar long-run average. Capital investment has been demonstrated to be a key determinant of productivity per Auerbach and Hassett (1992) and the broader growth accounting literature, and increasing capital per worker is one of the primary ways of increasing labor productivity. Capital deepening, or the rate of increase of capital per unit of labor input had reached historic lows in the years after the Great Recession (Figure 3). Recent years have generally seen stronger increases in capital worker, although this may have been in part due to labor market disruptions around the Covid pandemic and policy response. According to data from the National Income and Product Accounts on non-residential investment (Figure 4), fixed investment rates of firms vary across capital asset type. Intellectual property products show investment rates that have risen considerably over time, while equipment and structures investment rates have remained more stable over time. Investment rates have increased in the aggregate after certain tax reforms, yet the macro evidence by itself does not allow consideration of which firms are affected the most from various tax reforms and how their investment behavior changes accordingly. This motivates our more granular analysis of panel data of BEA asset classes that allows for a clearer identification of the relationship of investment to the user cost of capital than simply analyzing macro trends in

[4]Others have argued this is simply the result of a booming economy, which they argue is booming for reasons orthogonal to corporate tax reform such as pandemic-era fiscal stimulus. See Gale et al. (2022). However, this trend continues to persist now many years since the fiscal stimulus has subsided.

the aggregate, which are suggestive but affected by various contemporaneous shocks.

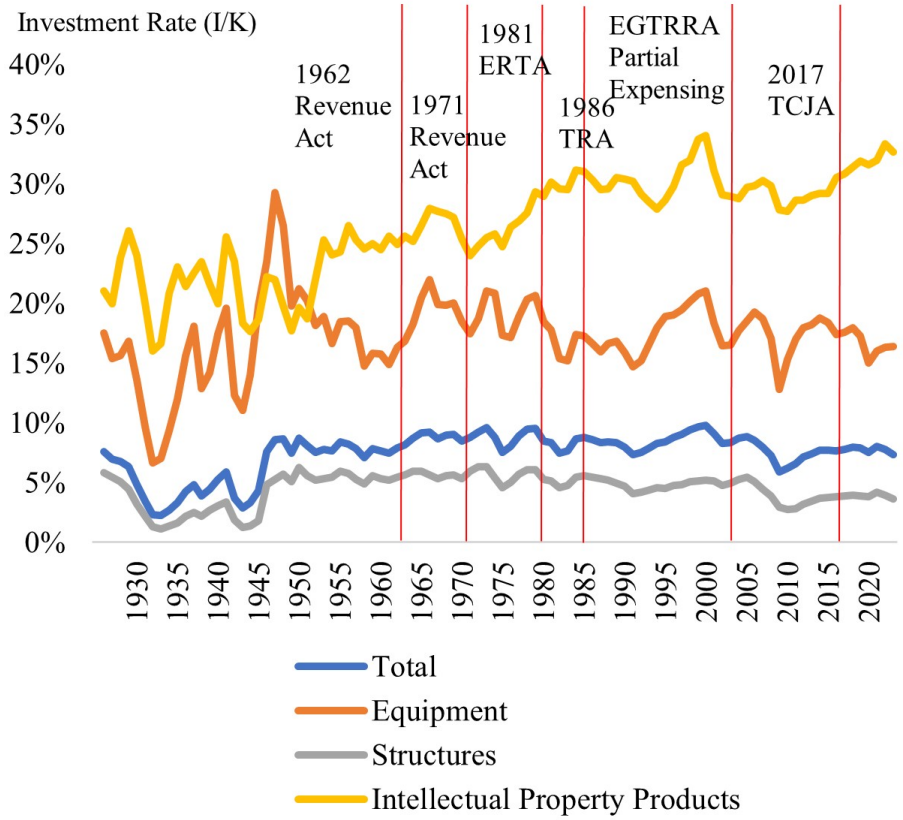
Several recent studies also consider various sources of cross-sectional variation in TCJA. Kennedy et al. (2024) study the differential behavior of C-corporations which are subject to the corporate tax code and S-corporations which are pass-through entities to infer the effects of TCJA. Chodorow-Reich et al. (2024) estimate capital effects in the context of a global investment model, relying on the implications in the model of estimated elasticities of domestic and international investment with respect to user costs of capital.

Figure 3: Capital Per Worker Annual Percentage Change (1948-2023)



Notes: Data for fixed investment are taken from the BEA Fixed Asset Tables while total civilian labor force is obtained from the BLS.

Figure 4: Aggregate Investment Over Capital By Asset Type From 1926 to 2023



Notes: Data for fixed investment are taken from the BEA Fixed Asset Tables. Investment is obtained from Table 2.7. "Investment in Private Fixed Assets, Equipment, Structures, and Intellectual Property Products by Type" while Capital Stock K is obtained from Table 2.1. "Current-Cost Net Stock of Private Fixed Assets, Equipment, Structures, and Intellectual Property Products by Type"

We are principally concerned with estimating to what degree the TCJA lowered U.S. firms' cost of capital and how those changes affected changes in their investment rates, using basic variation in the cost of capital across time and different assets as driven by the tax law. In earlier research, Auerbach and Hassett (1991); Cummins et al. (1994, 1995, 1996) developed a method (building on the previous work of Summers (1981) and Hayashi (1982)), using tax reform years as quasi natural experiments. With firm microdata from Compustat, they estimate the response of firm investment decisions to such "tax surprises" which lower their cost of capital. Auerbach and Hassett (1991) analyze the impact of the Tax Reform Act of 1986 and initially developed the empirical method of using tax reforms as natural experiments to measure the elasticity of investment with respect to user cost. (Cummins et al., 1994, 1995) analyze the impact of all U.S. corporate tax reforms in the post-war era up to and including the Tax Reform Act of 1986, estimating a user-cost coefficient of about -0.65. This paper extends this same method to analyzing the investment impact of corporate tax changes to the 2000s as well as corporate tax changes in the Tax Cuts and Jobs Act of 2017.

Our results derive from looking at investment rate changes as a function of user cost changes *relative to 2016* (one year prior to the passage of TCJA) on each annual horizon since the tax reform was passed. We believe this approach captures the dynamic effects of the tax reform which may vary over time as firms may be slow to adjust their investment decisions in response to policy uncertainty and other factors that create adjustment costs.

We find that BEA asset types with greater reductions in user cost of capital and marginal effective tax rate (METR) after the 2017 Tax Cuts and Jobs Act had greater statistically significant increases in their investment rates. We find that this is the case for several years after the tax reform. Our measured investment response to user cost

ranges from a 1.43 to 2.39 percentage point increase in the rate of investment in response to a 1 percentage point decrease in user cost. This is also larger than conventional estimates of the elasticity of investment with respect to user cost used by the Congressional Budget Office of around -0.7 (CBO, 2018). Hassett and Hubbard (2002) review the literature and find investment-user cost elasticities ranging from -0.5 to -1.0, citing estimates from Caballero (1994); Cummins et al. (1994, 1995); Caballero et al. (1995)[5]. To be clear, we do not directly estimate an investment-user cost elasticity, but rather the relationship between the investment and the user cost of capital informed by the theoretical results of Summers (1981) and Hayashi (1982). However, it is straightforward to convert our estimates into investment elasticities by dividing the coefficient by the mean investment rate and multiplied by the mean UCC following Hassett and Hubbard (2002). Doing so we find investment-user cost elasticities ranging from -1.42 to -2.38, still markedly higher than prior estimates. Our findings are robust across several specifications.

Chodorow-Reich et al. (2024) also calculate asset-class-based user costs, and they apply them in firm-level microdata. Their setup is distinct in that a firm can invest in two markets (domestic or foreign) and has separate user costs of capital for each. That paper models complementarity effects between foreign and domestic capital. For the purposes of the present analysis, we are only concerned with measuring user cost effects on U.S. investment and not foreign investment, in contrast to Chodorow-Reich et al. (2024) who consider both. BEA data of course does reflect foreign firm investment into the U.S. The implicit assumption in our simplified setup is that changes in user cost for foreign firm investment in the U.S. are similar to the domestic changes, and that the user cost for investment outside of the U.S. for foreign or multinational firms on the margin are not changing substantially or alternatively are not highly material due to high adjustment costs or other factors.[6] There were also no major concomitant corporate tax reforms in major advanced economies at the same time as the Tax Cuts and Jobs Act of 2017 that would meaningfully impact corporate investment in the U.S.. There are some exceptions such as the temporary 2017 French corporate tax increase from 33.3% to 38.3%. We think this would have relatively minor effects on foreign multinational investment in the U.S..

The paper proceeds as follows. Section 2 discusses the earlier empirical research on corporate taxation and investment, Section 3 describes our data and empirical approach, Section 4 presents our results, and Section 5 concludes.

2 Data and Empirical Strategy

2.1 Data

2.1.1 Investment

The neoclassical theory of investment to include the user cost of capital was originally developed by Jorgenson (1963), and further extended by Hall and Jorgenson (1967) to include corporate taxes. Auerbach (1983) uses this same user cost approach to assess the estimates in changes in the corporate tax code across the prior decades. Tobin's q was conceptualized by Tobin (1969) as an alternative approach to estimating investment, with the advantage of explicitly modeling the costs of adjustment. This approach is attractive in that it has the ability to distinguish delivery/adjustment lags from expectational lags. Summers (1981), Hayashi (1982) and Abel (1979) link the Tobin's q approach to investment with the firm's problem of determining an optimal investment path in the presence of adjustment costs, namely the presence of taxation. In addition, Hayashi (1982) lays out conditions under which

[5]Other recent literature estimates, such as Bitros and Nadiri (2017) and Dwenger (2014), cited in the literature review of Gravelle and Keightley (2024), find investment-user cost elasticity estimates of around 0.5 to 0.9. These papers use more structural approaches to estimating investment user cost elasticities rather than the reduced-form approach to studying exogenous tax reforms of Cummins et al. (1994, 1995)

[6]For example, locally concentrated firms face high adjustment costs of relocation. In the 2010s, there were on average only a few tax inversions per year, and were never more than eight tax inversions in a given year. Subsidiaries of globally integrated multinational firms can often make separate investment decisions based on local user costs. While global tax competition certainly matters for aggregate firm investment, our contention is that the cross-sectional variation within the U.S. in user-cost across asset types is a dominating force and alone sufficient to measure the investment response to user cost.

marginal q and average Q are equal (if the production cost function and the total adjustment cost function are homogenous of degree one). Summers (1981), Hayashi (1982) and Salinger and Summers (1983) estimate Tobin's q and tax-adjusted Q by estimating regressions for several individual firms using a time series of each firm's data relevant data from Compustat. Blanchard et al. (1993) and others have pointed out that the empirical performance of the Q model (its ability to explain variation in investment) has not been as impressive.

Cummins et al. (1994, 1995, 1996) introduced a new identification strategy that uses tax reforms as natural experiments and looks at the surprises in predicted investment as well as tax-adjusted Q following exogenous shocks to the user cost of capital through tax reforms. Cummins et al. (1994, 1995) find that such a method is able to explain more of the variation in investment during post-war tax reforms through the Tax Reform Act of 1986. Cummins et al. (1996) applies the same method to international tax reforms and find similar improvements. Cohen et al. (2002) and Cohen and Cummins (2006) look at the investment impacts of temporary partial expensing from the 2002 Bush tax reforms.

This paper seeks to apply the same methods to see to what degree changes in tax-adjusted user cost of capital can explain variation in investment following the Tax Cuts and Jobs Act of 2017. Other papers have also recently explored the effects of the Tax Cuts and Jobs Act of 2017.[7] Gale and Haldeman (2021) survey the literature and acknowledge that investment rose after TCJA albeit while arguing it was driven by trends in aggregate demand, oil prices, and intellectual capital (despite providing no evidence other than time series correlations). In the cross section, Wagner et al. (2020) examine which industries and firms benefited and lost from TCJA corporate tax changes in terms of differences in effective tax rates.

To measure the changes between user cost and investment following more recent tax reforms extending the original work of Auerbach and Hassett (1991) and Cummins et al. (1994) using corporate tax surprises as natural experiments, we obtain data on the relevant investment and user cost of capital variables using BEA asset data following the user cost method of Auerbach and Hassett (1991) which are calculated as follows.

Investment is often calculated as a percentage of prior period capital stock ($I_{i,t}/K_{i,t-1}$). $I_{i,t}$ is investment at time t for BEA asset type i. Data for fixed investment are taken from the BEA Fixed Asset Tables. Investment is obtained from Table 2.7, "Investment in Private Fixed Assets, Equipment, Structures, and Intellectual Property Products by Type". We aggregate across industries to get a measure of fixed investment by asset.

$K_{i,t}$ is the capital stock at time t for BEA asset type i. At the firm level, $K_{i,t}$ can also be Net Property, Plant and Equipment for firm i from Compustat. Capital Stock data is obtained from Table 2.1, "Current-Cost Net Stock of Private Fixed Assets, Equipment, Structures, and Intellectual Property Products by Type". We aggregate across industries to get a measure of capital stock by asset.

2.1.2 User Cost of Capital

The user cost of capital can be written several equivalent ways including the formulation of Hall and Jorgenson (1967) and DeBacker and Kasher (2018).[8]

We calculate cost of capital as:

$$\rho_{i,t} = \frac{r_t + \delta_{i,t} - \pi_t}{1 - \tau_t}(1 - k_{i,t} - \tau_t z_{i,t}) - \delta_{i,t}$$

where r_t is the discount rate, δ_t is the depreciation rate, π_t is the inflation rate, investment tax credit $k_{i,t}$, $z_{i,t}$ is the net present value of depreciation deductions from a dollar of new investment in period t. Without an investment tax credit $k_{i,t}$ (that has been absent in the U.S. since the Tax Reform Act of 1986) becomes:

[7]Other recent papers have also explored state-level variation in corporate taxation. Kumar (2020) uses exogenous state-level variation in tax changes and find that an income tax cut equaling 1 percent of GDP led to a 1 percentage point higher nominal GDP growth and about 0.3 percentage point faster job growth in 2018.

[8]We use open source code from the DeBacker and Kasher (2018) User Cost of Capital Calculator[9] and extend it back further in time with additional data.

$$\rho_{i,t} = \frac{r_t + \delta_{i,t} - \pi_t}{1 - \tau_t}(1 - \tau_t z_{i,t}) - \delta_{i,t}$$

We calculate $z_{i,t}$ using IRS information on depreciation rules. CPI inflation rates ($\pi_{i,s}$) are obtained from the BLS. Depreciation rates ($\delta_{i,t}$) by BEA asset type are obtained from BEA. Note that unlike other countries (such as Canada), the BEA has not updated depreciation rates since the 1970s which likely causes BEA capital stocks to be overstated. Additionally, intellectual property was not considered a distinct asset type by BEA until the mid-2010s. Previously software had its own treatment and was considered expense.

User cost of capital or $c_{i,t}$, which adds in depreciation rates, can be written as:

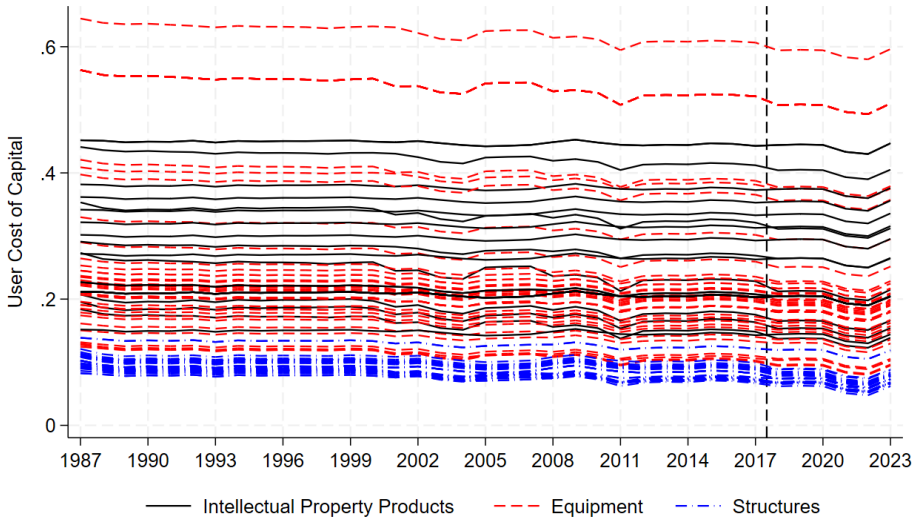
$$c_{i,t} = \rho_{i,t} + \delta_{i,t} = \frac{r_t + \delta_{i,t} - \pi_t}{1 - \tau_t}(1 - k_{i,t} - \tau_t z_{i,t})$$

For historical discount rates, some papers use discount rates from Gormsen and Huber (2023) which updates the Poterba and Summers (1995) discount rates from 2002 through the present. Since we seek to use a longer historical time series, we use the user cost of capital calculator from DeBacker and Kasher (2018) which calculates discount rates based on Moody's AA-rated corporate bonds.

To give a sense of magnitude of what a 1 percentage point decline in the user cost of capital amounts to in marginal corporate tax rate reduction terms: assuming a 2% constant inflation rate, a 2% constant interest rate rate, a 10% depreciation rate (depreciation rates for structures are typically higher while lower for equipment), an investment tax credit of 0%, and a z = 0.7, a 1% decline in the user cost of capital would be equivalent to decreasing the marginal corporate tax rate from 35% to 17%.

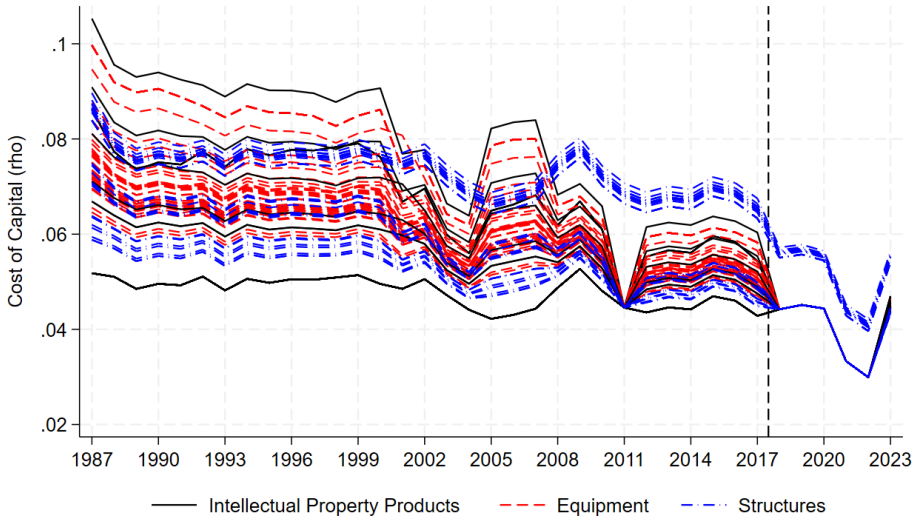
Figure 5 plots user cost of capital ($c_{i,t}$) by BEA asset type from 1987 to 2023. Note that many of the declines in user cost are on the magnitude of only a few percentage points. Figure 6 plots cost of capital which adds back in depreciation rates. Looking in the cross section, due to the new bonus depreciation schedules for equipment and there being more depreciation allowances for them, TCJA has a greater impact on the user cost of them compared to structures.

Figure 5: User Cost of Capital $c_{i,t}$ by BEA Asset Type (1987-2023)



Notes: User cost of capital calculated using IRS depreciation bonus rules, top marginal corporate tax rates from the IRS, discount rates from Moody's AA rated corporate bonds, and depreciation rates from the BEA.

Figure 6: Cost of Capital by BEA Asset Type (1987-2023)



Notes: Cost of capital calculated using IRS depreciation bonus rules, top marginal corporate tax rates from the IRS, discount rates from Moody's AA rated corporate bonds, and depreciation rates from the BEA.

2.2 Marginal Effective Tax Rate

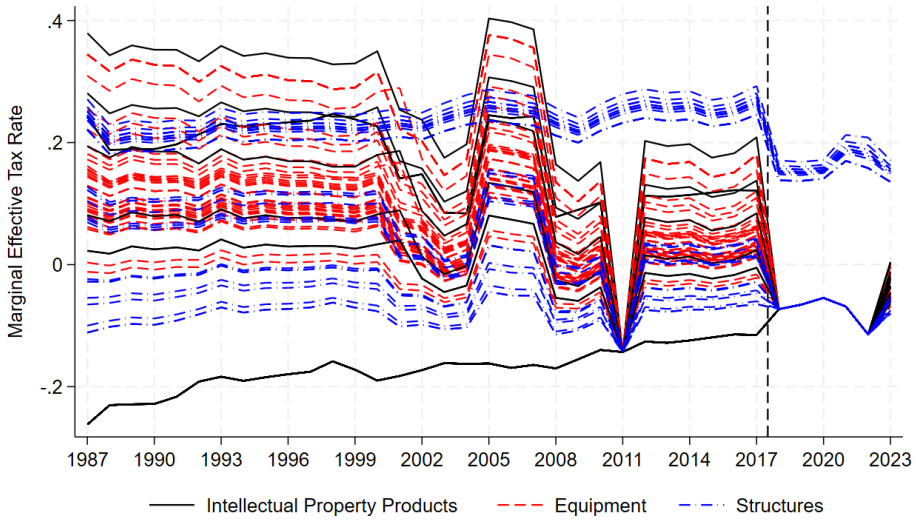
The marginal effective tax rate (METR) for a given asset type is calculated as the expected pre-tax rate of return on a marginal investment subtracting the real after-tax rate of return to the business entity divided by the pre-tax rate of return on the marginal investment:

$$METR_{i,t} = \frac{\rho_{i,t} - (r_{i,t} - \pi_{i,t})}{\rho_{i,t}},$$

Figure 7 plots METR by BEA asset type from 1987 to 2023. The variable $\rho_{i,t}$ can be thought of as the pre-tax rate of return on the marginal investment, $r_{i,t}$ is the discount rate and π is the rate of inflation ($r_{i,t} - \pi_{i,t}$ is the real after-tax rate of return). Giroud and Rauh (2019) calculate METRs at the state level, however, this paper ignores such tax rules. Note the decline in METR in the aggregate is typically not the full 14% decline in the top marginal corporate tax rate from 35% to 21% due to a number of other considerations in tax code changes. METR for structures falls by the most by nearly 10 percentage points after TCJA while METR for equipment falls by closer to 15 percentage points.[10] Note that METR also fell in 2011 due to one full year of temporary expensing provisions.

[10] Chodorow-Reich et al. (2024) finds that TJCA had only a 4 percentage point impact on the marginal effective tax rate (see Table E.4 of Chodorow-Reich et al. (2024); Eg. For Firm 1, the difference between (100-17.2)/(100-14.4)=0.967 pre and (100-10.2)/(100-9.5)=0.992 post).

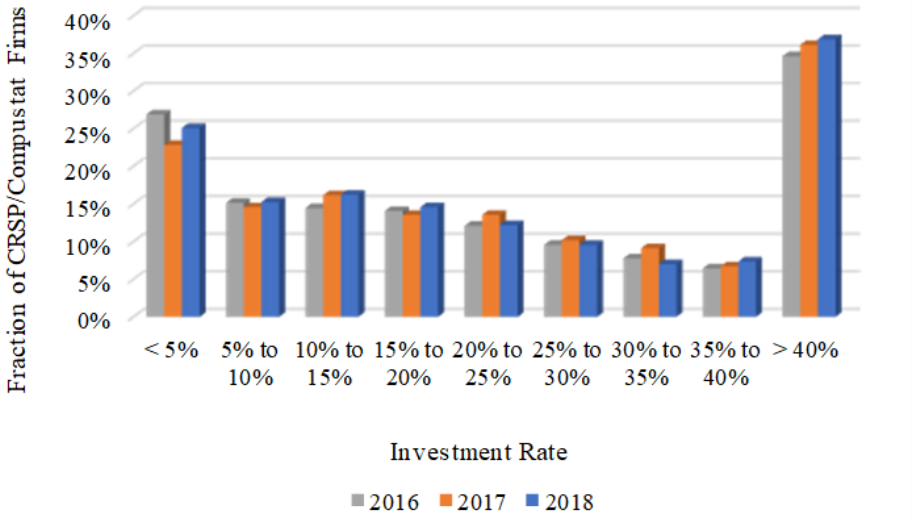
Figure 7: Marginal Effective Tax Rate (METR) by BEA Asset Type (1987-2023)



Notes: Marginal Effective Tax Rates (METR) calculated using IRS depreciation bonus rules, top marginal corporate tax rates from the IRS, discount rates from Moody's AA rated corporate bonds, and depreciation rates from the BEA.

3 Empirical Strategy

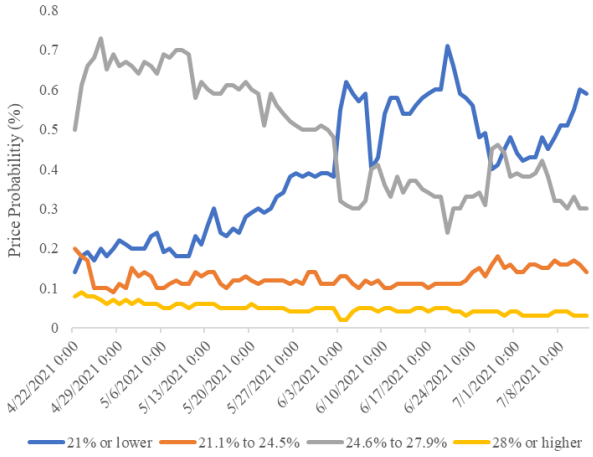
Figure 8: Distribution of Firm Investment Rates Across 2016, 2017, and 2018



Notes: Investment data are retrieved and calculated from the CRSP/Compustat Merged dataset. The investment rate is calculated as depreciation plus the change in net PPE from the prior year all divided by net PPE from the prior year.

To lend support for what is being observed in the BEA data, we first present some descriptive evidence of firm level investment trends before and after the passage of TCJA. Figure 8 plots the investment rates in 2016, 2017, and 2018 (the first year the TCJA became effective) for the thousands of firms with complete data from the CRSP/Compustat Merged database. This sample has only 962 firms, this is largely due to the fact that there are fewer U.S. publicly traded firms today versus 1987. The number of U.S. publicly traded firms has fallen from approximately 8,000 in 1996

Figure 9: PredictIt Prediction Market Prices For "What will be the corporate tax rate for 2022?"



to less than 4000 as of 2016 (Doidge et al., 2018). Interestingly, the fraction of firms with an investment rate of 5 percent or less falls substantially during and after the period that the TCJA is passed, while the fraction of firms with an investment rate above 40 percent increased.

To better isolate the effects of "tax surprises" and use tax reforms like the TCJA as a natural experiment, we repeat the approach of Auerbach and Hassett (1991), which looks at the differences in investment (I/K) as well as user cost (c) following the exogenous shock to the user cost of capital before and after recent corporate tax changes, applying it to the Tax Cuts and Jobs Acts reduction of the corporate income tax rate from 35 percent to 21 percent as well as changes to capital expensing. Our specification is as follows:

$$I_{i,t}/K_{i,t-1} - I_{i,t-1}/K_{i,t-2} = \alpha + \beta(c_{i,t} - c_{i,t-1}) + \varepsilon_{i,t},$$

Where $I_{i,t}/K_{i,t-1}$ is the firm investment rate in time t ($I_{i,t}$ is investment at time t and $K_{i,t-1}$ is capital at time t-1) and $c_{i,t}$ is the calculation of user cost for asset i in time t and α is a constant. Following Auerbach and Hassett (1991) and Cummins et al. (1994), we primarily wish to compare investment rates in the first period the tax reform law changes were in place (eg. 2018 in the case of TCJA) to the year before the tax reform legislation was passed (eg. 2016 in the case of TCJA). This is because tax reform expectations may influence investment decisions before tax reforms are passed.

One threat to identification may be whether the tax reform itself was already anticipated. Figure 9 shows prediction market prices for whether or not the U.S. corporate tax rate would be cut by 12/31/2017 and 3/31/2018. As recent as late October 2017, prediction market participants expected a corporate tax rate cut by March 31, 2018 with an approximate 60% probability. If tax changes were already affecting investment behavior in early 2017 given the anticipated tax reform, this is all the more reason to use 2016 as the base year for analysis.

Our results come from studying investment rate changes across asset classes as a function of user cost changes across asset classes *relative to 2016* (one year prior to the passage of TCJA) on each annual horizon since the tax reform was passed (eg. 2016 to 2018, 2016 to 2019, and so forth through 2023). We believe this approach captures the dynamic effects of the tax reform which may vary over time as firms may be slow to adjust their investment decisions in response to policy uncertainty and other factors that create adjustment costs.

Similarly we run regressions of changes in investment rates on changes in METR:

$$I_{i,t}/K_{i,t-1} - I_{i,t-1}/K_{i,t-2} = \alpha + \beta(METR_{i,t} - METR_{i,t-1}) + \varepsilon_{i,t},$$

4 Results

Table 1: Cumulative Investment Response to Tax Changes: User Cost and Effective Tax Rate Analysis

$\frac{I_{i,t}}{K_{i,t-1}} - \frac{I_{i,2016}}{K_{i,2015}}$	2017	2018	2019	2020	2021	2022	2023
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$c_{i,t} - c_{i,2016}$	0.754	-1.426*	-0.808	-1.219	-2.388**	-2.323**	-1.027
	(5.327)	(0.786)	(0.753)	(0.974)	(0.974)	(1.025)	(0.980)
Constant	0.001	-0.008	-0.002	-0.020	-0.049	-0.048	-0.010
	(0.016)	(0.007)	(0.007)	(0.0106)	(0.021)	(0.024)	(0.009)
R^2	0.0002	0.0401	0.0150	0.0229	0.0695	0.0632	0.0166
$METR_{i,t} - METR_{i,2016}$	0.334	-0.083*	-0.046	-0.053	-0.142**	-0.156**	-0.065
	(0.272)	(0.047)	(0.046)	(0.062)	(0.066)	(0.064)	(0.065)
Constant	-0.004	-0.003	-0.000	-0.013	-0.013	-0.013	-0.006
	(0.004)	(0.005)	(0.005)	(0.006)	(0.006)	(0.008)	(0.006)
R^2	0.0230	0.0410	0.0147	0.0127	0.0682	0.0856	0.0186
N	96	96	96	96	96	96	96

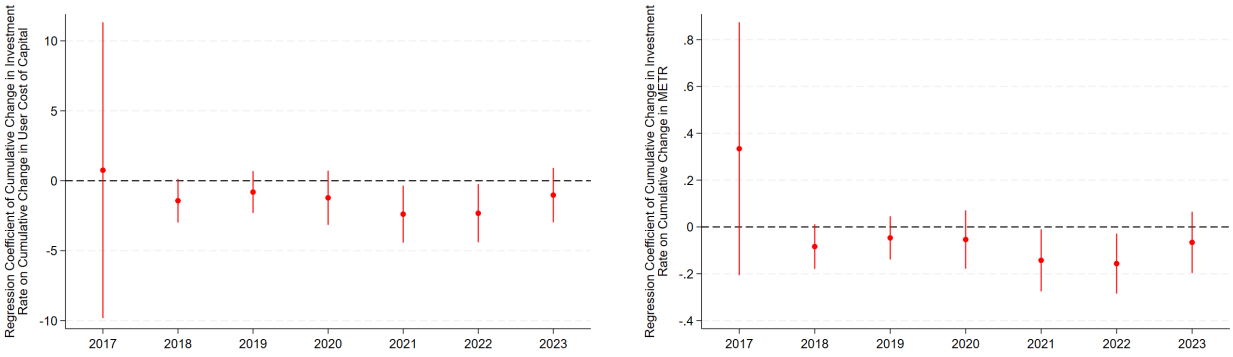
Notes: Robust standard errors in parentheses. *** p<0.01 ** p<0.05 * p<0.10. Data for fixed investment from BEA Fixed Asset Tables. User cost of capital and METR data from OSPC Cost of Capital Calculator. We calculate change in asset investment rates by year then winsorize the top 5% and bottom 5% of observations in each year.

When regressing on all 96 BEA asset types, coefficients are heavily affected by outliers in computer BEA types within intellectual property products. Some computer-related asset types saw massive declines from 2016 to 2018 after certain BEA asset types such as "Other computer and electronic manufacturing, n.e.c." (RD25) experienced a massive uptick in investment rate (I/K) from 0.45 to 2.44 from 2015 to 2016 and back down to 0.29 in 2017 and 0.23 in 2018. The inclusion of this outlier asset type as an individual observation leads to coefficient estimates on the magnitude of -10 since user cost did not fall significantly in these areas following TCJA. This is also a result of it being a small BEA asset type of around only 985 million USD in capital stock as of 2019.

As one way to deal with significant outlier volatility in certain BEA asset types, we winsorize the top 5% and bottom 5% of observations when sorting BEA assets by cumulative investment.[11] Specifically, for each year (for example from 2016 to 2018) we calculate the change in investment rate for each asset and winsorize in each year. When doing so, we find investment-user cost coefficients on the magnitude of -1.426 and -2.388 which is directionally consistent with evidence from past US tax reforms (Auerbach and Hassett (1991) and Cummins et al. (1994) analyze tax reforms through the Tax Reform Act of 1986), however our estimates are larger in magnitude than other literature estimates ranging from 0.5 to 0.9 from Cummins et al. (1994), Cummins et al. (1995), Bitros and Nadiri (2017) and Dwenger (2014). Figure 10 Panel A shows that the relationship between investment and user cost is negative and statistically significant consistent with Auerbach and Hassett (1991) and Cummins et al. (1994).

[11]Note that Tables 4 and 5 in the Appendix show results (for uncombined and combined computer asset types) with different amounts of winsorization (no winsorization, 2.5%, 5.0% and 10.0%. Note that winsorizing at the 2.5%, 5.0% and 10.0% levels qualitatively produce similar results (the estimates from winsorizing at the 2.5% level are the largest, followed by 5.0% and 10.0%). Note that with less than 100 asset types, winsorizing 1% is equivalent to no winsorization, which leaves the most volatile asset type in the sample.

Figure 10: Cumulative Investment Response to Tax Changes



(a) User Cost of Capital

(b) METR

Notes: Point estimates shown along with 95% confidence intervals. Data for fixed investment and capital stock by asset type from BEA Fixed Asset Tables. User cost of capital and METR calculated using IRS depreciation bonus rules, top marginal corporate tax rates from the IRS, discount rates from Moody's AA rated corporate bonds, and depreciation rates from the BEA Fixed Asset Tables. We calculate change in asset investment rates by year then winsorize the top 5% and bottom 5% of observations in each year.

Changes in the investment rate over longer periods of time vary significantly with the cost of capital (c) over time (Table 1). Between 2018 and 2016, a 1 percentage point decline in c is associated with a 1.426 percentage point increase in the investment rate, albeit at the 10% level of significance. Over a longer horizon, the change in the investment rate from 2016 to 2021 and 2022 also vary significantly with declines in the cost of capital (c) over those periods. We estimate a 1 percentage point decline in c is associated with a 2.388 percentage point and 2.328 percentage point increase in the investment rate for the 2016 to 2021 and 2016 to 2022 periods respectively. These estimates are meaningfully above the CBO's CapTax model which uses literature estimates (Cummins et al. (1994), Cummins et al. (1995), Bitros and Nadiri (2017) and Dwenger (2014)) finding that a 1% decrease in the user cost of capital is associated with a 0.7% increase in investment.[12]

Figure 10 Panel B shows that the relationship between investment and METR is negative and statistically significant. The change in investment rates between 2018 and 2016 varies significantly with the change in the marginal effective tax rate (METR) (a 1 percentage point decline in $METR$ is associated with a 0.083 percentage point increase in the investment rate). Looking at the longer horizon, a 1 percentage point decline in $METR$ is associated with a 0.142 percentage point and 0.156 percentage point increase in the investment rate for the 2016 to 2021 and 2016 to 2022 periods, significant at the 5% level.

Investment rates (I/K) for BEA asset type "Computers and peripheral equipment manufacturing" (RD21) experienced a massive uptick in investment rate from 45% to 244% from 2015 to 2016 and back down to 29% in 2017 and 23% in 2018. Accordingly, the BEA recommends combining with other computer asset types (which range from 41.0 billion USD to 69.5 billion USD) and weighting by capital stock. This involves combining the 4 following asset types (and weighting by capital stock (K)): Computers and peripheral equipment manufacturing (RD21), Communications equipment manufacturing (RD22), Navigational and other instruments manufacturing (RD24) and Other computer and electronic manufacturing, n.e.c. (RD25).

Figure 11 Panel A shows that the relationship between investment and user cost continues to be negative and statistically significant when combining computer-related asset types. When combining computer-related asset types and looking across different time periods (Table 2), a 1 percentage point decline in c from 2016 to 2018 is associated with a 1.274 percentage point increase in the investment rate. Over a longer horizon, a 1 percentage point decline in c is associated with a 1.652 percentage point and 1.850 percentage point increase in the investment rate for the 2016 to

[12]See CBO (2018): "In CBO's estimation, a 1 percent decrease in the user cost of capital translates into a 0.7 percent increase in investment"

2021 and 2016 to 2022 periods respectively.

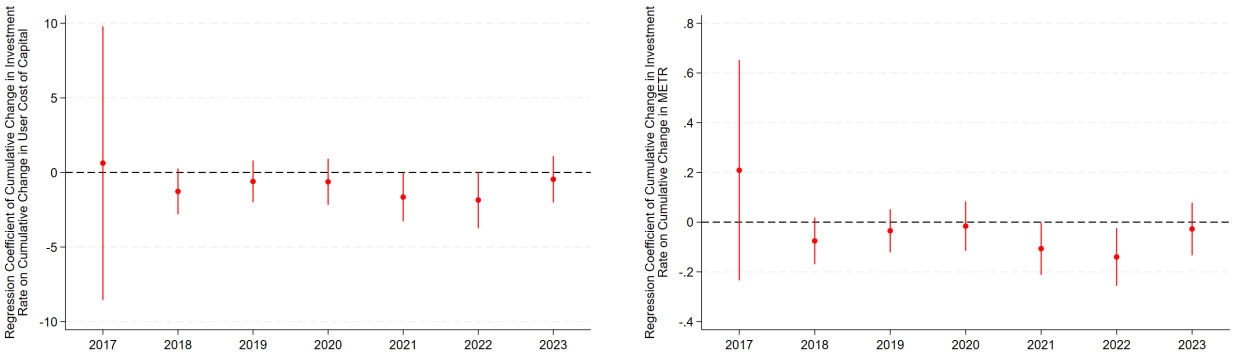
Table 2: Cumulative Investment Response to Tax Changes: User Cost of Capital and Effective Tax Rate Analysis (Computer-related asset types combined)

$\frac{I_{i,t}}{K_{i,t-1}} - \frac{I_{i,2016}}{K_{i,2015}}$	2017	2018	2019	2020	2021	2022	2023
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$c_{i,t} - c_{i,2016}$	0.624	-1.274	-0.605	-0.627	-1.652**	-1.850*	-0.459
	(4.617)	(0.773)	(0.706)	(0.776)	(0.820)	(0.949)	(0.782)
Constant	0.003	-0.006	-0.000	-0.012	-0.030	-0.034	-0.004
	(0.014)	(0.007)	(0.006)	(0.008)	(0.016)	(0.022)	(0.007)
R^2	0.0003	0.0330	0.0092	0.0088	0.0544	0.0514	0.0040
$METR_{i,t} - METR_{i,2016}$	0.208	-0.075	-0.034	-0.015	-0.106**	-0.140**	-0.027
	(0.223)	(0.047)	(0.043)	(0.050)	(0.053)	(0.058)	(0.053)
Constant	-0.001	-0.001	0.001	-0.008	-0.006	-0.008	-0.002
	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)	(0.007)	(0.004)
R^2	0.0128	0.0338	0.0088	0.0016	0.0618	0.0887	0.0037
N	93	93	93	93	93	93	93

Notes: Robust standard errors in parentheses. *** p<0.01 ** p<0.05 * p<0.10. Data for fixed investment from BEA Fixed Asset Tables. User cost of capital and METR data from OSPC Cost of Capital Calculator. User cost of capital and METR data from OSPC Cost of Capital Calculator. Computer-related asset types (RD21, RD22, RD24, RD25) are combined and weighted by capital stock to reduce volatility. We calculate change in asset investment rates by year then winsorize the top 5% and bottom 5% of observations in each year.

Figure 10 Panel B shows that the relationship between investment and METR continues to be negative and statistically significant when combining computer-related asset types. When combining computer-related asset types, a 1 percentage point decline in $METR$ from 2016 to 2018 is associated with a 0.075 percentage point increase in the investment rate. Looking at the longer horizon, a 1 percentage point decline in $METR$ is associated with a 0.106 percentage point and 0.140 percentage point increase in the investment rate for the 2016 to 2021 and 2016 to 2022 periods significant at the 5% level.

Figure 11: Cumulative Investment Response to Tax Changes (Computer-Related Asset Types Combined)



(a) User Cost of Capital

(b) METR

Notes: Point estimates shown along with 95% confidence intervals. Data for fixed investment and capital stock by asset type from BEA Fixed Asset Tables. User cost of capital and METR calculated using IRS depreciation bonus rules, top marginal corporate tax rates from the IRS, discount rates from Moody's AA rated corporate bonds, and depreciation rates from the BEA Fixed Asset Tables. Computer-related asset types (RD21, RD22, RD24, RD25) are combined and weighted by capital stock to reduce volatility. We calculate change in asset investment rates by year then winsorize the top 5% and bottom 5% of observations in each year.

We find that BEA asset types most impacted by the 2017 tax reform, with greater reductions in user cost of capital and marginal effective tax rate (METR) after the 2017 TCJA was implemented, had greater statistically significant increases in their investment rates, several years after the tax reform. Specifically, we find the magnitude of a 1 percentage point decrease in user cost being associated with a 1.42 to 2.39 percentage point in increase the rate of investment, larger than prior estimates found in Cummins et al. (1994), Cummins et al. (1995), Bitros and Nadiri (2017) and Dwenger (2014).

Following Cummins et al. (1994), we can calculate the elasticity of aggregate investment with respect to the user cost of capital. Taking our estimated coefficients from Table 1, we can divide by the sample mean investment rate (0.187) and multiply by the sample mean UCC (0.203) to get a range of elasticities of -1.54 to -2.59 (see Table 7 for more details). Alternatively, one could do a back of the envelope calculation to convert our coefficients to elasticities. Considering the mean investment rate in our sample is 18.7%, we would want to multiply our coefficients by a factor of 5.34 to convert from the investment rate to investment. Additionally, a 1 percentage point change taken at the mean UCC in our sample (from 0.203 to 0.213) equates to a 4.92% change. Multiplying our coefficients by 5.34/4.92 yields elasticities ranging from -1.55 to -2.59, almost identical to the results above using the method of Cummins et al. (1994). These elasticities are more than double the investment elasticity of -0.7 estimated by the CBO (CBO, 2018). There are some further challenges with interpretation. CBO wishes to use such short-run elasticities from Cummins et al. (1994) (estimated from cross-sectional data by using investment data from only one year after historical corporate tax reforms) for the purposes of long-run general equilibrium modeling. Our estimates in contrast look at the longer run, many years after the TCJA was implemented, and arguably would be even more applicable for such modeling purposes.

In principle, one could calculate user cost of capital for C-corporations versus S-corporations. However, this in practice is difficult for the purpose of measuring the effect of user cost on investment since a split of BEA aggregate capital stock by legal form does not exist. Not separating C-corps and S-corps may bias our estimates.

There are several other considerations including whether one would also want to account for capital gains taxes as well in calculating user cost of capital. One could make an argument that investors in the stock market rather than management may be responsible for decisions about fixed investment (this also raises several questions surrounding agency problems). We stick to calculating user cost from the perspective of management which we think is a fair assumption given how removed investors can be from such decisions, particularly in an era when passive investing is dominant.

One other question of interest is the extent to which changes to bonus expensing versus changes in the corporate tax rate (changes in τ) are influencing the results. To attempt to decompose these effects, we run a separate series of specification where we regress the cumulative change in investment rate on two covariates: one where τ changes and bonus depreciation changes are kept constant in UCC (cumulatively) and another where τ is kept constant and bonus depreciation changes in UCC (cumulatively) post-tax reform. In one specification, we regress on just the one covariate (where τ is kept constant). In a second specification, we regress on the second covariate (where bonus depreciation is kept constant). In a third specification, we regress on both specifications. The results of this regression are in Table 6. What one sees from these results is that the responses in investment in 2020 and 2021 are largely driven by changes in z (changes in capital expensing tax rules). This suggests that changes to capital expensing tax rules may be even more potent than changes in the corporate tax rate when it comes to promoting business investment.

5 Conclusion

Using historical U.S. corporate tax reforms as quasi natural experiments, this paper demonstrates that U.S. firms on average increased their fixed investment in response to exogenous decreases in user cost of capital and marginal effective tax rate (METR) resulting from TCJA tax reforms. In particular, we find that BEA asset types with greater reductions in user cost of capital and marginal effective tax rate (METR) after the 2017 Tax Cuts and Jobs Act had greater statistically significant increases in their investment rates. We find that this is the case for several years after the tax reform. Our measured investment response to user cost (in the magnitude of a 1 percentage point decrease in

user cost being associated with a 1.42 to 2.39 percentage point increase in the rate of investment) is also larger than conventional estimates of the elasticity of investment with respect to user cost of capital used by the Congressional Budget Office (around 0.7) (CBO, 2018). Our findings should be of interest to those scoring the costs of future changes to tax policy, especially the extension of TCJA provisions.

References

Key methods that cbo used to estimate the macroeconomic effects of the 2017 tax act—supplemental material for the budget and economic outlook: 2018 to 2028. 2018.

Andrew B Abel. Investment and the value of capital. 1979.

Alan J Auerbach. Corporate taxation in the united states. *Brookings Papers on Economic Activity*, 1983(2):451–513, 1983.

Alan J. Auerbach and Kevin Hassett. Recent U.S. investment behavior and the tax reform act of 1986: A disaggregate view. *Carnegie-Rochester Conference Series on Public Policy*, 35:185–215, Autumn 1991.

Alan J Auerbach and Kevin Hassett. Tax policy and business fixed investment in the united states. *Journal of Public Economics*, 47(2):141–170, 1992.

George C. Bitros and M. Ishaq Nadiri. Elasticities of business investment in the U.S. and their policy implications: A disaggregate approach to modeling and estimation. Technical report, July 2017.

Olivier Blanchard, Changyong Rhee, and Lawrence Summers. The stock market, profit, and investment. *The Quarterly Journal of Economics*, 108(1):115–136, 1993.

Ricardo J Caballero. Small sample bias and adjustment costs. *The Review of Economics and Statistics*, pages 52–58, 1994.

Ricardo J Caballero, Eduardo MRA Engel, John C Haltiwanger, Michael Woodford, and Robert E Hall. Plant-level adjustment and aggregate investment dynamics. *Brookings papers on economic activity*, pages 1–54, 1995.

Gabriel Chodorow-Reich, Matthew Smith, Owen M Zidar, and Eric Zwick. Tax policy and investment in a global economy. *NBER Working Paper 32180*, 2024.

Darrel S Cohen and Jason G Cummins. A retrospective evaluation of the effects of temporary partial expensing. *FEDS Working Paper*, 2006.

Darrel S Cohen, Dorthe-Pernille Hansen, and Kevin A Hassett. The effects of temporary partial expensing on investment incentives in the united states. *National Tax Journal*, 55(3):457–466, 2002.

Jason G Cummins, Kevin A Hassett, R Glenn Hubbard, Robert E Hall, and Ricardo J Caballero. A reconsideration of investment behavior using tax reforms as natural experiments. *Brookings Papers on Economic Activity*, 1994(2): 1–74, 1994.

Jason G Cummins, Kevin A Hassett, and R Glenn Hubbard. Have tax reforms affected investment? *Tax Policy and the Economy*, 9:131–149, 1995.

Jason G Cummins, Kevin A Hassett, and R Glenn Hubbard. Tax reforms and investment: A cross-country comparison. *Journal of Public Economics*, 62(1-2):237–273, 1996.

Jason DeBacker and Roy Kasher. Effective tax rates on business investment under the tax cuts and jobs act. *AEI Paper & Studies*, pages 1B–1B, 2018.

Craig Doidge, Kathleen M Kahle, G Andrew Karolyi, and René M Stulz. Eclipse of the public corporation or eclipse of the public markets? *Journal of Applied Corporate Finance*, 30(1):8–16, 2018.

Nadia Dwenger. User cost elasticity of capital revisited. *Economica*, 81(321):161–186, January 2014.

William G Gale and Claire Haldeman. Searching for supply-side effects of the tax cuts and jobs act. *Brookings Institution*, 2021.

William G. Gale, Kyle Pomerleau, and M. Steven Rosenthal. The booming economy, not the 2017 tax act, is fueling corporate tax receipts. *Brookings Institution*, 2022.

Javier Garcia-Bernardo, Petr Janský, and Gabriel Zucman. Did the tax cuts and jobs act reduce profit shifting by us multinational companies? *NBER Working Paper No. 30086*, 2022.

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

Robert Gordon. *The rise and fall of American growth: The US standard of living since the civil war*. Princeton university press, 2017.

Niels Joachim Gormsen and Kilian Huber. Corporate discount rates. 2023.

Jane G. Gravelle and Mark P. Keightley. Marginal effective tax rates on investment and the expiring 2017 tax cuts. Report 48153, Congressional Research Service, 2024.

Robert E Hall and Dale W Jorgenson. Tax policy and investment behavior. *The American Economic Review*, 57(3): 391–414, 1967.

Kevin A. Hassett and R. Glenn Hubbard. Tax policy and business investment. In Alan J. Auerbach and Martin Feldstein, editors, *Handbook of Public Economics*, volume 3, pages 1293–1343. Elsevier, 2002.

Fumio Hayashi. Tobin's marginal q and average q: A neoclassical interpretation. *Econometrica: Journal of the Econometric Society*, pages 213–224, 1982.

Dale W Jorgenson. Capital theory and investment behavior. *The American Economic Review*, 53(2):247–259, 1963.

Patrick J. Kennedy, Christine L. Dobridge, Paul Landefeld, and Jacob Mortenson. Heterogeneity in corporate tax incidence by worker characteristics. *AEA Papers and Proceedings*, 114:346–351, 2024.

Anil Kumar. Did the tax cuts and jobs act create jobs and stimulate growth? *FRB of Dallas Working Paper 2001*, 2020.

James M Poterba and Lawrence H Summers. A ceo survey of us companies' time horizons and hurdle rates. *MIT Sloan Management Review*, 37(1):43, 1995.

Michael A Salinger and Lawrence H Summers. Tax reform and corporate investment: A microeconometric simulation study. In Martin Feldstein, editor, *Behavioral Simulation Mthods in Tax Policy Analysis*. University of Chicago Press, 1983.

Lawrence H Summers. Taxation and corporate investment: A q-theory approach, brooking papers on economic activity 1. *Brookings Papers on Economic Activity*, pages 67–127, 1981.

James Tobin. A general equilibrium approach to monetary theory. *Journal of Money, Credit and Banking*, 1(1):15–29, 1969.

Alexander F. Wagner, Richard J. Zeckhauser, and Ziegler Alexandre. The tax cuts and jobs act: Which firms won? which lost? *NBER Working Paper 27470*, 2020.

6 Appendix

Table 3: Change in UCC by BEA Asset

Panel A: Change in UCC by Major Asset Group

Major Asset Group	Baseline UCC (2016)	Δ UCC 2018-2016	Δ UCC 2023-2016
Equipment	0.2763	-0.0102	-0.0094
Structures	0.0880	-0.0092	-0.0098
Intellectual Property	0.2717	-0.0055	-0.0043
Asset Average	0.2130	-0.0087	-0.0083

Panel B: Change in UCC by BEA Asset

Code	Asset Name	Major Asset Group	Baseline UCC (2016)	Δ UCC 2018-2016	Δ UCC 2023-2016
AE10	Theatrical movies	Intellectual Property	0.1511	-0.0139	-0.0123
AE20	Long-lived television programs	Intellectual Property	0.2307	-0.0185	-0.0157
AE30	Books	Intellectual Property	0.1794	-0.0142	-0.0133
AE40	Music	Intellectual Property	0.3254	-0.0142	-0.0133
AE50	Other entertainment originals	Intellectual Property	0.1674	-0.0142	-0.0133
EI11	Nuclear fuel	Equipment	0.3044	-0.0102	-0.0093
EI12	Other fabricated metals	Equipment	0.1430	-0.0071	-0.0071
EI21	Steam engines	Equipment	0.1056	-0.0097	-0.0092
EI22	Internal combustion engines	Equipment	0.2620	-0.0115	-0.0103
EI30	Metalworking machinery	Equipment	0.1750	-0.0083	-0.0080
EI40	Special industrial machinery	Equipment	0.1548	-0.0075	-0.0074
EI50	General industrial equipment	Equipment	0.1591	-0.0077	-0.0075
EI60	Electric transmission and distribution	Equipment	0.1038	-0.0096	-0.0091
ENS1	Prepackaged software	Equipment	0.6088	-0.0146	-0.0125
ENS2	Custom software	Equipment	0.3841	-0.0099	-0.0091
ENS3	Own account software	Intellectual Property	0.3760	-0.0018	0.0003
EO11	Household furniture	Equipment	0.1887	-0.0070	-0.0070
EO12	Other furniture	Equipment	0.1702	-0.0081	-0.0078
EO21	Farm tractors	Equipment	0.1985	-0.0091	-0.0086
EO22	Construction tractors	Equipment	0.2152	-0.0077	-0.0075
EO30	Other agricultural machinery	Equipment	0.1702	-0.0081	-0.0078
EO40	Other construction machinery	Equipment	0.2067	-0.0075	-0.0074
EO50	Mining and oilfield machinery	Equipment	0.2035	-0.0093	-0.0087
EO60	Service industry machinery	Equipment	0.2064	-0.0094	-0.0088
EO71	Household appliances	Equipment	0.2170	-0.0078	-0.0076
EO72	Other electrical	Equipment	0.2382	-0.0106	-0.0097
EO80	Other	Equipment	0.2007	-0.0092	-0.0086
EP12	Office and accounting equipment	Equipment	0.3680	-0.0119	-0.0106
EP1A	Mainframes	Equipment	0.5237	-0.0162	-0.0137
EP1B	PCs	Equipment	0.5237	-0.0162	-0.0137

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Table 3 Continued from previous page

Code	Asset Name	Major Asset Group	Baseline UCC (2016)	Δ UCC 2018-2016	Δ UCC 2023-2016
EP1C	DASDs	Equipment	0.5237	-0.0162	-0.0137
EP1D	Printers	Equipment	0.5237	-0.0162	-0.0137
EP1E	Terminals	Equipment	0.5237	-0.0162	-0.0137
EP1F	Tape drives	Equipment	0.5237	-0.0162	-0.0137
EP1G	Storage devices	Equipment	0.5237	-0.0162	-0.0137
EP1H	System integrators	Equipment	0.5237	-0.0162	-0.0137
EP20	Communications	Equipment	0.1650	-0.0079	-0.0077
EP31	Photocopy and related equipment	Equipment	0.2324	-0.0082	-0.0079
EP34	Nonelectro medical instruments	Equipment	0.1879	-0.0087	-0.0083
EP35	Electro medical instruments	Equipment	0.1879	-0.0087	-0.0083
EP36	Nonmedical instruments	Equipment	0.1879	-0.0087	-0.0083
ET11	Light trucks (including utility vehicles)	Equipment	0.2247	-0.0080	-0.0077
ET12	Other trucks, buses and truck trailers	Equipment	0.2247	-0.0080	-0.0077
ET20	Autos	Equipment	0.3900	-0.0125	-0.0110
ET30	Aircraft	Equipment	0.1356	-0.0055	-0.0059
ET40	Ships and boats	Equipment	0.1127	-0.0074	-0.0073
ET50	Railroad equipment	Equipment	0.1089	-0.0058	-0.0062
RD11	Pharmaceutical and medicine manu.	Intellectual Property	0.1460	-0.0018	-0.0019
RD12	Chemical manu., ex. pharma and med	Intellectual Property	0.2060	-0.0018	-0.0013
RD21	Computers and peripheral equipment manu.	Intellectual Property	0.4460	-0.0018	0.0009
RD22	Communications equipment manu.	Intellectual Property	0.3160	-0.0018	-0.0003
RD23	Semiconductor and other component manu.	Intellectual Property	0.2960	-0.0018	-0.0005
RD24	Navigational and other instruments manu.	Intellectual Property	0.3360	-0.0018	-0.0001
RD25	Other computer and electronic manu., n.e.c.	Intellectual Property	0.4460	-0.0018	0.0009
RD31	Motor vehicles and parts manu.	Intellectual Property	0.3560	-0.0018	0.0001
RD32	Aerospace products and parts manu.	Intellectual Property	0.2660	-0.0018	-0.0008
RD40	Software publishers	Intellectual Property	0.2717	-0.0075	-0.0073
RD50	Financial and real estate services	Intellectual Property	0.2060	-0.0018	-0.0013
RD60	Computer systems design and related serv.	Intellectual Property	0.4147	-0.0105	-0.0095
RD70	Scientific research and development serv.	Intellectual Property	0.2060	-0.0018	-0.0013
RD80	All other nonmanufacturing, n.e.c.	Intellectual Property	0.2060	-0.0018	-0.0013
RD91	Private universities and colleges	Intellectual Property	0.2104	-0.0062	-0.0064
RD92	Other nonprofit institutions	Intellectual Property	0.2104	-0.0062	-0.0064
RDOM	Other manufacturing	Intellectual Property	0.2060	-0.0018	-0.0013
SB10	Religious	Structures	0.0855	-0.0117	-0.0126
SB20	Educational and vocational	Structures	0.0855	-0.0117	-0.0126
SB31	Hospitals	Structures	0.0855	-0.0117	-0.0126
SB32	Special care	Structures	0.0855	-0.0117	-0.0126
SB41	Lodging	Structures	0.0978	-0.0131	-0.0139
SB42	Amusement and recreation	Structures	0.0789	-0.0047	-0.0054
SB43	Air transportation	Structures	0.0920	-0.0124	-0.0133
SB44	Local transit structures	Structures	0.0920	-0.0124	-0.0133
SB45	Other transportation	Structures	0.0920	-0.0124	-0.0133

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Table 3 Continued from previous page

Code	Asset Name	Major Asset Group	Baseline UCC (2016)	Δ UCC 2018-2016	Δ UCC 2023-2016
SB46	Other land transportation	Structures	0.0717	-0.0038	-0.0046
SC01	Warehouses	Structures	0.0904	-0.0122	-0.0131
SC02	Other commercial	Structures	0.0953	-0.0128	-0.0136
SC03	Multimerchandise shopping	Structures	0.0953	-0.0128	-0.0136
SC04	Food and beverage establishments	Structures	0.0953	-0.0128	-0.0136
SI00	Manufacturing	Structures	0.1022	-0.0136	-0.0143
SM01	Petroleum and natural gas	Structures	0.1245	-0.0052	-0.0057
SM02	Mining	Structures	0.0945	-0.0053	-0.0058
SN00	Farm	Structures	0.0769	-0.0088	-0.0085
SO01	Water supply	Structures	0.0754	-0.0087	-0.0084
SO02	Sewage and waste disposal	Structures	0.0754	-0.0087	-0.0084
SO03	Public safety	Structures	0.0920	-0.0124	-0.0133
SO04	Highway and conservation and development	Structures	0.0741	-0.0074	-0.0074
SOMO	Mobile structures	Structures	0.1055	-0.0057	-0.0061
SOO1	Office	Structures	0.0933	-0.0126	-0.0134
SOO2	Medical buildings	Structures	0.0933	-0.0126	-0.0134
SU11	Other railroad	Structures	0.0700	-0.0082	-0.0081
SU12	Track replacement	Structures	0.0736	-0.0045	-0.0052
SU20	Communication	Structures	0.0754	-0.0075	-0.0075
SU30	Electric	Structures	0.0726	-0.0073	-0.0073
SU40	Gas	Structures	0.1245	-0.0052	-0.0057
SU50	Petroleum pipelines	Structures	0.0717	-0.0038	-0.0046
SU60	Wind and solar	Structures	0.0785	-0.0040	-0.0048

Table 4: Cumulative Investment Response to Tax Changes: User Cost of Capital and Effective Tax Rate Analysis

$\frac{I_{i,t}}{K_{i,t-1}} - \frac{I_{i,2016}}{K_{i,2015}}$	2017	2018	2019	2020	2021	2022	2023
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$c_{i,t} - c_{i,2016}$:							
No Winsorization	33.787	-11.690	-10.281	-7.990	-10.228	-12.003	-14.355
	(35.690)	(8.437)	(7.381)	(5.390)	(6.220)	(7.927)	(10.721)
2.5% Winsorization	0.769	-1.816*	-1.633	-1.698	-3.187**	-3.226**	-1.445
	(7.500)	(0.957)	(1.102)	(1.0237)	(1.385)	(1.510)	(1.249)
5% Winsorization	**0.754**	**-1.426***	**-0.808**	**-1.219**	**-2.388****	**-2.323****	**-1.027**
	(5.327)	**(0.786)**	**(0.753)**	**(0.974)**	**(0.974)**	**(1.025)**	**(0.980)**
10% Winsorization	1.833	-1.054*	-0.525	-0.456	-1.391**	-1.628**	-0.618
	(3.565)	(0.621)	(0.641)	(0.628)	(0.620)	(0.780)	(0.696)
$METR_{i,t} - METR_{i,2016}$:							
No Winsorization	4.829	-0.719	-0.643	-0.468	-0.632	-0.687	-1.017
	(4.302)	(0.521)	(0.463)	(0.346)	(0.388)	(0.437)	(0.747)
2.5% Winsorization	0.551	-0.106*	-0.097	-0.080	-0.190**	-0.199**	-0.095
	(0.479)	(0.059)	(0.068)	(0.080)	(0.089)	(0.089)	(0.085)
5% Winsorization	**0.334**	**-0.083***	**-0.046**	**-0.053**	**-0.142****	**-0.156****	**-0.065**
	(0.272)	**(0.047)**	**(0.046)**	**(0.062)**	**(0.066)**	**(0.064)**	**(0.065)**
10% Winsorization	0.232	-0.060	-0.029	-0.009	-0.087**	-0.122**	-0.038
	(0.161)	(0.037)	(0.039)	(0.039)	(0.039)	(0.047)	(0.045)
N	96	96	96	96	96	96	96

Notes: Robust standard errors in parentheses. *** p<0.01 ** p<0.05 * p<0.10. Data for fixed investment from BEA Fixed Asset Tables. User cost of capital and METR data from OSPC Cost of Capital Calculator. We calculate change in asset investment rates by year then winsorize the observations at the top and bottom. The benchmark specification is bolded. Note that with less than 100 asset types, winsorizing 1% is equivalent to no winsorization

Table 5: Cumulative Investment Response to Tax Changes: User Cost of Capital and Effective Tax Rate Analysis (Computer-related asset types combined)

$\frac{I_{i,t}}{K_{i,t-1}} - \frac{I_{i,2016}}{K_{i,2015}}$	2017	2018	2019	2020	2021	2022	2023
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$c_{i,t} - c_{i,2016}$:							
No Winsorization	-3.335	-1.562	-0.953	-1.008	-2.231*	-2.178*	-0.453
	(6.725)	(1.071)	(0.943)	(1.091)	(1.173)	(1.282)	(0.976)
2.5% Winsorization	-0.447	-1.300	-0.721	-0.814	-1.916*	-1.824*	-0.483
	(5.209)	(0.794)	(0.769)	(0.918)	(1.060)	(1.061)	(0.964)
5% Winsorization	**0.624**	**-1.274**	**-0.605**	**-0.627**	**-1.652****	**-1.850***	**-0.459**
	(4.617)	**(0.773)**	**(0.706)**	**(0.776)**	**(0.820)**	**(0.949)**	**(0.782)**
10% Winsorization	1.708	-0.999	-0.511	-0.218	-1.329**	-1.459*	-0.219
	(3.381)	(0.606)	(0.645)	(0.551)	(0.640)	(0.779)	(0.639)
$METR_{i,t} - METR_{i,2016}$:							
No Winsorization	0.015	-0.092	-0.057	-0.033	-0.133*	-0.149*	-0.020
	(0.326)	(0.066)	(0.059)	(0.071)	(0.078)	(0.082)	(0.067)
2.5% Winsorization	0.162	-0.076	-0.040	-0.024	-0.116	-0.133**	-0.029
	(0.255)	(0.048)	(0.047)	(0.059)	(0.070)	(0.066)	(0.066)
5% Winsorization	**0.208**	**-0.075**	**-0.034**	**-0.015**	**-0.106****	**-0.140****	**-0.027**
	(0.223)	**(0.047)**	**(0.043)**	**(0.050)**	**(0.053)**	**(0.058)**	**(0.053)**
10% Winsorization	0.188	-0.058	-0.028	0.003	-0.084**	-0.117**	-0.010
	(0.153)	(0.037)	(0.039)	(0.034)	(0.040)	(0.047)	(0.042)
N	93	93	93	93	93	93	93

Notes: Robust standard errors in parentheses. *** p<0.01 ** p<0.05 * p<0.10. Data for fixed investment from BEA Fixed Asset Tables. User cost of capital and METR data from OSPC Cost of Capital Calculator. User cost of capital and METR data from OSPC Cost of Capital Calculator. Computer-related asset types (RD21, RD22, RD24, RD25) are combined and weighted by capital stock to reduce volatility. We calculate change in asset investment rates by year then winsorize the observations at the top and bottom. The benchmark specification is bolded. Note that with less than 100 asset types, winsorizing 1% is equivalent to no winsorization.

Table 6: Cumulative Investment Response to Tax Changes: User Cost of Capital and Effective Tax Rate Analysis

$\frac{I_{i,t}}{K_{i,t-1}} - \frac{I_{i,2016}}{K_{i,2015}}$	2018			2019			2020			2021			2022			2023		
	τ	*bonus*	Both	τ	*bonus*	Both	τ	*bonus*	Both	τ	*bonus*	Both	τ	*bonus*	Both	τ	*bonus*	Both
$c_{i,t} - c_{i,2016}$	-1.307		-1.307	-0.806		-0.768	-1.771*		-1.774*	-1.675		-1.591	-0.989		-0.599	-0.938		-0.649
(τ changes; *bonus* fixed)	(0.923)		(0.918)	(0.848)		(0.851)	(0.993)		(1.007)	(1.087)		(1.066)	(0.759)		(0.746)	(0.720)		(0.806)
$c_{i,t} - c_{i,2016}$		-0.922	-0.922		-0.521	-0.481		-0.176	0.022		-2.129**	-2.080**		-2.795***	-2.652***		-1.205	-0.831
(bonus changes; τ fixed)		(0.670)	(0.666)		(0.641)	(0.643)		(0.827)	(0.826)		(0.941)	(0.936)		(0.934)	(0.953)		(0.927)	(1.038)
Constant	-0.003	-0.004	-0.012	-0.000	-0.000	-0.004	-0.020	-0.011	-0.020	-0.030	-0.044	-0.070	-0.012	-0.061	-0.691	-0.007	-0.011	-0.012
	(0.006)	(0.006)	(0.008)	(0.005)	(0.006)	(0.007)	(0.007)	(0.008)	(0.009)	(0.018)	(0.019)	(0.025)	(0.014)	(0.022)	(0.024)	(0.005)	(0.007)	(0.007)
R^2	0.0209	0.0197	0.0406	0.0095	0.0070	0.0156	0.0327	0.0005	0.0327	0.0246	0.0516	0.0738	0.0177	0.0869	0.0932	0.0177	0.0177	0.0245
N	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96

Notes: Robust standard errors in parentheses. *** p<0.01 ** p<0.05 * p<0.10. Data for fixed investment from BEA Fixed Asset Tables. User cost of capital and METR data from OSPC Cost of Capital Calculator. We calculate change in asset investment rates by year then winsorize the top 5% and bottom 5% of observations in each year. Estimates for 2017 are excluded because both measures of UCC and METR are identical, thus collinear. Here we run a separate series of specification where we regress the cumulative change in investment rate on two covariates: one where τ changes and bonus depreciation changes are kept constant in UCC (cumulatively) and another where τ is kept constant and bonus depreciation changes in UCC (cumulatively) post-tax reform. In one specification, we regress on just the one covariate (where τ is kept constant). In a second specification, we regress on the second covariate (where bonus depreciation is kept constant). In a third specification, we regress on both specifications. The results of this regression are in Table 6. What one sees from these results is that the responses in investment in 2020 and 2021 are largely driven by changes in z (changes in capital expensing tax rules). This suggests that changes to capital expensing tax rules may be even more potent than changes in the corporate tax rate when it comes to promoting business investment.

Table 7: Aggregate Investment Elasticities

Year	Coefficient	Mean I/K	Mean UCC	Elasticity
2017	0.754	0.187	0.203	0.818
2018	-1.426*	0.187	0.203	-1.548
2019	-0.808	0.187	0.203	-0.877
2020	-1.219	0.187	0.203	-1.323
2021	-2.388**	0.187	0.203	-2.592
2022	-2.323**	0.187	0.203	-2.521
2023	-1.027	0.187	0.203	-1.118

Notes: This table presents conversions of our estimated coefficients into investment elasticities following the method of Cummins et al. (1994). Column 2 presents our estimated coefficients from regressions of the cumulative change in the investment rate on the cumulative change in UCC (see Table 1). Columns 3 and 4 report our sample mean investment rate and UCC, calculating from years 2016 through 2023. Column 5 presents the elasticities, which are calculating by taking the coefficient divided by the mean investment rate and multiplied by the mean UCC.