

Do Corporate Taxes Hinder Innovation?

Internet Appendix

A.1 Empirical Tests Supporting Main Results

1. Cross Country Analysis

In this section we report cross country results. We collected data on international corporate tax rates and patenting activity. Then we estimated a cross-country regression, using the same framework as our baseline regression. That is, we performed a difference-in-difference estimation at a country-year panel. Our dependent variable is the change in the number of patents filed by the country's inventors at the US Patent Office, while independent variables are the dummies corresponding to the corporate tax increase and decrease as reported in Thomson (2012). To take away broad any macro-economic trends, we control for region-year fixed effects.

Even in the cross-country setting, we find our results very similar to our baseline tests. While this goes some way towards answering questions on external validity of our results, the cost we incur is the loss of tightness of our identification. For instance, we cannot perform tests on firms located just across the country borders (both due to availability of data but also because unlike some of the US state pairs, countries are more likely to differ across other political and economic dimensions), or find enough information on the predictability of certain tax changes.

2. Large Sample Results with Actual Changes in Tax Rates

In the first three columns of Table A.2, we look at the actual changes in tax rates as our main explanatory variables. Our evidence shows that the number of patents gets affected in the two years following the tax change. In particular, a 1.5 percentage point increase in the state corporate income tax rate (a one standard deviation change) leads to a 4.1% (coefficient in Table A.2, column (2), 0.027, times 1.5) decline in a number of patents granted to the state's firms in the two years following the tax change. In terms of economic magnitude, this means that our average firm obtains 0.37 fewer patents (9.11 times 0.041) by the second year following a tax change. Since the number of patent grants has to be an integer, it is, perhaps, more reasonable to discuss economic magnitudes in terms of the fraction of firms that changed patenting activity. Going by this metric, the economic magnitude means that a 1.5 percentage point tax increase causes approximately 37% of affected firms to patent

one fewer innovation project, compared to a mean of about 9.11 patents per firm-year. Our estimated effect implies an elasticity of patents to corporate taxes of 0.6.¹

In columns (4)-(6), we report our large sample results (columns (1)-(3) of Table 2, Panel A in the paper). Here we split tax changes into increases and decreases and find that most of our effect comes from tax increases rather than tax cuts. In terms of economic magnitude, in the second year following a tax increase – which on average raises corporate taxes by around 1.1 percentage point – approximately 37% of treated firms patent one fewer innovation project, while there is no significant effect after tax decreases. In columns (7)-(9), we report results with binary indicators for tax increases and decreases results (columns (4)-(6) of Table 2, Panel A in the paper).

3. Robustness Checks on Standard Errors

In this section, we report robustness checks on standard errors. Our original choice of clustering by state was motivated by the fact that the tax changes are at the state level. If a tax change does have an effect, then many firms in the state of the change will be affected together, making their innovation policies correlated within state [Bertrand and Mullainathan (2003)]. Similarly, if there are macroeconomic changes at the state-level, then all firms within the state are also likely to be affected together, causing them to co-move. On the other hand, state clustering will not account for industry-level comovement, and hence, we examine if our conclusions are robust to such a specification. Panel A of Table A.3 reports results with one-dimension-clustering at firm-level (columns (1)-(3)), industry-level (SIC 4) (columns (4)-(6)), and year-level (columns (7)-(9)). Moreover, Panel B of Table A.3 reports results with two-dimension-clustering at firm-year level (columns (1)-(3)), industry-year level (SIC 4) (column(4)-column(6)) and state-year level (columns (7)-(9)). Our main results are robust to alternative methods of clustering the standard errors. In fact, in most of the specifications t-statistics for tax increases are greater than 3.

4. Robustness Checks on Predictability of Tax Changes

In this section we report robustness of our results (Table A.4) for unpredictable tax changes in a large sample, following the methodology described in Section 2.2.1. We take

¹From a sample mean effective total corporate tax rate of about 22.44% (federal plus state), a tax increase of 1 percentage point raises rates by 4.5%, relative to the base rate. So, the elasticity is $0.027/0.045=0.6$.

the position of an agent trying to predict tax changes out-of sample using macro information and available news on tax changes and only consider unanticipated tax changes based on the prediction model. We take the predicted value for each state and year, and classify tax changes as ‘unpredictable’ if the predicted probability of a change in that year is less than 0.1 (columns (1)-(3), Panel A) and 0.2 (columns (4)-(6), Panel A). In columns (1)-(3), Panel B, we report results where, instead of using all past data in the regression sample, we use 10-year rolling windows for estimation. In columns (4)-(6), Panel B, we only use macro information (without news coverage data). Again, reassuringly, our baseline conclusions remain.

5. R&D State

In this test, we rely only on firms that differ in their headquarter and R&D states for our identification. If the firm’s headquarter state is the most relevant one for tax purposes, while economic conditions surrounding innovation matter the most at the level of the R&D state, then we can identify the tax effect on innovation by exploiting the difference in economic conditions between the two states. Here we control for local economic shocks that change innovative conditions at the firm R&D state level by using R&D state times year fixed effects.² In other words, by controlling for R&D state times year fixed effects we are able to see how innovation changed through the channel of headquarter instructing its subsidiaries at R&D state to change innovation policies rather than due to local economic conditions. We define a firm’s R&D state as one in which most of the innovators that file a patent for the firm are located, and report the results in Table A.5.

6. Economic Recovery Tax Act (ERTA) Analysis

In this section we report results of a test where we look at state-corporate tax policy changes which occurred only as a response to negative shocks to the state fiscal position caused by federal legislation. Economic Recovery Tax Act of 1981 (ERTA81) implemented accelerated depreciation schedules (through its implementation of the accelerated cost recovery system (ACRS)), thereby reducing current tax revenues for states that followed federal rules. To offset this reduction, four states (Indiana, Iowa, Nebraska, and Wisconsin) increased the corporate income tax rate [Aronson and Hilley (1986); Giroud and Rauh (2015)].

²The identification here is similar in nature to Bertrand and Mullainathan (2003) where the legal changes that authors explore are at the level of firm’s state of incorporation. By controlling for trends at the level of a firm’s headquarter state, the authors are able to control for local economic conditions that firms face where presumably most operations are conducted and identify the effect of legal changes.

In Table A.6, we examine changes in innovation activity in the period around these tax changes (1978-1985) in a difference-in-differences setting. Here, we define treated states as the four states that changed taxes due to federal policy changes only. We exclude from the control group any other state which underwent a tax change in this period, so that we do not contaminate our control group (if we keep these firms in the control group, and these firms do respond to other tax changes, then the difference-in-differences coefficient estimate will be biased downward). Notice that the overall effect of the ACRS at the federal level would affect both our treatment and control firms, and hence, does not affect our analysis. Comfortingly, even in this entirely out-of-sample test, we find that innovation activity, as measured by patenting, declined two years after the tax change in affected states, with no significant effect in other years. Our magnitudes from this test are also similar to our overall sample results.

7. Instrumental Variables Approach

In this section we employ an instrumental variables regression approach, exploiting state-level differences in the majority provision required to pass a tax increase, and its interaction with state partisan balance.

Specifically, we look at three categorical variable instruments. Our first instrument is a state-level dummy variable that takes a value of one if the state in question requires more than 50% votes in its legislatures to pass a tax increase. Our second (third) instrument is a dummy variable that takes a value of one when Democrats have enough legislators (no party has enough legislators) in the state legislative chambers to pass a tax increase. Of course, a one-party majority or supermajority (which is correlated with our second and third instruments) might have an effect on firm innovation through policies other than taxes. However, in our instrumental variable tests, we carefully control for such potentially direct effects on innovation of the underlying level of simple majority of any party in the state. We thus attempt to examine *incremental* explanatory power of our latter two instruments, coming solely from states where parties can have a majority but not enough legislators to pass a tax increase, and vice-versa.³

Our instruments are likely to satisfy the exclusion restriction required for identification. First, it is unlikely that the exact number of legislators required by a party *to pass a tax increase* is something that a firm could have lobbied for. Second, since we are able to examine

³A point to note here is that the state level requirements we examine apply only to tax increases, so in this appendix we do not compare increases vs. decreases.

the majority requirement that *specifically* pertains to tax increases, controlling explicitly for other types of majority, it is likely that our variables affect innovation only through the tax channel.

The state partisan balance data in this section is from Klarner (2003), as well as from the updates available on the State Politics and Policy Web site.⁴

We start our analysis by examining whether our instruments indeed predict future changes in taxes. The evidence presented in Table A.7, column (1), shows that a list of macroeconomic variables we consider do not predict tax changes. However, this is not to say that the state's economic condition does not affect taxes, but rather that our list of *observable* past economic variables are not good predictors.

To this effect, in columns (2) and (3), we add our political variables. The results show that: (1) tax increases are 8.8-9.1% less likely when the state in question has a supermajority requirement for tax increases in place; (2) tax increases are 12.4-14.1% more likely when the Democratic Party has the majority required for a tax increase in a state's legislatures; and, (3) tax increases are 9.5% more likely when neither party has the majority required for a tax increase in the state's legislatures, with the latter two estimated in comparison to the base scenario of Republicans having enough legislators in both chambers. As mentioned above, note that these coefficients measure the *incremental* explanatory power of the political balance variables, since we directly control for Democrat (and no party) simple majority, as well for as Democrats (and no party) having the required numbers to pass the budget (which is sometimes also subject to supermajority requirements). Of particular note is the fact that our instruments continue to be significant in the presence of the budget majority dummy. This shows that the difference between majority provisions required to pass a tax increase and that required to pass the budget matters. This is a strong condition – one that is likely to hold only if the identification comes purely through the tax majority requirement channel. In addition, the budget majority dummy itself is not significant, which again is consistent with the view that it is not just any type of majority but rather the precise majority requirement for passing tax increases that matters for tax changes.

However, the F-statistics for the joint significance of these instruments is less than 5 in all of our specifications (Table A.7). This implies that our instruments are weak – tax changes are hard to predict. The problem with the standard point estimator, when instrumental variables are weak, is that it can have severe bias and incorrect standard error distributions [Andrews and Stock (2005)]. Thus, following Andrews and Stock (2005), we use fully weak IV-robust confidence intervals, based on the the Anderson-Rubin (AR) test.⁵ Specifically,

⁴See <http://www.indstate.edu/polisci/klarnerpolitics.htm>.

⁵Andrews and Stock (2005) write, "We therefore have focused on testing and CIs (confidence intervals)

confidence intervals are formed by inverting tests that are robust to weak instrumental variables. That is, a confidence intervals for a parameter β , say, is the set of points $[\beta_1, \beta_2]$ for which a weak instrumental variable robust test fails to reject the null hypothesis $H_0: \beta = \beta_0$.

In the results presented in Table A.8, we use all state-level macro variables in Table A.7 and firm level variables in Table A.2 as controls, except for our three instruments. Instead, we add predicted values of the tax increase variable based on the state-level regressions of Table A.7, taking care to ensure that our confidence intervals account for such two-step estimation. Results presented in columns (1)-(3) of Table A.8 correspond to the regression model in column (2) of Table A.7 (predictive power of instruments over and above the direct effect of Democrat/no party majority), while those in (4)-(6) correspond to column (3) of Table A.7. Our evidence shows that the instrumented tax increase variable significantly affects innovation in the third year after the tax change, while we cannot reject the hypothesis of no effect of taxes on innovation in the preceding years.

Unfortunately, although we are able to establish in this analysis that tax increases indeed have a negative effect on future innovation, our weak instruments do not allow us to provide precise point estimates of magnitudes.

8. Further Robustness Checks

In this section we report further robustness checks (Table A.9) to the specification in Panel A of Table 2. Row (1) reports the results for a regression where use Compustat headquarter information to identify firm's state. Row (2) reports results with the state name counts in 10-K forms [Garcia and Norli (2012)]. In row (3), we use the state where the highest proportion of firm's employees is located. Row (4) reports the results for firms that do not change their states during our entire sample period. Overall, we find that our basic result on tax increases is robust.

for weak IVs for which a solution is closer at hand than it is for estimation."

Table A.1: Cross Country Analysis

This table reports the results for cross country analysis. We collected data on international corporate tax rates and patenting activity. Then we estimated a cross-country regression, in the framework of our baseline with region-year fixed effects. All regressions include region-year fixed effects, not reported for brevity. Standard errors are clustered at country-level and reported in parentheses. *, **, and *** indicate significance at 10%, 5% and 1% respectively.

	$\Delta \text{Ln}(1+\#\text{Patents})_{t+k}$		
	k=1 (1)	k=2 (2)	k=3 (3)
Tax Decrease _{s,t}	-0.018 (0.044)	0.006 (0.042)	-0.00002 (0.052)
Tax Increase _{s,t}	0.044 (0.085)	0.075 (0.046)	-0.154 (0.086)*
Region-Year FEs	YES	YES	YES
Obs.	582	558	534

Table A.2: Large Sample Results with Actual Changes in Tax Rates

This table provides the regression results of the effect of corporate taxes on innovation. In columns (1)-(3), we use actual changes in taxes, while in columns (4)-(6) we partition the changes into positive and negative changes. In columns (7)-(9) we replace the changes with the indicators which allows us to include tax changes that cannot be directly quantified, and estimate the following regression:

$$\Delta \text{Ln}(1+\#\text{Patents})_{i,s,t+k} = \beta_D \Delta T_{st}^- + \beta_I \Delta T_{st}^+ + \delta \Delta X_{it} + \alpha_t + \epsilon_{i,s,t+k}$$

where $i, s, t+k$ index firms, states, years with $k = 1$ to 3 ; $\text{Ln}(1+\#\text{Patents})_{i,s,t+k}$ measures innovation activity by firm i in state s in financial year t . ΔT_{st}^- and ΔT_{st}^+ are indicators equaling one if state s decreased or increased its corporate tax rate in year t ; X_{it} are firm level factors that can affect innovation. All regressions include year fixed effects. Standard errors are clustered at state-level and reported in parentheses. *, **, and *** indicate significance at 10%, 5% and 1% respectively.

	$\Delta \text{Ln}(1+\#\text{Patents})_{t+k}$								
	k=1	k=2	k=3	k=1	k=2	k=3	k=1	k=2	k=3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\Delta \text{Tax Rate}_{s,t}$	-0.016 (0.011)	-0.027 (0.005)***	0.003 (0.008)						
$\Delta^- \text{Tax Rate}_{s,t}$				0.007 (0.016)	-0.020 (0.014)	0.007 (0.019)			
$\Delta^+ \text{Tax Rate}_{s,t}$				-0.019 (0.012)	-0.034 (0.005)***	-0.001 (0.007)			
Tax Decrease $_{s,t}$							-0.004 (0.013)	-0.001 (0.009)	0.004 (0.010)
Tax Increase $_{s,t}$							-0.055 (0.014)***	-0.053 (0.020)***	-0.060 (0.037)
$\Delta \text{Ln}(\text{Sales})_{i,t}$	0.023 (0.007)***	0.009 (0.005)*	-0.004 (0.006)	0.023 (0.007)***	0.009 (0.005)*	-0.004 (0.006)	0.022 (0.006)***	0.007 (0.005)	-0.002 (0.006)
$\Delta \text{Ln}(K/L)_{i,t}$	-0.0004 (0.006)	-0.010 (0.007)	-0.017 (0.007)**	-0.0003 (0.006)	-0.010 (0.007)	-0.017 (0.007)**	-0.003 (0.006)	-0.011 (0.007)	-0.017 (0.006)***
$\Delta \text{HHI}_{i,t}$	-0.115 (0.153)	-0.204 (0.176)	-0.184 (0.166)	-0.115 (0.153)	-0.205 (0.176)	-0.184 (0.166)	-0.113 (0.148)	-0.249 (0.181)	-0.309 (0.215)
$\Delta \text{HHI Sq}0_{i,t}$	0.144 (0.169)	0.332 (0.198)*	0.229 (0.162)	0.143 (0.169)	0.331 (0.197)*	0.228 (0.162)	0.178 (0.159)	0.363 (0.195)*	0.377 (0.211)*
$\Delta \text{R\&D/Sales}_{i,t}$	0.007 (0.009)	0.017 (0.006)***	-0.001 (0.008)	0.007 (0.009)	0.017 (0.006)***	-0.001 (0.008)	0.004 (0.008)	0.020 (0.005)***	-0.002 (0.007)
$\Delta \text{Profitability}_{i,t}$	-0.003 (0.003)	0.0005 (0.002)	0.002 (0.002)	-0.003 (0.003)	0.0005 (0.002)	0.002 (0.002)	-0.003 (0.003)	0.001 (0.002)	0.002 (0.002)
$\Delta \text{Tangibility}_{i,t}$	-0.057 (0.035)	0.039 (0.036)	0.043 (0.046)	-0.057 (0.035)	0.039 (0.036)	0.043 (0.046)	-0.056 (0.032)*	0.036 (0.037)	0.046 (0.036)
$\Delta \text{Rating}_{i,t}$	0.035 (0.015)**	0.00006 (0.018)	-0.019 (0.017)	0.035 (0.015)**	0.0002 (0.018)	-0.019 (0.017)	0.029 (0.014)**	-0.003 (0.018)	-0.016 (0.018)
$\Delta \text{Log(GSP)}_{s,t}$	0.236 (0.212)	0.155 (0.226)	-0.123 (0.191)	0.252 (0.210)	0.173 (0.232)	-0.116 (0.193)	0.319 (0.203)	0.121 (0.228)	0.050 (0.185)
$\Delta \text{Taxes as \% of GSP}_{s,t}$	-0.0001 (0.022)	0.008 (0.013)	-0.005 (0.017)	0.0002 (0.022)	0.009 (0.013)	-0.005 (0.017)	0.008 (0.018)	0.008 (0.014)	0.026 (0.010)**
$\Delta \text{Log(Population)}_{s,t}$	0.960 (0.425)**	0.770 (0.356)**	10.261 (0.358)***	0.888 (0.423)**	0.724 (0.349)**	10.239 (0.352)***	0.753 (0.417)*	0.740 (0.384)*	10.024 (0.336)***
$\Delta \text{Unemployment Rate}_{s,t}$	0.017 (0.011)	0.014 (0.014)	-0.002 (0.012)	0.017 (0.012)	0.014 (0.015)	-0.002 (0.012)	0.018 (0.011)	0.012 (0.015)	0.002 (0.012)
Obs.	40,092	35,433	30,812	40,092	35,433	30,812	42,192	37,317	32,557

Table A.3: Clustering of Standard Errors

This table provides further robustness checks to the specification in Panel A of Table 2. Here we alter the clustering level for standard errors. Panel A reports results with one dimension clustering at firm-level (columns(1)-(3)), industry-level (SIC 4)(columns(4)-(6)) and year-level (columns(7)-(9)), respectively. Panel B reports results with two dimension clustering at firm-year level (columns(1)-(3)), industry-year level (SIC 4) (columns(4)-(6)) and state-year level (columns(7)-(9)), respectively. All regressions include firm-level and state-level controls, and year fixed effects, not reported for brevity. Standard errors are reported in parentheses. *,**, and *** indicate significance at 10%, 5% and 1% respectively.

Panel A: One Dimension

	Firm			Industry			Year		
	$\Delta \text{Ln}(1+\#\text{Patents})_{t+k}$								
	k=1	k=2	k=3	k=1	k=2	k=3	k=1	k=2	k=3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Tax Decrease _{s,t}	-0.004 (0.009)	-0.001 (0.010)	0.004 (0.010)	-0.004 (0.008)	-0.001 (0.009)	0.004 (0.009)	-0.004 (0.008)	-0.001 (0.012)	0.004 (0.012)
Tax Increase _{s,t}	-0.055 (0.017)***	-0.053 (0.017)***	-0.060 (0.026)**	-0.055 (0.016)***	-0.053 (0.017)***	-0.060 (0.018)***	-0.055 (0.008)***	-0.053 (0.013)***	-0.060 (0.029)**
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Obs.	42,192	37,317	32,557	42,192	37,317	32,557	42,192	37,317	32,557

Panel B: Two Dimensions

	Firm-Year			Industry-Year			State-Year		
	$\Delta \text{Ln}(1+\#\text{Patents})_{t+k}$								
	k=1	k=2	k=3	k=1	k=2	k=3	k=1	k=2	k=3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Tax Decrease _{s,t}	-0.004 (0.006)	-0.001 (0.011)	0.004 (0.011)	-0.004 (0.007)	-0.001 (0.012)	0.004 (0.011)	-0.004 (0.011)	-0.001 (0.009)	0.004 (0.011)
Tax Increase _{s,t}	-0.055 (0.007)***	-0.053 (0.013)***	-0.060 (0.029)**	-0.055 (0.004)***	-0.053 (0.009)***	-0.060 (0.029)**	-0.055 (0.008)***	-0.053 (0.015)***	-0.060 (0.034)*
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Obs.	42,192	37,317	32,557	42,192	37,317	32,557	42,192	37,317	32,557

Table A.4: Predictability of Tax Changes

This table provides further robustness checks to the columns (1)-(3) of Panel B, Table 2. We take the position of an agent trying to predict tax changes out-of sample using the macro information and available news on tax changes and only consider unanticipated tax changes based on the prediction model. We take the predicted value for each state and year, and classify tax changes as ‘unpredictable’ if the predicted probability of a change in that year is less than 0.1 (columns (1)-(3), Panel A) and 0.2 (columns (4)-(6), Panel A). In columns (1)-(3), Panel B, we report results where, instead of using all past data in the regression sample, we use 10-year rolling windows for estimation. In columns (4)-(6), Panel B, we only use macro information (without news coverage data). Standard errors are reported in parentheses. *, **, and *** indicate significance at 10%, 5% and 1% respectively.

Panel A: Recursive with Fixed Cut-offs

	Recursive with 10% Cut-off			Recursive with 20% Cut-off		
	$\Delta \text{Ln}(1+\#\text{Patents})_{t+k}$					
	k=1	k=2	k=3	k=1	k=2	k=3
	(1)	(2)	(3)	(4)	(5)	(6)
Tax Decrease _{s,t}	-0.006 (0.013)	-0.001 (0.010)	-0.007 (0.008)	-0.0001 (0.014)	0.0005 (0.009)	-0.0002 (0.011)
Tax Increase _{s,t}	-0.056 (0.016)***	-0.038 (0.023)	-0.086 (0.036)**	-0.055 (0.014)***	-0.053 (0.020)***	-0.060 (0.037)
Controls	YES	YES	YES	YES	YES	YES
Obs.	42,192	37,317	32,557	42,192	37,317	32,557

Panel B: Other Robustness

	Rolling Window with 20% Cut-off			Only State-Level Macro Data		
	$\Delta \text{Ln}(1+\#\text{Patents})_{t+k}$					
	k=1	k=2	k=3	k=1	k=2	k=3
	(1)	(2)	(3)	(4)	(5)	(6)
Tax Decrease _{s,t}	-0.00007 (0.014)	0.0005 (0.009)	-0.0002 (0.011)	0.009 (0.014)	-0.004 (0.010)	0.007 (0.011)
Tax Increase _{s,t}	-0.051 (0.016)***	-0.052 (0.021)**	-0.063 (0.037)*	-0.055 (0.014)***	-0.053 (0.020)***	-0.060 (0.037)
Controls	YES	YES	YES	YES	YES	YES
Obs.	42,192	37,317	32,557	42,192	37,317	32,557

Table A.5: R&D State

This table reports the results for tests where we draw a wedge between a firm's headquarter state and its R&D state. Here we control for the local economic shocks that change innovative conditions at the firm R&D state level by using R&D state *times* year fixed effects. We define a firm's R&D state as one in which most of the innovators that file a patent for the firm are located. All regressions include firm level and state level controls, not reported for brevity. Standard errors are clustered at state level and reported in parentheses. *, **, and *** indicate significance at 10%, 5% and 1% respectively.

	$\Delta \text{Ln}(1+\#\text{Patents})_{t+k}$		
	k=1 (1)	k=2 (2)	k=3 (3)
Tax Decrease _{s,t}	-0.044 (0.029)	-0.027 (0.020)	-0.0007 (0.021)
Tax Increase _{s,t}	-0.077 (0.038)**	-0.055 (0.050)	-0.065 (0.045)
Controls	YES	YES	YES
R&D State-Year FEs	YES	YES	YES
Obs.	15,113	13,357	11,615

Table A.6: Economic Recovery Tax Act (ERTA) Analysis

This table reports the results for state-corporate tax policy changes which occurred as a response to negative shocks to the state fiscal position caused by federal legislation. Economic Recovery Tax Act of 1981 (ERTA81) implemented accelerated depreciation schedules (through its implementation of the accelerated cost recovery system (ACRS)), thereby reducing current tax revenues for states that followed federal rules. To offset this reduction, four states (Indiana, Iowa, Nebraska, and Wisconsin) increased the corporate income tax rate [Aronson and Hilley (1986); Giroud and Rauh (2015)]. Here, we examine changes in innovation activity in the period around these tax changes (1978-1985) in a difference-in-differences setting. We define treated states as the four states that changed taxes due to federal policy changes only. All regressions include firm-level and state-level controls, and year fixed effects, not reported for brevity. Standard errors are clustered at state-level and reported in parentheses. *, **, and *** indicate significance at 10%, 5% and 1% respectively.

	$\Delta \text{Ln}(1+\#\text{Patents})_{t+k}$		
	k=1	k=2	k=3
	(1)	(2)	(3)
ERTA Tax Increase	0.028 (0.043)	-0.125 (0.016)***	0.117 (0.091)
Controls	YES	YES	YES
Obs.	8,684	8,189	7,664

Table A.7: Predictors of Tax Increase

This table reports the results for an OLS regression of Tax Increase dummy on state partisan balance data, state level economic controls and state and year fixed effects. We estimate the regressions in a system of panel data at state and year level. In column (1), we include macro-economic controls and state and year fixed effects. In column (2), we further include state partisan balance variables for a tax increase and variables indicating overall state partisan balance. In column (3), we include state partisan balance needed to pass the budget as additional predictors. All regressions are with state fixed effects and year fixed effects, not reported for brevity. Standard errors are clustered at state-level and reported in parentheses. *, **, and *** indicate significance at 10%, 5% and 1% respectively.

	Tax Increase Dummy		
	(1)	(2)	(3)
More than 50% Votes Necessary to Pass any Type of Tax Increase		-0.091 (0.041)**	-0.088 (0.041)**
Democrats Have Sufficient Majority for Passing a Tax Increase in Both Houses		0.124 (0.043)***	0.141 (0.043)***
No Party Has Sufficient Majority for Passing a Tax Increase in Both Houses		0.095 (0.036)***	0.094 (0.040)**
Democrats Have Simple Majority in Both Houses		-0.019 (0.034)	
No Party Has Simple Majority in Both Houses		-0.017 (0.024)	
Democrats Have Sufficient Majority to Pass Budget in Both Houses			-0.038 (0.035)
No Party Has Sufficient Majority to Pass Budget in Both Houses			-0.015 (0.026)
Budget Deficit as % of $GSP_{s,t-1}$	0.018 (0.016)	0.020 (0.017)	0.020 (0.017)
Taxes as % of $GSP_{s,t-1}$	-0.020 (0.015)	-0.016 (0.016)	-0.017 (0.016)
$\text{Log}(GSP)_{s,t-1}$	0.104 (0.105)	0.161 (0.109)	0.152 (0.109)
Real GSP Growth $_{s,t-1}$	-0.0006 (0.003)	-0.001 (0.003)	-0.001 (0.003)
Unemployment Rate $_{s,t-1}$	-0.014 (0.009)	-0.008 (0.010)	-0.008 (0.010)
Obs.	824	807	807
F-Stat	NA	3.56	4.21

Table A.8: Instrumental Variables Approach

This table presents instrumental variables regression confidence intervals (CIs) for our main variable of interest, Tax Increase_{s,t}. These CIs are constructed by inverting weak IV robust tests of coefficient significance. We present 95% CIs constructed by inverting Andersen and Rubin (AR) weak IV robust test. The dependent variable in our regression equation is $\Delta \text{Ln}(1+\#\text{Patents})_{i,s,t+k}$ where $i, s, t+k$ index firms, states, years with $k = 1$ to 3. All specifications include all firm-level controls in Table A.2, all state-level macro controls in Table A.7, as well as firm and year fixed effects. In column (1)-(3) we include variables indicating overall state partisan balance and state partisan balance needed to pass the budget in column (4)-(6). All CIs are robust to heteroskedasticity and clustering of standard errors at the state-level. *** indicates that the instrumented coefficient is significantly different from zero at the 99% level (that is, the 99% CI does not contain zero).

Instruments More than 50% votes necessary to pass any type of tax increase, Democrats have sufficient majority in state legislatures for passing a tax increase, and No party has sufficient majority in state legislatures for passing a tax increase						
$\Delta \text{Ln}(1+\#\text{Patents})_{t+k}$						
	k=1	k=2	k=3	k=1	k=2	k=3
	(1)	(2)	(3)	(4)	(5)	(6)
AR	[-0.0606, 1.51] [-0.0606, 1.67] [-0.585,-.0202]***			[-0.0606, 1.232] [-.141, 1.353] [-0.424,-0.0202]***		
State partisan balance controls	Democrats have simple majority in both houses No party has simple majority in both houses			Democrats have sufficient majority to pass budget in both houses No party has sufficient majority to pass budget in both houses		
Other controls	State level controls from Table A.7, firm level controls from Table A.2, firm and year FEs			State level controls from Table A.7, firm level controls from Table A.2, firm and year FEs		
Obs.	42,026	37,167	32,424	42,026	37,167	32,424

Table A.9: Further Robustness Checks

This table provides further robustness checks to the specification in Panel A of Table 2. All regressions include firm level and state level controls and year fixed effects, not reported for brevity. Row (1) reports the results for a regression where use Compustat headquarter information to identify firm's state. Row (2) reports results with the state name counts in 10-K forms [Garcia and Norli (2012)]. In row (3), we use the state where the highest proportion of firm's employees is located. Row (4) reports the results for firms that do not change their states during our entire sample period. Standard errors are clustered at state-level and reported in parentheses. *,**, and *** indicate significance at 10%, 5% and 1% respectively.

	$\Delta \text{Ln}(1+\#\text{Patents})_{t+1}$			$\Delta \text{Ln}(1+\#\text{Patents})_{t+2}$			$\Delta \text{Ln}(1+\#\text{Patents})_{t+3}$		
	Tax Decrease	Tax Increase	Obs.	Tax Decrease	Tax Increase	Obs.	Tax Decrease	Tax Increase	Obs.
(1) Compustat HQ State	-0.008 (0.012)	-0.053 (0.013)***	42,144	-0.002 (0.008)	-0.038 (0.019)**	37,271	0.003 (0.007)	-0.060 (0.034)*	32,512
(2) 10-K State	-0.002 (0.011)	-0.033 (0.018)*	39,169	-0.007 (0.008)	-0.053 (0.018)***	35,014	0.009 (0.012)	-0.062 (0.034)*	30,877
(3) Max. Employment State	-0.010 (0.011)	-0.044 (0.017)**	30,307	-0.011 (0.008)	-0.066 (0.022)***	27,280	0.012 (0.008)	-0.059 (0.036)	24,289
(4) Same State	-0.007 (0.012)	-0.058 (0.017)***	36,119	-0.002 (0.010)	-0.045 (0.022)**	31,844	0.006 (0.008)	-0.069 (0.037)*	27,676

A.2 Keywords Searched in Factiva News Database

We search for keywords in each state in the US. Following is the example of keyword search for Alabama:

Tax increases: ("corporate income tax increase" OR "corporate income tax increased" OR "corporate income tax to be increased" OR "increase in corporate income taxes" OR "increase in corporate income tax" OR "corporation income tax increase" OR "corporation income tax increased" OR "corporation income tax to be increased" OR "increase in corporation income taxes" OR "corporate income tax raised" OR "corporate income tax to be raised" OR "corporate income tax raise" OR "raise in corporate income taxes" OR "raise in corporate income tax" OR "corporation income tax raise" OR "corporation income tax raised" OR "corporation income tax to be raised" OR "raise in corporation income taxes" OR "corporate income tax rise" OR "rise in corporate income taxes" OR "rise in corporate income tax" OR "corporation income tax rise" OR "rise in corporation income taxes") AND Alabama

Tax decreases: ("corporate income tax decreased" OR "corporate income tax to be decreased" OR "corporate income tax decrease" OR "decrease in corporate income taxes" OR "decrease in corporate income tax" OR "corporation income tax decrease" OR "corporation income tax decreased" OR "corporation income tax to be decreased" OR "decrease in corporation income taxes" OR "corporate income tax reduced" OR "corporate income tax to be reduced" OR "corporate income tax reduction" OR "reduction in corporate income taxes" OR "reduction in corporate income tax" OR "corporation income tax reduction" OR "corporation income tax reduced" OR "corporation income tax to be reduced" OR "reduction in corporation income taxes" OR "corporate income tax lowered" OR "corporate income to be tax lowered" OR "lower corporate income tax" OR "lower corporate income taxes" OR "lower corporate income tax" OR "corporation income tax lowering" OR "corporation income tax lowered" OR "corporation income tax to be lowered" OR "lower corporation income taxes" OR "corporate income tax slashed" OR "corporate income tax to be slashed" OR "corporate income tax slash" OR "slash in corporate income taxes" OR "slash in corporate income tax" OR "corporation income tax slash" OR "corporation income tax slashed" OR "corporation income tax to be slashed" OR "slash in corporation income taxes" OR "corporate income tax to be cut" OR "corporate income tax cut" OR "cut in corporate income taxes" OR "cut in corporate income tax" OR "corporation income tax cut" OR "corporation income tax to be cut" OR "cut in corporation income taxes") AND Alabama

A.3 Models of Innovator Incentives

A.3.1 Taxes in a General Equilibrium Model of Innovator Incentives

In this section we summarize the relevant sections of the structure in Jaimovich and Rebelo (2015), and show that corporate tax changes affect the agents' decision whether to work as innovators or regular workers, and this decision has further implications for the number of patents and products produced in the economy.

Production: Final-good producers operate a constant-returns-to-scale production function that combines labor (L) with a continuum of measure n of intermediate goods (x_i):

$$Y = L^\alpha \int_0^n x_i^{1-\alpha} di$$

The final goods producer maximizes overall after-tax profits, given by:

$$\pi^f = (L^\alpha \int_0^n x_i^{1-\alpha} di) - \int_0^n p_i x_i di - w.L)(1 - \tau)$$

where p_i is the price of the final good, w is the wage rate, τ is the corporate income tax rate.

The first order conditions for this problem yield:

$$p_i = (1 - \alpha)L^\alpha x_i^{-\alpha} \tag{1}$$

$$w = \alpha L^{\alpha-1} n x_i^{1-\alpha} \tag{2}$$

with $\pi^f = 0$ in equilibrium.

Innovators own permanent patents on the intermediate good that comes out of their innovation, so each innovator is a monopolist over his intermediate good. Each unit of the intermediate good uses η units of the final good. So the profit from each intermediate good is given by

$$\pi^i = (p_i - \eta)x_i(1 - \tau) \tag{3}$$

From (1) and (3), shows the optimal price-quantity pair is:

$$p_i = \frac{\eta}{(1 - \alpha)}$$

$$x_i = L \cdot \left[\frac{(1 - \alpha)^2}{\eta} \right]^{\frac{1}{\alpha}} \tag{4}$$

These expressions demonstrate a key source of confusion that can affect studies like ours – in partial equilibrium set-ups, the price or quantity of the innovation good produced is not directly affected by corporate taxes (see above expressions, for example). This is because,

while tax expenses increase with a higher tax rate, given tax deductibility of investments in innovation, tax benefits also rise.

However, as demonstrated below, in a general equilibrium setting, this does not imply that taxes do not matter for innovation. Even if price and quantity do not change in a partial equilibrium, the size of the after tax profits decline, which reduces the pie available to innovators and thus their incentive to innovate. Such an effect elicits a general equilibrium response in terms of occupational choice, making some innovators switch to less innovative tasks (become regular workers in the model), and thus affecting aggregate innovation in response to tax changes.

Given the structure of the model, all producers choose the same p_i and x_i yielding the after-tax level of (maximized) profits:

$$\pi = \alpha(1 - \alpha)^{\frac{2-\alpha}{\alpha}} \eta^{-\frac{(1-\alpha)}{\alpha}} L(1 - \tau) \quad (5)$$

From (2) and (4), the wage rate equals:

$$w_t = \alpha n_t \left[\frac{(1 - \alpha)^2}{\eta} \right]^{\frac{1-\alpha}{\alpha}} \quad (6)$$

The agent's optimization problem:

Agents differ in their innovative ability, a . An agent with the ability a can produce $\partial a n_t$ new goods if he chooses to be an innovator. The utility, which an agent with ability a maximizes, is given by:

$$U(a) = \int_0^{\infty} e^{-\rho t} \frac{C_t(a)^{1-\sigma} - 1}{1 - \sigma} dt \quad (7)$$

with $C_t(a)$ denoting her consumption in period t .

In each period, the agent has to choose whether he will work in the job that gives him the best chance of coming up with a successful innovation, or move elsewhere in the job market. For modelling simplicity, we model the extreme case where he either remains an innovator, or switches to being a worker (a zero-one decision to innovate).

If he chooses to be a worker, he gets a per-period wage w_t . Therefore, the period-by-period budget constraint is:

$$\dot{b}_t(a) = r_t b_t(a) + w_t l_t(a) + m_t(a) \pi_t + \frac{\pi^f}{H} - C_t(a) + \frac{T_t}{H} \quad (8)$$

where $l_t(a) = 1$ if the agent chooses to be a worker in period t (0 otherwise); $b_t(a)$ is the agent's bond holding in period t ; r_t is the real interest rate; T_t is the total (lump-sum) transfer from the government; H is the population size. $m_t(a)$ is the number of patents

owned by an agent of ability a at time t . Assume that individuals with the same ability start from the same endowment of patents, and also that the initial endowment of bonds is 0. Then the equation describing the motion of m_t is:

$$\dot{m}_t(a) = \partial a n_t [1 - l_t(a)] \quad (9)$$

The no-Ponzi condition for bonds is $\lim_{t \rightarrow \infty} e^{\int_0^t r_s ds} b_t(a) = 0$. This condition means that the agent cannot always plan to finance consumption by borrowing very large amounts.

Solving the model:

Since the structure of the model follows Jaimovich and Rebelo (2015), we only state the conditions that are relevant in our setting. The reader interested in the details of equilibria in the different markets is kindly referred to Jaimovich and Rebelo (2015).

Choosing between being a worker and an innovator is determined by a threshold ability-level a^* , such that any agent with innovative ability greater than a^* becomes an innovator, while those with lower abilities become workers:

$$a^* \partial n_t \frac{\pi}{r} = w_t \quad (10)$$

The number of new products C (which is also the number of new patents here) is then:

$$\dot{n}_t(a) = H \partial n_t \int_{a^*}^{a^{max}} a dF \quad (11)$$

where $F(a)$ is the cdf of a , and a^{max} is the maximum value of a in the data.

This condition simply states that since anyone with ability greater than a^* innovates, the aggregation of their innovations gives the total per-period volume of patents in the economy.

The equilibrium condition in the labor market is then:

$$H \int_{a_{min}}^{a^{max}} l_t(a) dF = L \quad (12)$$

where a_{min} is the lower bound of innovative ability in the data (which can be 0 or otherwise).

The fraction of the population that works in the final goods sector (not innovators) is:

$$L = H.F(a^*) \quad (13)$$

The threshold value of a^* in the general equilibrium of this model is then:

$$\partial H(1 - \alpha)a^*F(a^*)(1 - \tau) = \sigma \partial H \int_{a^*}^{a^{max}} a dF + \rho \quad (14)$$

Condition (14) above shows that as the corporate tax rate τ rises, the threshold level determining occupational choice, a^* , has to increase. This can be summarized as:

Proposition 1: The threshold ability level above which the agent chooses to innovate increases with the corporate tax rate. Hence, corporate taxes affect innovation adversely through their effect on the incentives to innovate.

Given equation (11), which determines the law of motion for patents/products, this implies that the number of patents/new products generated in equilibrium must decline as corporate taxes increase.⁶

Testing the model's key prediction empirically requires interpreting a few assumptions. First, in this framework, innovation only happens in entrepreneurial firms and the outside option for innovators is shutting the entrepreneurial firm and entering the labor force as a "worker". However, in a more general sense, one can consider all innovative firms (or research divisions within a firm) as the "entrepreneurial firm", and employees at less innovative firms (or in non-research divisions within the firm) as the "workers".⁷ The outside option to researchers then naturally becomes employment as a "worker", as defined above – either inside or outside their existing firms.

A.3.2 A Model of Convex Tax Schedules

In this section, we show – following Gentry and Hubbard (2000) – that if the rewards to innovation are more variable than the rewards to safe investments, an increase in the convexity of the tax schedule can discourage innovative activity by raising the average tax burden on risky innovation.⁸

Assume that the firm faces two projects, each of which requires an investment I . A safe project earns S for sure. An innovative project faces uncertain income, and earns H with a probability of p , and L otherwise.

The firm is subject to a piecewise-linear income tax system with three brackets and increasing marginal tax rates across the brackets. The first bracket has a marginal tax rate of T_1 and covers the first E_1 dollars of income. The second bracket has a marginal tax rate

⁶Note that as none of our discussion above referred to any distributional assumptions for $F(\cdot)$ that Jaimovich and Rebelo (2015) make, the result that patenting declines following an increase in corporate taxes is general.

⁷In the model, post-tax profits in innovative firms accrue to innovators. One might argue that firm profits do not accrue to research personnel working therein. However, innovative firms do motivate their key innovative employees with compensation contracts linked to sales contributions of new products, or value of patents produced by the innovator's research (stock options are popular in many innovative firms, year-end bonuses are also linked to divisional performance). This is sufficient to generate the response central in the model.

⁸The tax schedule can become more convex, for example, with a top bracket tax change under a progressive rate or an increase in surcharges which affect the tax bill of high tax firms disproportionately more. These two tax changes are quite common in US state corporate tax systems.

of T_2 and covers income between E_1 and E_2 dollars. In the third bracket, a marginal tax rate of T_3 applies to income above E_2 dollars. All investment is tax deductible. Consider the case where:

$$L - I < E_1 < S - I < E_2 < H - I.$$

The firm makes a decision whether to invest in the safe project or in an innovative project based on its expected after-tax income. In particular, the firm will choose the innovative project if:

$$(1 - p)(1 - T_1)(L - I) + p[(1 - T_3)(H - I) + (T_2 - T_1)E_1 + (T_3 - T_2)E_2] > (1 - T_2)(S - I) + (T_2 - T_1)E_1$$

We can now examine the comparative statics of this expression. For expositional simplicity, we model an increase in the convexity of the schedule as an increase in the top corporate tax rate T_3 . The derivative of firm's decision expression with respect to the highest marginal tax rate T_3 is:

$$p(E_2 - H + I)$$

This expression is negative, given the assumption that the successfully innovating firm ends up in the highest marginal tax bracket. Summarizing the discussion above,

Proposition 2: An increase in top bracket taxes will reduce incentives for firms to undertake innovation projects, particularly if the innovation projects are more risky.

Intuitively, since the top tax rate reduces the rewards from extremely successful outcomes, the investment in projects with particularly uncertain payoffs should decline if the top tax rate is changed by more than the rates in the other brackets.

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